AN EVALUATION OF SITE OPERATIVES' KNOWLEDGE, BEHAVIOUR, MOTIVATION, BELIEFS AND ATTITUDES TOWARD CONSTRUCTION & DEMOLITION WASTE MANAGEMENT

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Thesis submitted to the Galway-Mayo Institute of Technology,
in part fulfilment of the requirements for the M.Sc. in Environmental Systems

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ABSTRACT

Despite ever-evolving environmental concerns resulting from increased awareness of environmental sustainability and the rising costs of landfill levies, taxes and raw materials, the Construction and demolition (C&D) industry remains a large producer of waste, both in Ireland and globally. Though the common focus of research in the field of C&D W management has largely concentrated on how C&D W management practices contribute to the generation, minimisation and reuse of C&D W, significantly less focus has been paid to the potential effect of individual differences (e.g. knowledge, motivation, beliefs and attitudes) on C&D W management practices. The overall aim of the current programme of research was to examine, through a mixed methods approach to data analysis, the effects of a 'tool-box-talk' C&D W management training intervention on site operatives' knowledge, behaviour, motivation, beliefs and attitudes towards waste management. Results from the current research programme revealed: (1) that the 'tool-box-talk' training intervention significantly enhanced knowledge towards waste management; (2) a positive variance in behaviour towards waste management from pre-to-post- intervention assessment; (3) there was no effect of the tool-box-talk training intervention on motivation, beliefs or attitudes towards waste management; (4) there was an effect of time on both positive beliefs and attitudes towards waste management; (5) there was no effect of age, years on-site/experience or education on waste management knowledge, overall motivation, beliefs or attitudes; (6) there was a significant effect of position/trade on waste management knowledge, in which electricians scored significantly higher than non-electricians on waste management knowledge, overall motivation and two motivation sub-scales (i.e. help-seeking and control of beliefs); (7) overall motivation was significantly correlated with all motivation sub-scales and positive beliefs at pre-testing, but only with motivation towards effort regulation at post-testing; (8) positive beliefs about waste management was significantly correlated with motivation towards control of beliefs at pre-testing; (9) beliefs about waste management were correlated with attitudes towards waste management at post-testing, as was motivation to control beliefs; (10) though age and years on-site/experience were both positively correlated with each other, they were both negatively correlated with pre-intervention knowledge; and (11) though the operatives rated the tool-box-talk training favourably, they thought it would be too difficult to implement, given that what the training presents as appropriate waste management protocol is both restricted (by "space, time and organisation" [participant IM]) and contradictory to the site practices they indicate are imposed on them. Overall, the results suggest that the 'tool-box-talk' C&D W management training intervention is an efficacious learning method, as it was shown, empirically, to enhance site operatives' waste management knowledge and was shown to have further beneficial effects on site operatives' waste management behaviour. Empirical and theoretical implications of these results and future research possibilities are discussed in light of past research.

ACKNOWLEDGEMENTS

Above all else, I like to thank my supervisor, Dr. Mark Kelly for his valuable guidance and support.

Furthermore, I would like to thank BAM Building Ltd. and their employees for their time and patience, during data collection for this thesis.

Finally, I would like to thank my family for their perpetual support throughout the duration of my education.

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CHAPTER 1

CONSTRUCTION & DEMOLITION WASTE FRAMEWORKS

1.1 Overview

This chapter will begin with an introduction to the concept of construction & demolition waste (C&D W) through the provision of data on C&D W composition and quantification. It will then provide definitions of C&D W, in order to better understand how C&D W is identified in C&D W literature. The remainder of this chapter will focus on the legislative frameworks currently in place for the management of C&D W. Specifically, the legislation, policies and regulations which have had the greatest effect on C&D W management, in Ireland, will be presented and discussed. The final section in this chapter will focus on discussion of the ISO14001:2004 certification, as the company which took part in the current research (i.e. BAM Building Limited), will have been required to meet the requirements of this certification. Such discussion is necessary in order to understand both what *quality* means with reference to an environmental management system and the managerial setting that governs the work environment examined in the current research.

1.2 Introduction

C&D W and its management is one of many developing and ever-evolving environmental concerns. This is due to the increased awareness of environmental sustainability and perhaps equally, to the rising costs of landfill levies, taxes and raw materials. However, despite these concerns, the construction industry remains "notorious" for (over) producing massive amounts of C&D W (Kwan et al., 2003).

The harmful effects of C&D W are plentiful. For example, C&D W contributes to waste sent to landfill. Such C&D W frequently comprises 10–30 per cent of the waste received at many landfill sites around the world (Fishbein, 1998). Similarly, the C&D industry is one of the largest waste producers in the Republic of Ireland, in which C&D W (i.e. including contaminated soils) accounts for approximately 22 per cent (Figure 1.1) of total waste going to landfill (EPA, 2012b).

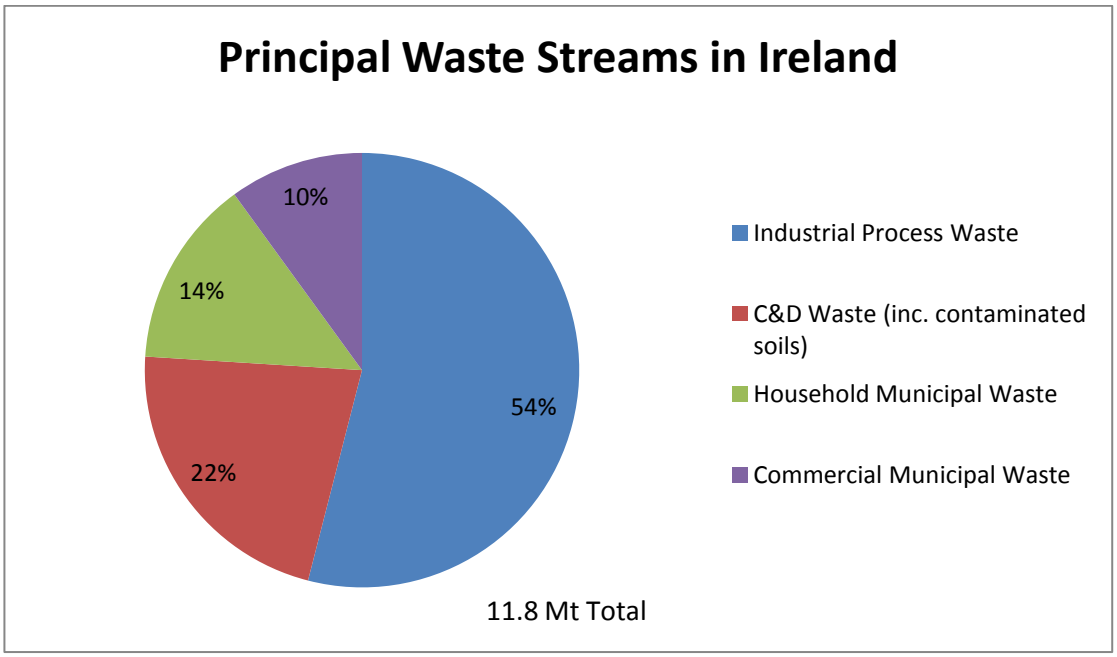


Figure 1.1 Principal Waste Streams in Ireland (EPA, 2012b)

Consequently, a large amount of land resources are consumed through the construction of landfill sites (Poon et al., 2003). For example, according to the EPA (2010) as of July 2009, there were 48 open landfill sites (i.e. including MSW, inert and mono landfill sites) and 395 closed landfill sites. Open landfills at that time covered 275Ha (EPA, 2010). This is quite a large quantity of land to be used simply for burying waste, considering the whole of Ireland measures 8,442,100Ha. C&D W can also cause harm to surrounding areas, through hazardous pollution (Esin & Cosgun, 2007). More

specifically, unauthorised or badly monitored landfills can allow harmful chemicals (e.g. heavy metals such as lead from lead flashings or cadmium from PVC-window frames) to flow into surface water, ground water and soil, in the form of leachate (EPA 2010). Notably, since the EPA began regulation of landfills, the operational standards of landfill sites has greatly improved. For example, by July 2009, all open MSW landfills (i.e. which also accept non-hazardous C&D waste for backfilling [Engineering the West Team, 2011]) were operating under the requirements of the Landfill Directive (e.g. use of lined cells, leachate collection, environmental monitoring, weighbridge operation and maintenance of waste records). Consequently, the incidence of hazardous pollution has been greatly reduced (EPA, 2010).

Material wastage also contributes to a greater demand for raw materials which, in turn, contributes to the overuse of natural resources. The overuse of natural resources by the construction industry has resulted in it becoming, globally, one of the largest consumers of virgin, raw materials. Holm (1998) suggests that roughly 40 per cent of the materials produced worldwide are consumed alone by the construction industry. Moreover, Holm (1998) postulates that the industry is responsible for the consumption of 25 per cent of the virgin wood produced and 40 per cent of raw stone, gravel and sand extracted annually. Thus, one of the main environmental benefits of reducing C&D W is the reduced need for extraction and provision of virgin, raw materials.

Research has long emphasised that high levels of waste in construction, would significantly reduce the availability of materials and energy in the future (Wyatt, 1978). Although attention has been brought to the subject of waste reduction, rather than reducing quantities of waste produced in the C&D industry, waste output quantities

have continued to grow. This is perhaps, due in part to the materialistic and consumptive nature of today's society (Hostovsky, 2004). Waste quantification studies have estimated that C&D W accounts for somewhere in the region of 40 per cent of the total waste generated, globally (Holm, 1998). Notably, a majority of C&D W in Ireland is either land-filled or illegally dumped (Duran, Lenihan & O'Regan, 2005). According to the EPA (2012b) 58% of all waste produced in Ireland in 2010 went to landfill. Also, due to the lack of internal markets for recyclable materials, much of the waste suitable for recovery/recycling is still exported abroad. For example according to DECLG (2011), in 2009 60 –70 per cent of total plastic waste generated was exported abroad for further treatment. Notably, C&D W plastic accounts for 6 per cent of the total plastic waste stream. Furthermore, there are no facilities available in the Republic of Ireland for the recycling of ferrous metal, glass, paper or cardboard. Hence, these waste streams are all exported abroad for treatment. Timber is the only material that is recovered exclusively within Ireland (EPA, 2002a). Nevertheless, although the majority of recyclable waste is currently exported abroad for treatment, a small indigenous treatment capacity is developing (EPA, 2012b).

However, it is acknowledged that since the onset of the Irish economic downturn, C&D W generation has decreased in quantity (EPA, 2012a). According to the EPA (2012a), the amount of waste generated by the construction sector alone, has dropped by 81 per cent since 2007 (Figure 1.1). Such figures indicate that C&D W generation has been growing and falling simultaneously with the performance of the Irish economy. As a result, it is expected that the amount of C&D W generated will return to its previously high levels in the future, in tandem with potential economic growth in the country. However, projected waste generation rates may be reduced, provided that significant

changes (i.e. with respect to the management of C&D W generation) are made in the industry during the interim. Consequently, C&D W management has become a focus of environmental research, in order to ensure that both waste generation on C&D projects does not return to previous levels (such as in economic prosperity) and to further minimise C&D W generated, as in the current economic downturn.

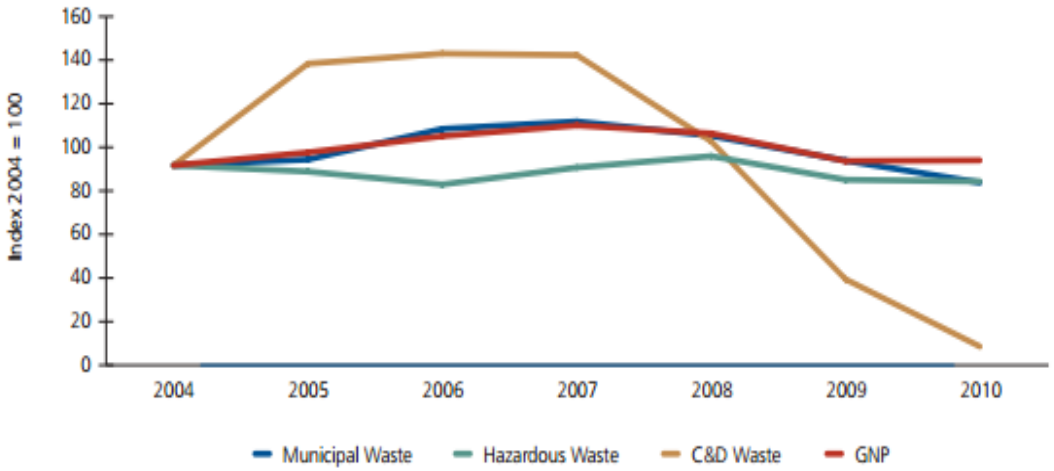


Figure 1.2: Waste generation and economic performance in Ireland (EPA, 2012b)

1.3 What is C&D W?

In order to better understand the focus of both the Irish engineering and construction industries on C&D W management, it is important to first establish how C&D W is defined in this thesis. Though many definitions of C&D W exist (Harvard Green Campus Initiative, 2004; Hong Kong Polytechnic; 1993; Kulatunga et al., 2006; Osmani, 2012; Skoyles & Skoyles, 1987), only those which are (1) based on both European and Irish law, or are commensurate with such laws; (2) commonly used; and (3) detailed and unambiguous will be presented in this thesis.

In the C&D industry, C&D W is commonly understood to be solid waste which is generated by construction and demolition activities (Yuan & Shen, 2010). However, one of the most common definitions used by researchers is derived from the European Council Directive 91/156/EEC, which refers to *waste* as:

"*any substance or object in the categories set out in Annex 1, which the holder discards or intends or is required to discard*"

(European Communities, 1991).

The European Council Directive 91/156/EEC also defines *C&D W* as:

"*any substance or object which the holder disposes or is required to dispose, which arises from construction, renovation and demolition activities*"

(European Communities, 1991).

Though the EC Directive provides what can be considered a very general definition of C&D W, a more detailed definition is presented by Skoyles & Skoyles (1987) who define C&D W as a material:

"*which needs to be transported elsewhere from the construction site or used on the site itself other than the intended specific purpose of the project due to damage, excess or non-use or which cannot be used due to non-compliance with the specifications, or which is a by-product of the construction process*"

(Skoyles & Skoyles, 1987).

Notably, subsequent to the definition provided by Skoyles and Skoyles (1987), the European Commission developed the Communication on waste and waste by-products (COM/2007/59). The communication provides a number of examples in order to distinguish the difference between waste and by-products. This distinction has been made in order to aid the re-use of materials as incorrect classification of a by- product could cause environmental damage or unnecessary costs for a C&D company.

In order to further clarify the classification of C&D W from an Irish perspective, the Irish Environmental Protection Agency have developed their own definition for the National Waste Database, which refers to C&D W as comprising of:

"*all waste that arises from construction, renovation and demolition activities and all wastes mentioned in Chapter 17 of the European Waste Catalogue*".

(EPA, 2000)

The EPA (2002b) definition includes all left-over and damaged goods and materials that occur on construction works, as well as dredge spoil (see Appendix B for the full European Waste Catalogue [EWC]). According to Osmani (2012), this definition applies to all waste, irrespective of whether or not it is destined for disposal or recovery operations. The EWC also lists and categorises all types of C&D W that may arise, for purposes of simplifying the identification and eventual treatment of wastes. For example, according to the EWC categorisation protocol, wastes are allocated 6-digit codes for ease of identification. Their numerical identification values (see Table 1.1) are assigned as follows:

- The first two digits refer to the waste category, of which there are 20 (e.g. C&D W is in Chapter 17; therefore, the first two digits of the reference code are *17).*
- The second couplet of digits refers to the sequential arrangement of each waste sub-group (i.e. where each sub-group is positioned), defined by their main physical features/composition (e.g. metals, including alloys, come 4th in the list and are, thus, presented as *04*).
- The final 2 digit pair refers to the positioning *within* the sub-group (e.g. 'Tin' is number 6 on the list of metals; thus, the last two digits are *06*).

Table 1.1: Example of numerical identification coding from Chapter 17 of the European Waste Catalogue

17 04	**Metals (including their alloys)**
17 04 01	copper, bronze, brass
17 04 02	Aluminium
17 04 03	Lead
17 04 04	Zinc
17 04 05	iron and steel
17 04 06	Tin
17 04 07	mixed metals
17 04 09*	metal waste contaminated with dangerous substances
17 04 10*	cables containing oil, coal tar and other dangerous substances
17 04 11	cables other than those mentioned in 17 04 10

Construction waste is also identified in Chapter 10 "Wastes from thermal processes" of the EWC. Construction wastes are identified under "Wastes from manufacture of ceramic goods, bricks, tiles and construction products" which includes waste tiles,

ceramics, bricks, construction products, particulates and dust. Construction waste is also identified under "Wastes from manufacture of cement, lime and plaster and articles and products made from them" which includes concrete sludge, waste concrete, and waste from cement based composite materials.

1.3.1 Hazardous C&D W

C&D W may also contain hazardous wastes, which must be identified in order to ensure that the waste is dealt with properly (i.e. in terms of handling, transportation and disposal). Within the EWC, wastes that are deemed hazardous, or are capable of becoming hazardous, are marked with an asterisk (see Table 1.2 for an example). According to the catalogue, in order for a waste to be classified as hazardous it must first fulfil the following criteria (EPA, 2002b):

(1) Appear on the hazardous waste list or be prescribed under section 4(2)(a)(ii) of the Waste Management Act; and also
(2) Display one or more of the properties indicated in the Second Schedule to the Act.

Table 1.2: Example of hazardous wastes identified with an asterisk in Chapter 17 of the European Waste Catalogue

17 06	**Insulation materials and asbestos-containing construction materials**
17 06 01*	insulation materials containing asbestos
17 06 03*	other insulation materials consisting of or containing dangerous substances
17 06 04	insulation materials other than those mentioned in 17 06 01 and 17 06 03
17 06 05*	construction materials containing asbestos (18)

Sixteen of the 44 C&D W types listed in Chapter 17 of the EWC are classified as hazardous. Examples of hazardous C&D W included in the list are: bituminous mixtures containing coal tar, C&D W containing polychlorinated biphenyls (PCBs) and insulation materials containing asbestos (see Table 1.2 for an example of hazardous wastes identified which are identified with an asterisk in Chapter 17 of the EWC). Notably, treatment, collection and transfer of hazardous wastes are subject to separate, stringent regulatory controls, (e.g. the requirement to obtain a Waste Transfer Form (WTF) when moving hazardous waste within Ireland). Hazardous waste regulatory controls are described fully in the Waste Management (Hazardous Waste) Regulations 1998 (RPS, 2004) and the European Communities (Shipments of Hazardous Waste Exclusively within Ireland) Regulations 2011.

1.3.2 Further Categorisation

Skoyles (1976) further categorises C&D W based on its derivation (i.e. direct or indirect waste). Direct waste involves an absolute loss of materials, where the materials are damaged to the extent that they cannot be salvaged, or are just lost. Direct waste is typically removed from site. Conversely, indirect waste does not involve material loss but rather, solely a monetary loss. Indirect waste may occur, for example, as a result of placing of steel bars with diameters thicker than that specified by the structural design (Formoso et al, 2002); and as a result, the quantity of excess steel used can be considered an indirect waste. Interestingly, Pinto (1989) found that indirect waste can be higher in quantity than direct waste. Notably, quantification of indirect waste on site can often prove difficult as the waste is not being transported away from sight. However, a simple method of measuring of the quantity of indirect waste on site would

be to compare the quantity of materials specified for the project versus the quantity of materials used.

Furthermore, the Waste Framework Directive 2008/98/EC provides a specification for when waste ceases to be waste and becomes a useful product or secondary raw material. Under the Directive, in order for specified wastes to obtain End-of-Waste (EoW) status, it must be submitted to a recovery or recycling process; and the resultant material must then comply with multiple specified legal criteria (i.e. End-of Waste criteria). Specifically, these criteria include:

> *(1)* "*The substance or object is ordinarily used for specific purposes;*
>
> *(2) A market or demand exists for such a substance or object;*
>
> *(3) The substance or object fulfils the technical requirements for the specific purposes and meets the existing legislation and standards applicable to similar products; and*
>
> (4) *The use of the substance or object will not lead to adverse environmental or human health impacts*".

(European Commission, 2012)

The provision of EOW criteria for C&D materials supports the recycling sector through the removal of the administrative problems associated with waste legislation. It also creates the provision of environmentally safe and premium waste materials (European Commission, 2008). These supportive measures may subsequently, in the future, have the positive effect of growth in Irish markets associated with recycled products.

1.3.3 Definition of C&D W used in this thesis

Cumulatively, the definitions and descriptions presented conceptualise C&D W as follows:

> *"Any material that appears in Chapter 17 of the European Waste Catalogue, which arises as a result of the construction process that needs to be transported away from the construction site; or is used onsite for purposes other than its original, intended purpose on the project, as a result of damage or excess; or cannot be used due to non-compliance with the specifications."*

For the remainder of this thesis, mention of C&D W will refer to this conceptualisation. Likewise, the management of C&D W – *C&D W management* – will refer to the process of actively avoiding (or preventing), re-using, recycling, recovering, disposing or dealing with the generation of C&D W, consistent with the requirements of the Waste Framework Directive 2008/98/EC (European Union, 2012).

1.4 Quantification and Composition of C&D W

Historically, C&D W has been assumed to be composed of primarily inert materials (Franklin Associates, 1998; cited in Llatas, 2011). As a result, according to Wang et al. (2004), the effects of C&D W were assumed to not pose such a negative effect on the environment as other waste streams (e.g. Municipal Solid Waste (MSW) or hazardous wastes). However, given the definition of C&D W provided above (e.g. which include hazardous wastes), this perspective is incorrect. Nevertheless, as a result of this dated perspective, the C&D W stream has, traditionally, not been controlled as stringently as other waste streams. Therefore, long- term quantification data and waste flow statistics are lacking (Llatas, 2011). This lack of data is exemplified by Cochran and Townsend (2010), who argue that the actual quantity of C&D W generated in the United States is simply, unknown. Similarly, much of the data and statistics currently available and quoted in official European documents were only collected in 1999, by a group of European consultants working for the European Commission (Symonds, 1999).

Despite the relative lack of quantification and compositional study data, the recent, existing research has yielded some interesting findings. In research by Duran, Lenihan and O'Regan, (2005) and Rameezdeen and Kulatunga, (2004), the majority of waste produced on C&D sites was found to consist of concrete, bricks and blocks. However, C&D W is not limited to these three materials; it may also refer to materials such as lime, cement, sand, timber, rubble, steel and paint. In Ireland, The EPA National Waste Report 1995 (1996) conducted a survey of C&D sites and found that C&D W is primarily comprised of soils and stones (51%); concrete, bricks, tiles and ceramics (39%); wood, glass and plastic (2%); metals (2%); asphalt and tar (2%); and 'other' (4%) materials.

Furthermore, research by both Reinhart et al. (2003) and Cochran et al. (2007) plotted the financial value of the construction, maintenance and demolition projects versus previously estimated generation rates for each category of C&D W, in order to predict construction waste generation rates. Both concluded that there were nine categories of waste arising on C&D projects (i.e. wood, block, concrete, asphalt, drywall, plastic, metal, ceramic and other debris). Kofoworola and Gheewala (2009) developed this method further, through accessing information (e.g. waste quantities output and development type) retrieved from building permits in Thailand. The researchers found that a waste generation factor of 21.38 kg/m^2 could be applied to the construction of dwellings and a factor of 18.99 kg/m^2 for non-dwelling construction. To clarify, for every m^2 of a construction dwelling built, 21.38kg of waste would arise and for every m^2 of non-dwelling construction built, 18.99 kg of waste would arise. However, the generation factors provided by Kofoworola and Gheewala (2009) are much greater than those quoted by Lu et al. (2001) who found that waste generation factors on C&D sites in China ranged from 3.275 kg/m^2 to 8.791 kg/m^2. Moreover, Kelly and Hanahoe (2009) found Irish waste generation factors to be in the region of 70 kg/m^2 for new residential construction and 87 kg/m^2 for new private non-residential construction. Therefore, the use of waste generation factors appears to be specific to the country wherein they are calculated. This may be due to the variance from country to country in waste regulations and legislations.

One of the first European studies to focus on estimating and quantifying C&D W was carried out by Bossink and Brouwers (1996) in the Netherlands. The research focused on C&D W arisings on 184 dwellings, spread over five different construction projects. The waste arisings were then categorised and weighed. This resulted in the development

of nine different waste categories; debris piles, concrete, bricks, blocks, mortars, aggregates, tiles, packages and other. One of the most noteworthy conclusions stemming from the research was that, depending on the category of material brought to site, between 1 per cent and 10 per cent of the total mass eventually becomes waste (Bossink & Brouwers, 1996).

Notably, waste audit tools have been developed in order to aid the management and quantification of site waste. For example, the Building Research Establishment (BRE) have developed the *SMARTwaste*® software programme Further to quantification of site waste, the software tool also aids the preparation, implementation and review of Site Waste Management Plans (SWMPs) on construction projects. The programme was developed based on previous research by BRE and offers an integrated quantification function, which has the ability to calculate the total volume of waste generated over the duration of any given project. (*SMARTwaste* ®, 2010). The Waste and Resources Action Programme (WRAP). WRAP have also developed a suite of online tools which aid in the quantification and management of site waste (e.g. WRAP's SWMP Template, SWMP 'lite', SWMP Tracker and the Site-Specific Waste Analysis Tool). Finally, Kelly and Hanahoe (2009) developed a paper based audit book. The audit sheets contained within the book require the inclusion of information such as:

- Skip size;
- Compaction of skip;
- Percentage full (based on visual assessment); and
- Material description.

Notably, the ease of use associated with an ‘on-the-spot’ analysis tool, makes this method very accessible for members of the C&D industry who wish to document waste quantities on site, without the necessity for extensive training on IT based tools.

1.5 Management of C&D W Debris in Ireland

Although the current levels of C&D W generation have decreased in volume, when compared with generation levels present during the Irish economic ‘boom’ (EPA, 2012a), overall quantities of waste generation volumes have decreased across all sectors. Therefore, C&D W volumes still comprise a large proportion of the overall waste generated. This waste must eventually be either treated or disposed. Despite the decrease in overall waste generated, the need to further decrease the generation of C&D W remains. Thus, it is important to identify current quantities of waste arisings and their eventual management.

1.5.1 Quantities of C&D W produced in Ireland

The Irish EPA are responsible for providing national statistics on both waste generation and waste management. In order to relay this information to the public, they publish the *National Waste Report*. Table 1.3 presents a summary table of the quantities of C&D W arisings, quantities of C&D W disposed at landfill and quantities of waste recovered, between the years 1995 and 2011 inclusive. EPA statistical data is obtained through analysis of the annual returns acquired from waste permit collection holders.
Information on the eventual treatment of C&D W arisings was obtained using survey responses from three main sources. These sources were as follows:

(1) EPA licensed landfill facilities

(2) EPA licensed waste treatment facilities; and

(3) Local authority permitted and Certificate of Registration[1] (CoR) facilities

The reports from 2008 onward were conducted, in part, in order to assess Ireland's progress in meeting the requirements set out by the Waste Framework Directive 2008/98/EC (i.e. the target of 70 per cent by weight for preparing for re-use, recycling and other recovery of construction and demolition non-hazardous waste; which is to be achieved by 2020). Notably, the data collected by the EPA in this manner is useful for researchers, in order to ascertain where improvements in waste management can be made.

[1] In relation to C&D W acceptance, facilities require Certificates of Registration if they recover <25,000 total tonnes of inert or dredge spoil to land, <10,000 total inert waste to land and/or use unaltered quarry or excavation material for onsite restoration (EPA, 2008a).

Table 1.3 Summary of quantities of C&D W reported by EPA National Waste Database Reports and National Waste Reports

Year of publication	Statistics for year:	Quantity of C&D W arising	Quantity of C&D W disposed at landfill	Quantity of C&D W recovered
1996*	1995	1.52 Mt	0.87 Mt	0.53 Mt
1998*	1998	> 2.7 Mt	1.5 Mt	1.2 Mt
2001*	2001	3.7 Mt	1.3 Mt	2.4 Mt
2004	2004	11.2 Mt	1.6 Mt	9.5 Mt
2006	2005	14.9 Mt	1.92 Mt	12.98 Mt
2008	2006	16.8 Mt	0.4 Mt	13.4 Mt
2009	2007	17.8 Mt	0.9 Mt	12.8 Mt
2009	2008	13.5 Mt	0.23 Mt	10.1 Mt
2011	2009	5 Mt	0.05 Mt	4.95 Mt
2012	2010	3.5 Mt	0.035 Mt	1.7
2013	2011	3.0 Mt	0.026 Mt	2.0 Mt

Mt=Million tonnes
Years marked with * are from the National Waste Database Reports, years without * are from the National Waste Reports

The most recent findings of the *National Waste Report for 2011* (EPA, 2013) revealed that, of the 3,003,691 tonnes of C&D W (i.e. both hazardous and non-hazardous) collected in 2011, 1,975,844 tonnes was comprised of soil and stones. The remaining 1,027,847 tonnes consisted of miscellaneous C&D W materials (e.g. metals, rubble, wood, plastic timber, glass, and mixed C&D W).

In total, 2,498,946 tonnes of C&D W were managed in 2011. Of the total tonnage of C&D W, 2,358,714 tonnes (i.e. 94% of managed C&D W) were recovered (i.e. waste serving a useful purpose through recycling or energy generation). Furthermore, 35,404

tonnes (i.e. 2% of managed C&D W) were sent to landfill. Notably, there is a discrepancy in the figures (i.e. 504, 745 tonnes) quoted by the national waste report. This discrepancy is between volumes of waste collected and volumes of waste managed. This is primarily due to the unreliability of the data collected on managed waste quantities from CoR waste facilities and waste collection permit holders due to the fact that many of the sites receiving C&D W do not have weighbridges in operation and as a result, many of the quantities provided to the EPA are based on estimations (EPA 2013).

Furthermore, on analysis of the quantities of waste arisings presented in Table 1.3, it is evident that quantities of waste increased significantly between 2004 and 2008. Thus, in order to avoid repetition of waste arisings of this magnitude in the future, it is important that reliable data is obtained from all waste collectors and waste facilities. Reliable data will allow for informed decisions on the drafting and implementation of appropriate measures to avoid and reduce C&D W.

1.6 Legislation and Policies Affecting C&D W Management in Ireland

1.6.1 Introduction

Since the early 1980's the issue of sustainable development[2] has become a focus of both developing nations and industrial nations, worldwide (World Commission on Environment and Development, 1987). Within Europe, such focus has resulted in the consolidation of the EU legislative framework surrounding many issues pertaining to sustainable development. One of the major issues effecting sustainable development is the issue of *waste*. A large fraction of total *waste* is comprised of C&D W (Figure 1.1); hence, it has also been affected by legislative changes. These changes have resulted in the setting of targets for C&D W reduction, which have long been considered disproportionately high (World Commission on Environment and Development, 1987). Consequently, in the last two decades Ireland too has experienced major changes as a result of the legislative framework regarding C&D W management. Specifically, a series of European Directives regarding waste management have been transposed into Irish law and, as a result, have greatly improved the Irish waste regulatory system and have had a direct, positive effect on waste management within the C&D sector (e.g. the requirement to obtain waste permits and licences; and the introduction of landfill levies). Given that policies, legislation and regulations have had such a significant influence on C&D W management, the following section outlines the main legislative and policy drivers and their effects on C&D W management in Ireland.

[2] Development which meets the needs of present generations without impairing the ability of future generations to meet their own needs (European Commission, 2013a)

1.6.2 EU Waste Policies and Legislation

EU policies have provided the basis for the subsequent drafting of Irish regulations regarding the issue of waste. The 3 main EU policies pertaining to waste are:

(1) Community Strategy for Waste Management (1989)

(2) Review of the Community Strategy for Waste Management (1996)

(3) Taking Sustainable Use of Resources Forward - A Thematic Strategy on the Prevention and Recycling of Waste (2005)

1.6.2.1 European Community Strategy for Waste Management of 1989 *SEC (89) 934 final*

Possibly the most influential of the three policies is the *European Community Strategy for Waste Management of 1989* SEC (89) 934 final, which called for identification, capture & control of waste movement and introduced specific controls for high risk wastes disposal. The concept of a waste hierarchy was first addressed in the European Union Waste Framework directive 1975 (75/442) however, the *European Community Strategy for Waste Management of 1989* organised the concept into a hierarchy of waste management options, known as the *Waste Management Hierarchy* (Figure 1.3). The categories depicted in the waste management hierarchy are arranged as a pyramid, with the top being the most favourable option - the prevention of waste. After material waste (1) prevention and (2) minimisation, the material must then either be (3) re-used, (4) recycled or (4) provide energy recovery (i.e. sent to a facility which facilitates energy recovery from the waste) and finally, the least favourable option, (5) disposed.

Finally, the policy confirms the concept of the 'proximity principle' which suggests that waste should be dealt with, as close as possible, to the source of its arising.

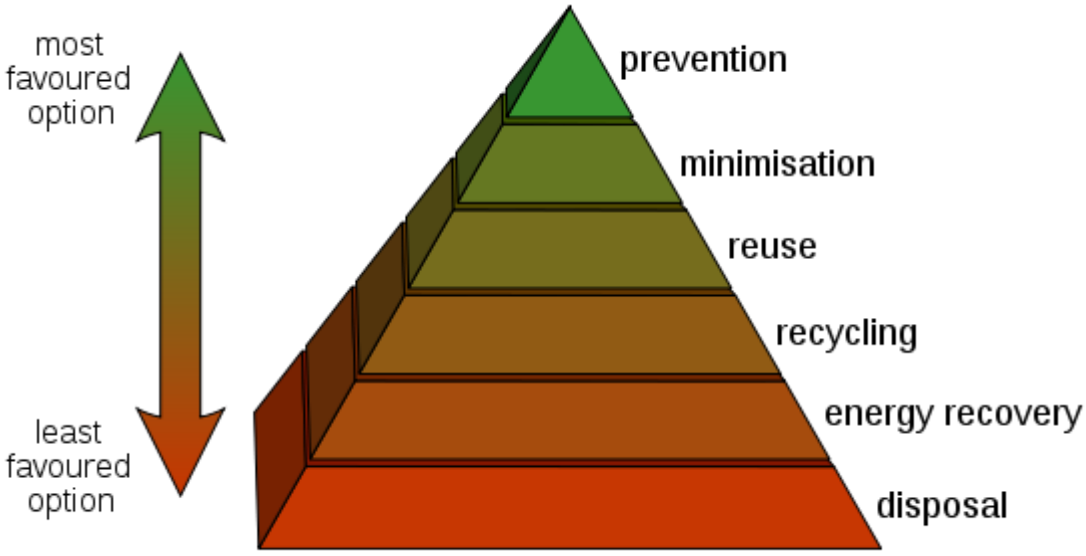


Figure 1.3: Waste management hierarchy (Commission of the European Communities, 1989)

1.6.2.2. Review of the Community Strategy for Waste Management of 1996 (COM (96) 399 Final 1996)

The *Review of the Community Strategy for Waste Management of 1996* (COM (96) 399 Final 1996) (Commission of the European Communities, 1996) re-examined the 1989 strategy. It re-established all the policies set out in the 1989 strategy and included the following amendments:

- The acknowledgement that energy recovery may, in some cases be environmentally superior to recycling;
- The recommendation for the inclusion of the principle of producer responsibility in all future measures under consideration;

- The introduction of binding targets in order to reduce waste generation and in order to increase waste recovery;
- The plan to provide landfill controls
- The plan to further investigate the use of waste as a fuel at incineration plants which had not originally been designed for this purpose.

1.6.2.3 Taking Sustainable Use of Resources Forward - A Thematic Strategy on the Prevention and Recycling of Waste 2005(COM 2005/666).

The *Taking Sustainable Use of Resources Forward - A Thematic Strategy on the Prevention and Recycling of Waste* 2005(COM 2005/666), proposed modernisation of the existing legal frameworks within the EU, in order to provide a superior level of environmental protection. The long-term objective, proposed by this policy, is for the EU to become a *recycling society*. In such a society, waste should be avoided and waste which does arise, should be used as a resource. Within the policy, it is proposed that, with the introduction of high environmental standards, internal markets will be able to develop and will further aid recycling and recovery of waste.

1.6.2.4. Construction and Demolition Waste Project Group

As a result of the Community Strategy for Waste Management (1989), the European Commission commenced the Priority Waste Streams Programme in 1991, which identified six waste streams, one of which was C&D W. As a result, the following year, the Commission formed the Construction and Demolition Waste Project Group, in order to invite and encourage the development of strategies and analyses, from industry organisations and groups from within the EU, aimed at C&D W management. Specifically, the purpose of the project group was to develop and decide on the methods

best able to increase recycling and reduce the quantity of waste going to landfill. In 1995, the C&D W project group published several reports which provided 55 recommendations on actions to improve C&D W management. The findings and suggestions of the C&D W project group can be grouped under five main headings, which are as follows:

(1) Waste management planning and regulations
(2) Pre-construction and post-construction actions
(3) C&D site management
(4) Execution of the strategies
(5) Subsequent monitoring of the strategies

1.6.2.4.1Waste management planning and regulations

The group found that there were deficiencies in waste management terminology and definitions. Furthermore, they found deficiencies in the availability of reliable C&D W data. As a result, the group recommended the inclusion of targets for waste reduction and targets for an increase in recovery rates in C&D W management plans. Furthermore, the group found that the existing permitting and licensing systems for C&D W transportation should be amended in order to promote the reduction of C&D W and to increase materials recovery. Finally, the group recommended that the matter of waste management should be addressed by construction enterprises in order to qualify for CEN/ CENELEC standards.

1.6.2.4.2 Pre-construction and post-construction actions

Education and training was identified by the project group as a crucial means of preventing the production of otherwise preventable waste. Such education and training was recommended for all members of the built environment (i.e. owners, contractors, designers and operatives). Furthermore, it was recommended that in order for prospective purchasers to make informed decisions, they should be supplied with environmental information on construction materials, products and technologies. Furthermore, the indeterminate quality of secondary raw materials was identified as a constraint to the reuse of construction materials. As a result, it was recommended that improvements should be made to the standards and specifications of secondary materials. Finally, the group agreed that the public had a great role in providing secondary markets for construction markets. Also, an informed public was considered a main driver in the promotion of good waste management practices.

1.6.2.4.3C&D site management

The group identified the provision of reliable standards for products manufactured from recovered materials as highly problematic. As a result, several recommendations were made for source segregation of waste. Furthermore recommendations were made for the development of Codes of Practice on the following:

- Activities which produce C&D W
- Transport of C&D W
- Training for contractors and transporters
- Take-back and collection systems to be operated by suppliers, manufacturers and collection authorities

1.6.2.4.4 Execution of the strategies

It was acknowledged by the group that, no lone measure would develop successful secondary markets. However, many of the recommendations and measures proposed by the group support the development of secondary markets. As a result, the group identified that the cumulative impact of their implementation may lead to secondary markets for C&D recovered materials. Furthermore, recommendations were made for the creation of legislation and regulations to support the proposed strategies. However, such legislation and regulations were to provide a standardised framework with a minimum of bureaucracy.

1.6.2.4.5 Subsequent monitoring of the strategies

Finally, it was recommended that the momentum which had been established by the project group should be continued with the development of a working group who would subsequently carry on the work of the project group.

1.6.2.5. Construction and Demolition Waste Management Practices and Their Economic Impacts

Following the report issued by the C&D W Project Group the European Commission funded a Study by the Symonds Consultancy Group (1999) entitled "*Construction and Demolition Waste Management Practices and Their Economic Impacts".* The aim of the report was to identify the quantities of C&D W produced in the European Union and to describe the measures which each of the 15 Member States has taken in order to increase the re-use and recycling of C&D W. Finally, the report illustrates the best practices and economics involved in C&D W re-use and recycling (Symonds et al., 1999).

1.6.2.6 Directive 75/442/EEC on Waste

The earliest Directive pertaining to waste is Directive 75/442/EEC (European Communities, 1975). The Directive provides broad proposals for waste management and waste disposal. It also introduces the concept of the waste management hierarchy. The Directive set out the following measures for implementation by Member States:

- The prevention or reduction of waste;
- The recovery of waste through re-use, recycling, reclamation or by means of energy recovery; and
- The development of waste management plans by each Member State.

Such measures were designed to be implemented without causing any harm to human health or the environment. The Directive also requires Member states to implement the following:

- The prohibition of uncontrolled discarding, discharge and disposal of waste
- The promotion of the waste management hierarchy

Finally, the Directive introduces the concept of the *proximity principle* which stipulates that waste is disposed as close as possible to the source of its generation. Notably, this only applies to waste disposal facilities and excludes waste that is to be shipped for recovery or recycling.

1.6.2.7 Council Directive 91/156/EEC

Council Directive 91/156/EEC amends the previous Directive 75/442/EEC on waste. The Directive reaffirms the importance of the prevention and reduction of waste and the recovery of waste through recycling, reuse or reclamation and the use of waste as a source of energy. Furthermore, the Directive includes the stipulation that the cost of the disposal of waste should be imposed on the producer of the waste, in accordance with the *polluter pays principle*.

1.6.2.8 Directive 2004/35/EC on Environmental Liability

Directive 2004/35/EC develops the *polluter pays principle*. As a result of the introduction of the *polluter pays principle*, Ireland has seen an increase in the cost of landfill levies. This increase in the cost of waste disposal has greatly increased the financial incentive for large scale waste producers to reduce the quantity of waste going to landfill, through the implementation of waste reduction, recycling and reuse (European Union, 2011). Furthermore, inadequate environmental controls on landfills have been improved through the introduction of a compulsory licensing scheme. Consequently, the cost of licensing facilities has also been passed on to the polluter; thus, further increasing the financial incentive to reduce landfill waste.

1.6.2.9 Waste Framework Directive 2006/12/EC on Waste

The Waste Framework Directive 2006/12/EC on Waste (European Commission, 2006) consolidated and replaced Directive 75/442/EEC on Waste but did not change the content of the requirements set out in the earlier Directive. The primary objective of Directive 2006/12/EC was to safeguard human health and the environment from the

negative effects resulting from the '*collection, transport, treatment, storage and tipping of waste'.* The Directive requires that Member States fulfil the following:

- Develop regulation on waste disposal and recovery;
- Encouragement of the use of recovered materials as secondary raw materials
- Encourage waste reduction;
- Reduce the movement of waste
- Encourage clean technologies and products; and
- Consider '*existing or potential market opportunities for recovered waste*'.

1.6.2.10 Directive 2008/98/EC on Waste (Waste Framework Directive)

The Waste Framework Directive 2008/98/EC (European Commission, 2008) replaced and consolidated the Waste Framework Directive 2006/12/EC. It developed definitions for waste and basic criteria pertaining to waste. It also set out basic waste management principles which require that waste is managed within EU member states, without endangering human health or the environment. Furthermore, it requires that member states employ policies which are consistent with the new waste management hierarchy (Figure 1.4). The categories depicted in the waste management hierarchy are arranged as an inverted pyramid, with the top being the most favourable option - the prevention of waste. After material waste (1) prevention, the material, which is then classified as waste, must either be prepared for (2) re-use, (3) recycled or (4) recovered (i.e. sent to a facility which facilitates energy recovery from the waste) and finally, the least favourable option, (5) disposed.

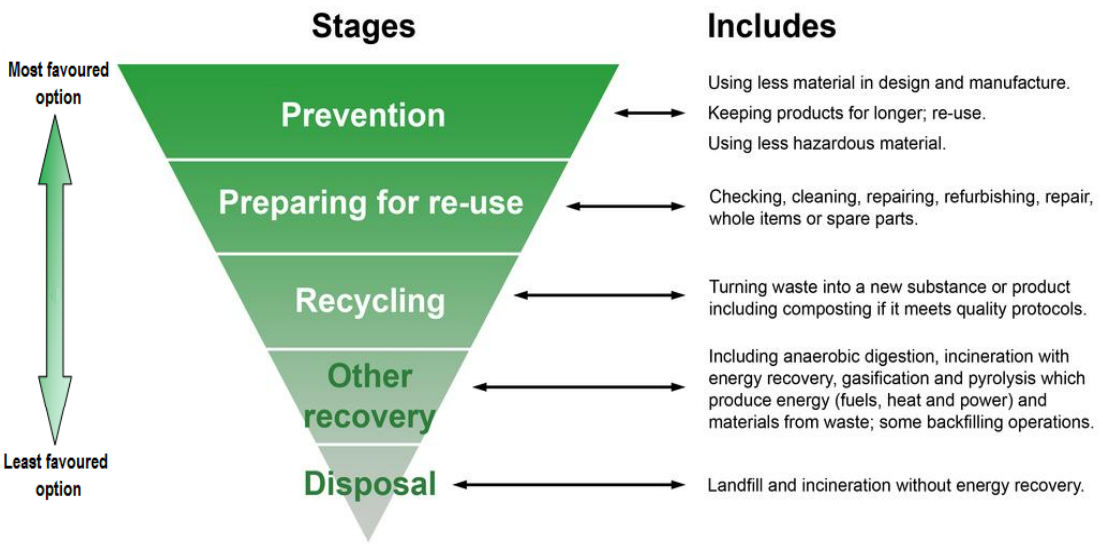


Figure 1.4: Waste Management Hierarchy WFD (Defra, 2011)

The directive also provided provisions on hazardous waste and waste oil. Furthermore, the directive developed the following principles regarding waste:

- The 'polluter pays' principle (i.e. the polluter must pay for treatment of the waste they produce) and
- 'Extended producer responsibility' (i.e. environmental costs are included throughout the lifecycle of a material).

Finally, the directive set a target of 70 per cent, by weight, for preparing C&D non-hazardous waste for re-use, recycling and other recovery methods – a target which is to be achieved by 2020 (European Union, 2012).

1.6.3. Irish Waste Policies, Acts and Regulations

1.6.3.1 Changing Our Ways 1998

Changing Our Ways (1998) was the first policy statement on waste management, prepared by the Irish Department of the Environment and Local Government (DoELG). The policy statement developed a framework for local governments to adopt and implement set targets for recycling, municipal solid waste (MSW) diversion from landfill, rationalisation of landfills and finally, in relation to C&D W:

"*Recovery of at least 50 per cent of construction and demolition waste by 2003, with a progressive increase to at least 85 per cent by 2013*"

(DELG, 1998)

Notably, the target to recover 85 per cent of non-hazardous C&D W by 2013 is considerably higher than the target set by the Waste Framework Directive 2006 (i.e. 70% by 2020). Although the target set by Changing our Ways appears quite high, according to the EPA National Waste Report for 2010 (2012) this target was exceeded in 2010. Ireland achieved 98 per cent recycling (excluding energy recovery). However, the achievement of this target, so far ahead of schedule could possibly be attributed to an overall reduction in C&D activities across Ireland (i.e. as a result of the economic downturn) rather than as a result of the introduction of legislation and policies.

1.6.3.2 Delivering Change – Preventing and Recycling Waste, 2002,

The Delivering Change – Preventing and Recycling Waste policy statement was aimed at ensuring that the targets for C&D W recycling set by Changing our Ways (i.e. 50%

by 2003 and 85% by 2013) were met. It identified objectives in order to support the promotion of waste minimisation, reuse and recycling. These included:

(1) The introduction of a market policy group concentrating on the development of markets for recyclables;
(2) The expansion of the network of materials recycling facilities.

The policy also emphasised the need to decouple the generation of C&D W and economic growth however, it did not provide any tangible methods of implementing this recommendation.

1.6.3.3. Waste Management – Taking Stock and Moving Forward, 2004

The Waste Management:-Taking Stock and Moving Forward policy document was released in 2004. The document assessed the progress in waste policy implementation up to 2004. The document also provided policy actions to be taken in light of the findings from the assessment, namely:

(1) The National Waste Prevention Programme; and
(2) The formation of a Market Development Group.

Through the provision of appropriate funding, the document provided a structure for the immediate implementation of the above objectives which had been set in previous policy statements.

1.6.3.4. A resource opportunity- Waste management policy in Ireland 2012

A resource opportunity- Waste management policy in Ireland 2012 primarily aimed to provide measures in order to further develop Ireland into a 'recycling society'. The policy does not set any new targets, however it references the targets pertaining to C&D W in EU legislation. In relation to C&D W, a review of the *producer responsibility* initiatives was undertaken. The C&D industry was found to generate a great deal of waste without the implementation of any successful voluntary initiatives to prevent, minimise or recycle waste. As a result, producer responsibilities were considered for C&D W producers, producing waste over a certain threshold.

1.6.3.5 Waste Management Act 1996

The Waste Management Act 1996 (Government of Ireland, 1996) was brought into effect in May 1996. The main objectives of the Act were:

(1) To provide coherence and organisation to the roles of the local authorities , the EPA and the Minister;
(2) To introduce and facilitate measures which improve the performance of waste prevention, minimisation and recycling or recovery of waste; and
(3) To provide an Irish regulatory framework for the implementation of EU waste legislation in Ireland

The Act also reasserts the polluter pays principle through the implementation of costs on waste producers and allows for the imposition of obligations to minimise waste on C&D waste producers.

1.6.3.6. Waste Management (Hazardous Waste) regulations 1998 (S.I No. 163/1998)

According to the Hazardous Waste regulations 1998 (S.I No. 163/1998), producers of hazardous waste must keep records (i.e. for three years), of the following:

- The amount, type and origin of hazardous waste produced;
- Any treatment carried out on the waste; and
- The amount, type, destination and method of transport of hazardous waste produced, if transferred to another individual.

The regulations also stipulate the following:

- Waste which is temporarily stored at the location of its production should be labelled and not mixed with any other waste;
- In relation to asbestos waste, Best Available Techniques Not Entailing Excessive Cost (BATNEEC) should be employed in order to control the production of asbestos waste; and
- The disposal of waste oils to water courses or drainage systems is prohibited.

1.6.3.7. Planning and Development Act 2000

The Planning and Development Act, 2000 (Government of Ireland, 2000) consolidates all preceding Planning Acts and the Environmental Impact Assessment regulations. It has provided Local Authorities with the ability to impose conditions on planning consent. For example, as a condition to the granting of planning permission, the applicant may be required to produce a Waste Management Plan. Furthermore, these conditions may require that C&D W be recovered or disposed of in a particular manner.

1.6.3.8.Waste Management (Permit) Regulations 1998 (S.I. No. 165/1998)

Under the regulations, activities which require waste permits are as follows:

- Recycling and recovery facilities
- Disposal facilities which accept <5000 tonnes of waste (excluding hazardous waste and landfills)

Furthermore, according to the regulations, temporary storage of hazardous materials in excess of specified quantities requires registration from a Local Authority.

Notably, it is the responsibility of the C&D W producer to ensure that the facility where they are disposing of their waste is in possession of the appropriate waste permit.

1.6.3.9 Waste Management (Landfill Levy) Regulations, 2002 (S.I. 86/2002)

The landfill levy came into effect on 1st June 2002. Though the starting rate was set at €15 per tonne, the regulations allow for an annual increase of €5 maximum. The current landfill levy, in 2013, stands at €75 per tonne. Specifically, the levy applies to waste intended for disposal at landfill sites. This includes C&D W; however, exemptions are provided for both inert (i.e. non-hazardous) C&D W intended for land reclamation and waste used for landfill site engineering. The latter may include concrete, tiles, bricks, blocks etc. with a particle size less than 150mm (DECLG, 2013). The increasing price of landfill disposal further emphasises the need to reduce C&D W and encourages avoidance, re-use and recycling.

1.6.3.10 Waste management (Licensing) Regulations 1997(S.I. No. 133), 2001 (S.I. No. 397) and 2004 (S.I. No.395)

The Waste Management (Licensing) Regulations require that specified waste recovery and disposal activities are licensed by the EPA. C&D waste activities which require waste licences are as follows:

- Landfill disposal
- The recovery > 10000 tonnes per annum of inert C&D waste
- The recovery of >10000 tonnes of inert waste to land
- The recovery of >250000 tonnes of inert excavation or dredge spoil to land

Furthermore, the regulations specify procedures on the following:

(1) The making of waste licence applications; and
(2) The method of review of waste licences.

Finally, it is the responsibility of the C&D W producer to ensure that the facility where they are disposing of their waste, holds the appropriate waste licence, if applicable.

1.6.3.11 Waste Management (Packaging) Regulations 1997 & amendments 2004; 2006

The Waste Management (Packaging) Regulations (1997 amended by 2004 & 2006) transposed the European Packaging Waste Directive (94/62/EC) into Irish law. The regulations assign responsibility for recovery and recycling of any packaging waste to persons who handle packaging waste at any phase of the supply chain. Local councils

are legally responsible to enforce these regulations within their respective administrative areas.

Notably, in relation to construction activities, contractors should identify whether their materials suppliers are members of Repak (i.e. an Irish packaging waste recovery scheme). If a supplier is not a member of Repack, then they are legally compelled to take back packaging materials. Finally, failure to fulfil the requirements of the packaging regulations may lead to prosecution.

1.6.3.12. Waste Management (Collection Permit) Regulations 2007 (SI 820/2007)

The Waste Management (Collection Permit) Regulations 2007 (Statutory Instruments, 2007) replace the Waste Management (Collection Permit) Regulations, 2001 (Statutory Instruments, 2001) and the Waste Management (Permit) Regulations, 1998 (Statutory Instruments, 1998). The primary objective of the regulations is to ensure that the environment is protected during the collection of waste. The regulations provide requirements for the making of a permit application and allow the local authority to recoup costs incurred in the monitoring of a collection permit and the costs of inspections of permitted activities.

Finally, the regulations require that C&D W producers must only give waste to collectors who are permitted under the regulations. Notably, almost all waste collectors are required to be in possession of a waste permit to collect, transport and manage C&D W. Collectors who do not require waste permits are local authorities and collectors who are in possession of waste licences.

1.6.3.13 Waste Management (Landfill Levy) Regulations 2011 (SI No. 434/2011)

The Waste Management (Landfill Levy) Regulations 2011 (Statutory Instruments, 2011) took effect in September 2001 and increased the landfill from €30 per tonne of waste disposed at landfill sites to €50 per tonne. The levy must be paid on top of the fee charged by the landfill operator. The regulations also allowed for the increase of the levy by a minimum of €5 per year. As a result, the current levy (i.e. in 2013) stands at €75 per tonne. Notably, in relation to C&D W this levy only applies to waste disposed as mixed waste at landfill sites. Exemptions are applied for the following C&D W materials:

- Non-hazardous C&D W (e.g. concrete, bricks and tiles) which may be used at landfills for site engineering, restoration or remediation purposes; and
- Excavation spoil used at landfill sites for site engineering, restoration or remediation purposes.

The provision of these exemptions further supports the on-site segregation of C&D W through the avoidance of unnecessary costs to the contractor.

1.7 ISO 14001:2004 Environmental Management System Standard

1.7.1 Introduction

As identified in the previous section, the legislative and regulative focus on the environmental performance of the construction industry has been developing and has greatly improved since the early 1980's. Subsequently, the European Union have introduced a voluntary environmental management instrument (i.e. the Eco-Management and Audit Scheme [EMAS]) in order to assist organisations in the following:

- Meeting the requirements of applicable laws (i.e. both environmental laws and non-environmental laws) and regulations;
- Prevention/minimisation of processes which may have a negative effect on the environment; and
- To continually improve the foregoing.

(European Commission, 2013b)

The internationally recognised ISO 14001:2004 Environmental Management System (EMS) has been developed and its requirements are integral to the EMAS. However, the requirements of the EMAS are more rigorous and holders of the ISO 14001:2004 certification must complete extra steps in order to achieve EMAS registration (European Commission, 2013c). The outcome of an organisations implementation of either, EMAS registration or ISO 14001:2004 certification is an improved management of environmental matters (i.e. which includes waste management) within organisations and provision of credible information on environmental issues to the public.

Furthermore, it is important to consider the requirements of the EMS Standard, given that the current research was conducted on employees of a company (i.e. BAM Building Limited) who have conformed to the requirements of the Standard and are currently ISO 14001:2004 certified. Understanding of the requirements for certification will also provide greater clarity regarding the environmental standards maintained within the company.

1.7.2 Description of the ISO 14001:2004 EMS

The ISO 14001:2004 is an EMS which describes requirements for environmental management systems (Praxiom, 2013). The Standard provides a framework for companies to improve environmental performance (e.g. reduction of energy use, prevention of pollution and waste reduction). It also provides companies with a certification of achievement, which can be utilised to gain access to new markets, by proving that specified standards of environmental performance have and are being achieved (Turk, 2008). Implementing the requirements set out by the ISO 14001:2004 can also benefit the organisation through reduced costs, reduced insurance risks and reduced prosecution risks (Whitelaw, 2004).

The Standard consists of both the EMS specification and also a total of 17 clauses and sub-clauses. The clauses are neither prescriptive nor specific; and are written in such a manner for the purpose of exhibiting relevance to a wide group of organisations. The requirements illustrate broad outcomes and do not contain any particular methods which an organisation must employ in order to achieve such outcomes (Mc Donald, 2003). The requirements of the ISO 14001:2004 Standard include:

- The requirement to develop an environmental policy;
- The identification of the environmental areas which the organisation has an effect on and the subsequent evaluation of the associated environmental impacts;
- The establishment of relevant legal and regulatory requirements;
- The development and maintenance of environmental objectives and targets;
- The implementation of a documented system, which includes elements of training, operational controls and dealing with emergencies;
- The implementation of monitoring and measurement of the organisations operational activities; and
- Implementation of environmental internal auditing

1.7.3. Discussion of the ISO 14001:2004 EMS Clauses

There are six main clauses of the ISO 14001:2004 EMS. The following is a summary of their titles:

- 4.1 General Requirements
- 4.2 Environmental Policy
- 4.3 Planning
- 4.4 Implementation and Operation
- 4.5 Checking and Corrective Actions
- 4.6 Management Review

Clause 4.1: "General Requirements" sets out the broad purpose of the EMS (i.e. that an overall improvement of environmental management will, in turn, improve environmental performance). Clause 4.2: "Environmental Policy", requires that the

organisation puts together an environmental policy and makes it “available to the public”. The purpose of making environmental policies available to the public encourages open, observable environmental objectives. Consequently, in such instances where objectives have not been delivered, environmental objectives will be open to public scrutiny. The clause also suggests that proposed environmental policies do not conflict with global corporate strategies. The intentions of non-conflicting policies and strategies are that environmental policies become an integral part of wider organisational strategies and that higher-management organisational strategies do not prohibit the completion of environmental policies at lower-management levels (e.g. at site level).

Clause 4.3: “Planning” highlights key areas of the planning process where the EMS is relevant. It is recommended that environmental aspects of the planning process are identified, consisting of both direct and indirect environmental impacts. Indirect environmental impacts include activities carried out by an external party (e.g. suppliers or customers) and are incorporated as their eventual actions may have a greater impact on the environment than the activities of the organisation itself. Legal and other environmental requirements are also identified as areas for examination. The clause requires that the organisation possesses adequate knowledge of environmental laws and codes of practice within their sector, and must first comply with those requirements. As organisations are obliged, by law, to comply with legislative requirements, this constraint is a baseline for ISO 14001:2004 certification.

Environmental policies must then be translated into unambiguous, achievable objectives which, in turn must be measured by prescribed targets. Although the EMS must strive for continuous improvement, some objectives may take a longer to realise with respect

to observing an overall improvement in environment performance (e.g. an objective that may require additional investment or technological advancement). Such occasions are acknowledged by the Standard and are wholly acceptable.

Clause 4.4 “Implementation and Operation” is included in order to facilitate the organisation to carry out the environmental management system on an every-day basis, in line with the requirements of the Standard (Whitelaw, 2004). The seven sub-clauses included in this section are as follows:

Clause 4.4.1: Resources, roles, responsibility and authority

Clause 4.4.2: Competence, training and awareness

Clause 4.4.3: Communication

Clause 4.4.5: Control of documents

Clause 4.4.6: Operational control

Clause 4.4.7: Emergency preparedness and response

Notably, according to Whitelaw (2004), as part of the ISO 14001:2004 certification, an organisation must identify needs for training within the organisation; and subsequently, measure the success of the training. In the context of ISO 14001:2004, the end product of any training must be environmental awareness; and the resulting gain in knowledge should make employees implement more informed decisions when handling environmentally related matters. Within the ISO 14001:2004 framework, informed decision making is considered ‘competence’. The certification requires that the organisation finds methods of measuring competence, given that, although participants in a training setting may seem equally receptive to the information presented during

training, this does not ensure that participants' behaviour will improve, despite a potential gain in knowledge. Finally, according to Whitelaw (2004, p. 14), Annex A.4.2 suggests that:

"*levels of training, and competence, be related to the significance of the individuals to influence environmental impacts within the organization*".

(Whitelaw 2004, p. 14)

Clause 4.5: "Checking and corrective action" indicates that *checking* must be carried out in order to prove that planned actions and activities have been carried out. Consequently, ISO 14001:2004 recommended an internal audit system for carrying out checks; however, reviews and reports identifying failures are equally acceptable. In the event that checks result in failure to meet targets, the sub-clauses in clause 4.5 also detailed the implementation of corrective action (i.e. in the form of procedures and preventative measures), in order to prevent repetition of the same failures.

Finally, Clause 4.6 "Management review" requires an organisation to consider all the previous steps that the organisation has taken, in a structured manner. Core questions, structured around the preceding clauses, must be addressed.

1.8 Conclusion

A number of frameworks for C&D W and waste management were discussed in this chapter in order to aid in the conceptualisation of both C&D W and C&D W management used in this thesis. The legislative frameworks currently in place for the management of C&D W were also discussed and evaluated. The final section of this chapter presented a discussion of the ISO14001:2004 certification, as the company which took part in the current research (i.e. BAM Building Limited), was required to meet the requirements of this certification. The following chapter will evaluate the available literature on attitudes, behaviours, beliefs, motivation and knowledge, in order to formulate the research hypothesis, aims and objectives.

CHAPTER 2

REVIEW OF THE LITERATURE ON C&D W MANAGEMENT BEHAVIOURS, ATTITUDES, BELIEFS, KNOWLEDGE & MOTIVATION

2.1 Overview

In the current research, it is hypothesised that C&D W management training will enhance knowledge, behaviour, motivation, positive beliefs and positive attitudes towards C&D W management onsite. Thus, in this chapter, a detailed review of the literature on knowledge, behaviour, motivation, beliefs and attitudes towards C&D W management onsite is presented. However, before fully describing the effects of each of these five variables on C&D W management, it is important to first present a critical analysis of the current trends in research on C&D W, such as the quantification of C&D W and the origins of C&D W.

2.2 Introduction

The traditional focus of research on C&D W management has largely concentrated on existing frameworks regarding how work practices, procedures, protocols, processes and relevant technologies contribute to the generation of C&D W management (Formoso *et al*., 1993; Bossink and Brouwers, 1996; Poon, 1997; Faniran and Caban, 1998). Subsequently, implications are made in the research for how such frameworks may potentially facilitate C&D W minimisation. Though both C&D W minimisation and resource optimisation also receive great focus in the research literature (e.g. Osmani, 2012; Kulatunga et al., 2006), less is paid to practices involving the inevitable management of C&D W. This is interesting to consider given that waste has been

accepted as an inevitable by-product of the C&D industry, with a strong belief that minimisation practices will not be able to completely eliminate the generation of C&D W (Teo and Loosemore, 2001). According to Kulatunga et al. (2006) and Skoyles and Skoyles (1987), these negative outlooks are the main impediments to effective waste management.

Yuan & Shen (2010) conducted a systematic trend analysis of eight of the most recognised scholarly journals publishing C&D W related research from the years 2000 to 2009. The six most frequent topic areas identified in the analysis were C&D W generation; reduction; reuse; recycling; management (in general); and human factors affecting C&D W management. According to Yuan and Shen (2010), though existing research in these topic areas has taken into account human factors in both their research methodologies and their recommendations, this consideration has been to a lesser extent than other C&D W topic areas identified.

Despite this, some research has focused on these more 'human' factors, such as attitudes, behaviours and knowledge (e.g. Begum et al., 2009; Fabrigar, 2004; Herresman & Allwright, 2000; Jashapara, 2004; Kulatunga et al., 2006; Teo & Loosemoore, 2001; Teo et al., 2000); and has revealed interesting findings, which may have important implications for both C&D W management practice and future research. Such findings and implications are important to consider given that, in their trend analysis, Yuan and Shen (2010) concluded that human factors in C&D W management should be one of the primary focuses of future research. More specifically, the question of *"How to improve practitioners' attitudes towards waste reuse?"* was identified as a future research objective, following their analysis of what was lacking in the existing

C&D W management research. Notably, a large body of research has identified a lack of training as a major cause for operatives' poor attitudes, beliefs, knowledge, behaviours and motivation towards C&D W minimisation (e.g. Teo et al., 2000; Lingard et al. 2000; McDonald & Smithers, 1998); however, there is a substantial gap in the research which evaluates the effectiveness of training on attitudes, beliefs, knowledge, behaviours and motivations. These 'human' factors are further important to consider given that they are the primary variables examined in the current research. However, before discussing the theory and research behind each of these variables, it is important to first briefly discuss them in light of sources of waste on-site, that is, in order to further inform the development of the training used to enhance these variables (i.e. knowledge, beliefs, attitudes, motivation and behaviour)**.**

2.3 Factors Affecting C&D W Arisings

According to Esin & Cosgun (2006) C&D W arises at all stages during the lifecycle of a building; from the initial design stage to the final end-use (i.e. either renovation or demolition). However, in order to construct useful training materials for site operatives, it is necessary to identify the origins of site waste specifically, during the construction phase of a building. A great deal of research isolates the design stage as the primary cause of construction waste (e.g. Osmani et al., 2007, 2006; Innes, 2004; Chandrakanthi et al., 2002; Ekanayake & Ofori, 2000; Faniran & Caban, 1998; Bossink & Brouwers, 1996). However, Al-Sari (2012) found that the quantification of waste on C&D projects depends on a multitude of variables associated with the magnitude of the building project, such as:

- The overall area of the constructed building;
- The financial value of the project;
- The quantities of input materials (i.e. design specifications);
- Construction techniques used; and
- The performance of the contractor(s) working on the project.

Notably, Al-Sari (2012) identified the '*performance of the contractor(s) working on the project*' as a particularly complex constituent of the construction phase to modify, as contractors' waste management attitudes are reflected in behavioural impediments.

Overall, the origins of waste on construction projects are influenced by several factors, both external and internal. These occur in varying magnitudes throughout the duration of the project - from the initial planning stages to completion (Kulatunga et al. 2006). According to Craven et al. (1994), Gavilan and Bernold (1994) and Kulatunga et al. (2006), the sources of waste on construction projects are classified into six main categories:

(1) Design;
(2) Procurement;
(3) Materials Handling;
(4) Operation;
(5) Residual; and
(6) Other (sources).

Each category of waste source is either directly or indirectly influenced by the 'human' aspect. Thus, as an extension of this, waste sources are either directly or indirectly affected by the attitudes, beliefs, knowledge, behaviours and motivation of employees in the construction industry. That is, site personnel have a major, direct impact on the waste sources above. This perspective is consistent with research by Skoyles et al. (1974) who suggested that waste levels have a greater dependence on human factors than on the type of construction taking place, or the type of building company employed.

Given that site personnel have such a major influence on many of the areas which have been identified in the research as sources of waste, it is important that site personnel possess positive attitudes, beliefs, motivations towards waste minimisation in order to instigate positive waste minimisation behaviours. However, Formoso et al., (1999) and Alwi et al., (2002) both found that construction labourers' attitudes towards activities involving waste minimisation are negative. Likewise, Teo et al. (2000) found that knowledge and training were both lacking at operative level. Thus, an improvement in knowledge and attitudes (and other human factors) towards waste management, through the implementation of training, may have a positive effect on the level of waste generated on-site.

2.4 Attitudes and Behaviours regarding C&D W Management

2.4.1 What are Attitudes and Behaviours?

Attitude is conceptualised as an evaluative view which is either, positive, neutral or negative, that an individual has towards an object or a *behaviour*. Notably, in this

context, ‘behaviour’ is the action taken by the individual towards that object (Ajzen, 1985; 1993; Teo & Loosemore, 2001; Wang & Yuan, 2010). According to Teo and Loosemore (2001), ‘attitude’ can be separated into four different dimensions, namely:

- ‘affective’ (feelings/emotions);
- ‘behavioural’ (intentions/actions);
- ‘cognitive’ (knowledge/beliefs); and
- ‘evaluative’ (values/likes or dislikes).

Attitudes are formed in order to provide regularity, for purposes of making a rationale available for interpretation of situations and objects at later times (Olsson & Zanna, 1993). In this context, attitudes are formed from an individual’s pre-existing schemas, which are mental frameworks for how individuals interpret the world.

Furthermore, behavioural decisions are often based on attitudinal bias, whether it is conscious or not (Begum et al., 2009). However, Barr et al. (2001) found that the link between attitudes and behaviours can be complicated (e.g. as a result of *cognitive dissonance*, which refers to the discrepancy between an individual’s attitudes/beliefs and the actions they make, for example, having a negative attitude towards smoking, yet being a smoker anyway). Research by Peterson and Dutton (1975) suggests that only ‘extreme’ attitudes influence behaviour. This is commensurate with research by Van Doorn, Verhoef and Bijolt (2007) who also argue that the relationship between environmental attitudes and behaviours are non-linear (i.e. a positive attitude does not always predict positive behaviour). Nonetheless, according to Al-Sari et al. (2012), the attitudes of workers in the construction industry heavily influence waste generation.

Thus, in an effort to positively influence waste management behaviour, one's attitude must correspond, accordingly.

2.4.2 Attitudes and Behaviours in the Construction Industry

Though the traditional focus of research on C&D W management has largely concentrated on existing practices and relevant technologies, it is reasonable to suggest that the influence of attitudes towards C&D W management was acknowledged as far back as 1974. According to Hussey and Skoyles (1974), it is a change in the attitude towards waste and its management, rather than a change in procedure, that is likely to have the greatest effect on waste management behaviour. This sentiment was echoed Skoyles and Skoyles (1987) and Loosemore et al. (2002), in that C&D W can be prevented, or at least minimised, by changing people's attitudes towards waste management. Research by both Skoyles and Skoyles (1987) and Loosemore et al. (2002) suggests that attitudes towards waste management impact not only the way in which waste is actually managed, but also the amount of waste produced (Loosemore et al., 2002; Skoyles & Skoyles, 1987).

In addition, research by Teo and Loosemore (2001) indicates that attitude toward waste reduction is one of the major impediments to waste management in the construction industry. Furthermore, attitudes regarding waste differ from one company to another, depending on the company's waste management policies and its organisational culture (i.e. hierarchy of power; e.g. operatives, supervisors, management, higher-management, etc.). Furthering this concept, Kulatunga et al. (2006) notes that for the successful implementation of waste management procedures, a cumulative effort at enhancing positive attitudes towards waste management, from all involved parties, is necessary.

Moreover, with respect to the Irish context, research indicates that while the general population reports concern over the quality of the environment (Davies & Fahy, 2005; Drury, 2000; 2003). However, at the same time, low levels of activity directed towards environmental protection or enhancement has been cited (Drury, 2000; 2003).

In research by Teo et al. (2000), a survey was conducted for purposes of assessing the external and internal influences upon attitudes of operatives from 5 differing employment groups, across 8 construction sites. Ajzen's *Theory of Planned Behaviour* (Ajzen, 1985; 1987; 1991; 1993) was utilised as a basis for modelling the structure of the attitudinal survey. The survey assessed the following:

- Operatives' definitions of waste;
- Operatives' recycling practices;
- Levels of operative training in waste management;
- Identification of responsibilities to reduce waste;
- The perceived importance of waste, specifically, as a project goal;
- Perceived acceptable levels of waste;
- Operatives knowledge of what happens to waste generated on construction projects;
- Operatives general experience of waste management on past projects;
- Identification of factors which prevent operatives from reducing waste;
- Identification of motivations to reduce waste; and
- Levels of support for good waste management practices.

Results revealed that operatives' attitude towards construction waste management was positive. However, behaviour was not necessarily influenced by attitudes; rather, obstructed by a deficiency in higher management, through a lack of commitment to plans of waste reduction. Teo et al. (2000) concluded that the issue of operative training needs addressing, both in order to pass on knowledge and to communicate organisational policies to site operatives, but also to communicate to operatives the standards which they are required to achieve. Furthermore, a model of attitudinal formation (Figure 2.1) was developed, which identified knowledge, beliefs, education and training as internal influences on positive attitude and potentially, behaviour. Moreover, results revealed that though operatives exhibited a lack of knowledge regarding both what happens to waste and how to potentially reduce waste, they also expressed a desire to obtain such knowledge. Finally, Teo et al., (2000) recommended that proper training of site operatives in waste management should be include information on the consequences of improper waste management, both in terms of safety and the environment. Such recommendations were heeded in the current research; specifically, during the development of the 'tool-box-talk' waste management training.

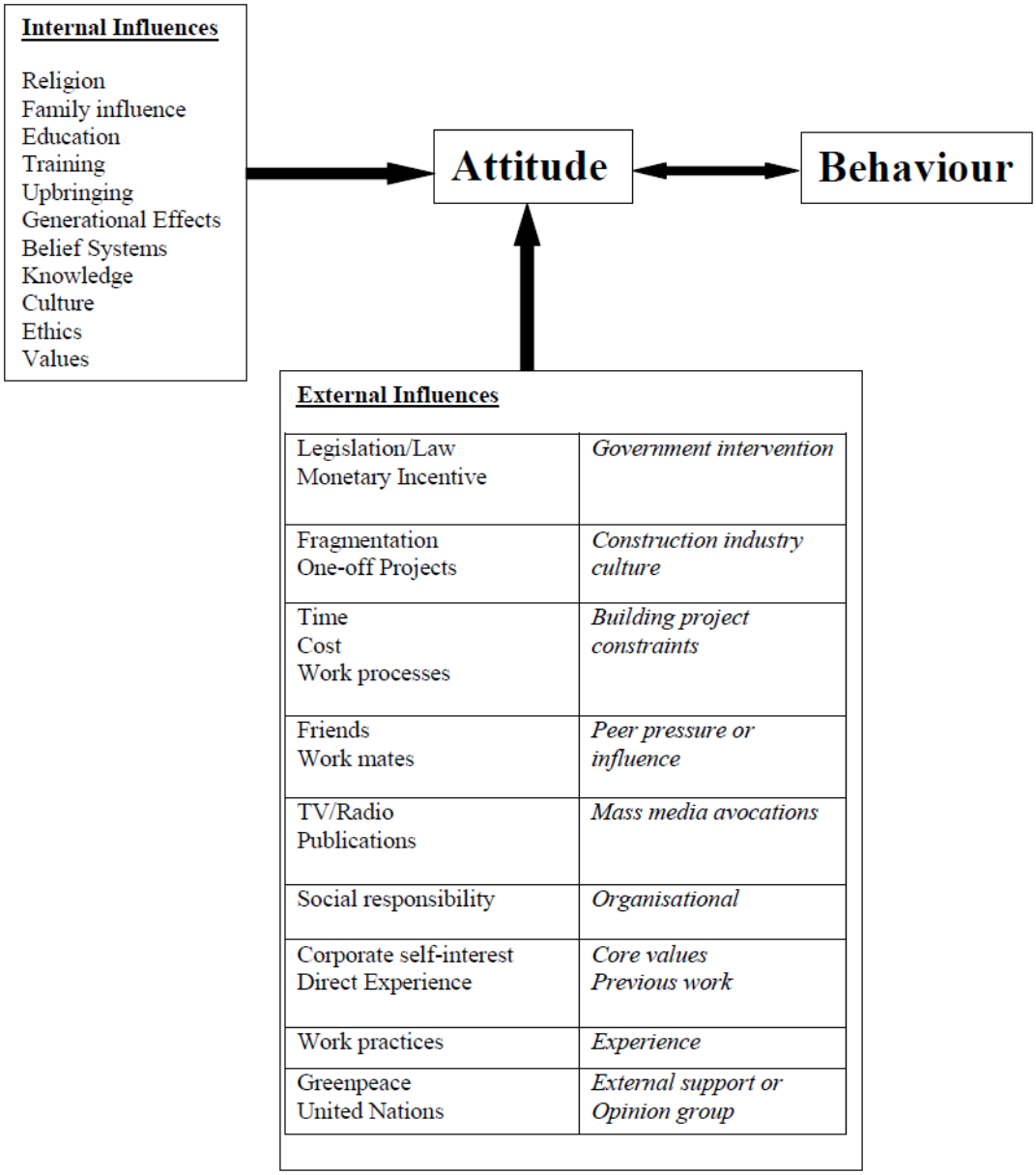


Figure 2.1: Model of Attitude Formation (Teo et al., 2000)

Kulatunga et al. (2006), expanded on the research of Teo et al. (2000) by administering a questionnaire which assessed operatives' attitudes and perceptions of multiple occupations within the construction workforce. Four separate questionnaires were disseminated to four different sections of the construction workforce, specifically:

(1) Project managers/site managers;

(2) Supervisors;

(3) Labourers; and

(4) Estimators.

Kualatunga et al. (2006) found that labourers assigned the least attention to site waste management practices, due to a lack of both time and perceived personal benefit to be gained from implementing good site waste management practices. Furthermore, Kulatunga et al. (2006) found that labourers' knowledge of the existence of waste management strategies was low when compared with that of higher ranking personnel (i.e. managers, supervisors and estimators). Notably, given that labourers are the eventual handlers of waste on site, Kulatunga et al. (2006) recommended that circulation of knowledge regarding waste management strategies within the organisation (i.e. through the implementation of waste management training) would increase labourers' knowledge and, in turn, the frequency of implementation of such strategies would increase. Finally, though Kualaunga et al. (2006) found that the attitudes towards waste management of the overall sample were positive, such results were not consistent with waste management behaviours. Thus, it was reported that a lack of available time was the main impediment to implementation of good waste management practices.

Attitudes toward environmental management practices often dictate related *behaviours* (Begum et al., 2009; Fabrigar, 2004; Herresman & Allwright, 2000). Thus, behaviours towards C&D W management are an equally important 'human' factor for consideration. The EPA (2006) have emphasised that changing waste management

behaviours is neither straightforward nor simple, as human behaviour is dictated by multiple factors (e.g. social, cultural, and both contextual and individual factors). Ekins (2004) has provided a simplified interaction map for how external and internal influences may interrelate with behaviour (Figure 2.2). Such complexity (i.e. with respect to the multiplicity of influences on behaviour) presents difficulty when investigating strategies aimed at positively influencing waste management behaviours.

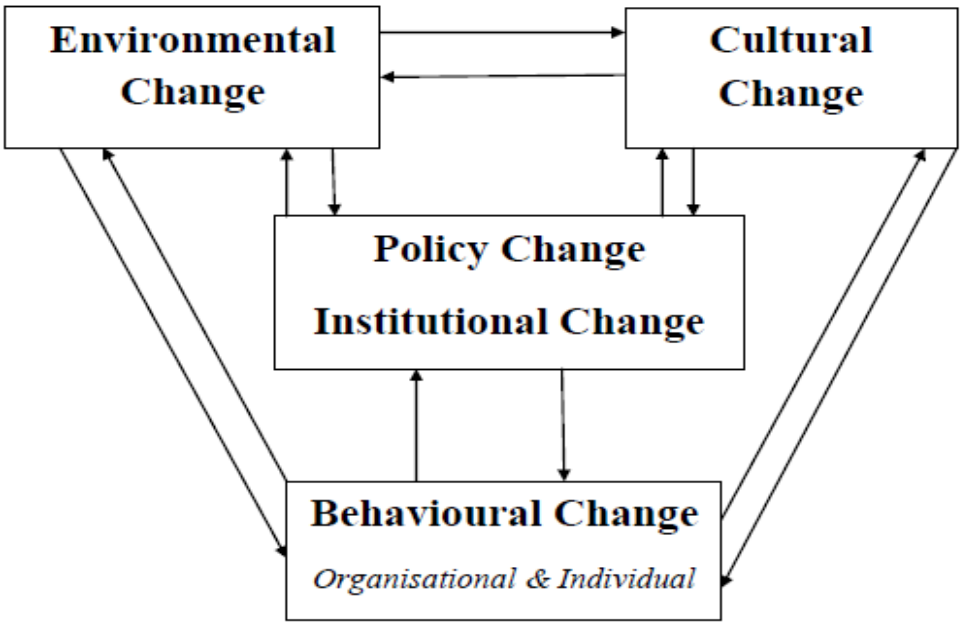


Figure 2.2: Influences on Waste Management Behaviour (Ekins, 2004; adapted by the EPA, 2006).

Teo and Loosemore (2001) also examined the effects of operatives' attitudes towards waste management on their waste management behaviour. Similar to Teo et al. (2000), Ajzen's (1985; 1993) *Theory of planned behaviour* was again used as the theoretical basis for informing the conceptualisation of attitude and behaviour within the research. Also similar to research by Teo et al. (2000), the authors employed a mixed methods approach to data analysis and collection (i.e. both quantitative and qualitative research).

Results revealed that operatives' attitudes towards C&D W management were generally positive; however, their ability to implement good waste management practices was often hindered by a lack of dedication from management. Notably, these findings mirror those from research by Teo et al. (2000). Results also revealed that managers' concerns focused on operatives' knowledge, values and building project limitations. In total, five impediments to positive attitudes towards waste management were identified:

(1) Management support;
(2) Perceptions of waste;
(3) Participation;
(4) Incentives; and
(5) Training.

Furthermore, nine impediments to appropriate waste management behaviour were also identified:

(1) A lack of managerial commitment;
(2) The belief that it was not the industry norm;
(3) The complexity of modifying existing work practices;
(4) A lack of incorporation of operatives' expertise with waste management processes;
(5) The perception that waste reduction practices are not financially viable, economical, realistic or were simply non-compatible with construction activities;
(6) The belief that waste is '*accepted as an inevitable by-product of construction*';

(7) An unwillingness to reuse or recycle materials with a low financial value;
(8) The available financial incentives for implementing good waste management practices are not passed on to operatives; and
(9) Waste management responsibilities are inadequately identified.

Teo and Loosemore (2001) concluded with a number of recommendations for managers, which could potentially aid in improving operatives' attitudes and subsequent behaviours toward C&D W reduction. These included:

(1) Commitment towards site waste reduction should be demonstrated;
(2) The economic benefit of waste reduction should both appear to exist and be shared equally between the company and operatives;
(3) Good quality and site specific knowledge should be provided to operatives on site waste reduction protocols through the implementation of training programmes and awareness campaigns;
(4) An increase in the number of educational activities aimed at increasing awareness of the social and ethical implications of site waste management practices;
(5) The creation of and communication of site waste policies to operatives should be implemented, in order to increase operatives knowledge of performance requirements;
(6) Such performance requirements should be both promoted and imposed equally on both operatives and higher management; and
(7) Waste management should be commensurate with other project objectives (e.g. safety).

Notably, these recommendations are important to consider with respect to the rationale for the current research, which is presented in the following chapter.

More recently, research by Begum et al., (2009) investigated the effects of attitudes and behaviours on waste management in the C&D industry. The final survey (i.e. subsequent to testing and modification) included questions pertaining to:

(1) Contractor characteristics (i.e. size and type);
(2) C&D W collection and disposal methods;
(3) Onsite waste practices (e.g. sorting, reduction, reuse and recycling practices);
(4) Training, education and awareness programmes completed by employees;
(5) Construction waste management attitudes and perceptions; and
(6) Behavioural questions concerning source reduction, reuse and recycling of construction waste.

Notably, two of the six areas examined by the questionnaire related to attitudes and behaviours, specifically: "Attitudes and perceptions toward construction waste management and disposal"; and "Behaviours with regard to source reduction and the reuse and recycling of construction waste".

Results from the analysis revealed:

(1) A negative relationship between category of contractor and waste management behaviours;

(2) A positive relationship between category of contractor and waste management attitudes;
(3) Smaller contractors displayed more positive behaviour towards good C&D waste management than larger contractors;
(4) Construction-related education had a significant effect on waste management behaviours;
(5) Contractors' experience in construction significantly affected waste management behaviour (i.e. lower levels of experience increased consciousness of waste management practices); and
(6) Contractors with more positive attitudes towards construction waste management also displayed more positive waste management behaviours.

Begum et al. (2009) concluded that the relationship between attitude and behaviour differed based on the size of the contracting firm. This is also consistent with research by Teo & Loosemore (2001), which found that attitudes varied from one organisation to another. Furthermore, Begum et al. (2009) found that the majority of contractors examined did not practice positive waste management behaviours (e.g. source segregation, reduction techniques, reuse or recycling). This was attributed to a lack of knowledge pertaining to the outcomes of construction waste and the potential for construction waste reduction or minimisation. Overall, Begum et al. (2009) found that the most prominent factors that positively influence behaviours towards waste minimisation and management were:

- Experience;
- Education among employees;

- Source reduction techniques;
- Frequency of reuse of materials;
- Construction waste disposal behaviours and attitudes regarding construction waste management; and
- Contractors' positive attitudes towards construction waste minimisation significantly, positively affected their waste management behaviour.

Al-Sari et al. (2012) examined the relationship between attitudes and behaviours towards construction waste management in occupied Palestinian territory. A questionnaire was designed to measure contractors' attitudes towards waste minimisation. Results from the analysis found that there were three main factors affecting attitudes:

(1) Material prioritisation;
(2) Number of unskilled workers; and
(3) Category of the contractor (i.e. size of the contracting firm).

Findings indicated, contrary to Begum et al. (2009), that contractors working for smaller construction firms held more positive attitudes towards waste reduction than larger construction firms. However, they were consistent with past theory and research in that contractors' attitudes and perceptions of the impact of construction waste on the environment had the greatest effect on behaviour (e.g. Begum et al., 2009; Fabrigar, 2004; Herresman & Allwright, 2000). The number of skilled employees working for the firm and the main contractors' level of materials optimisation also had an effect on sorting and disposal behaviour. In particular, contracting firms in the occupied

Palestinian territory (i.e. where the research was conducted), with higher numbers of skilled employees, showed less positive behaviour toward waste reduction than firms with a low number of skilled employees. These findings are interesting to note as, in a territory without a regulatory waste framework, voluntary attitudes and behaviours are directly influenced, either positively or negatively, by economics.

Influences on behaviour have also been examined in other construction practices that are affected by behaviour (e.g. health and safety). Such research is also important to consider in light of the current study given that, the current study of C&D W management behaviour is being carried out on the same category of research participant (i.e. site operatives). Lingard and Rowlinson (1997) assessed the effectiveness of behaviour-based safety management on construction site operatives. More specifically, motivation based management techniques were studied in order to assess their effectiveness on operatives safety performance on construction sites. *Safe* and *unsafe* practices were identified by the researcher, to facilitate the identification of *good* or *bad* safety behaviour. Behaviour was then measured by means of direct observation of operatives at work. In an effort to support positive safety behaviour, motivational activities such as goal setting, provision of incentives, provision of feedback and the fostering of healthy competition were applied to site operatives. The behaviour which followed was then recorded. The results of the analysis were as follows:

- Goal setting with feedback improved housekeeping behaviour;
- Removal of goal setting and feedback resulted in a deterioration in housekeeping behaviour;

- Mixed results (i.e. a significant statistical improvement on 2 sites and a significant statistical deterioration on 1 site), were obtained regarding safety behaviour on working at heights after implementation of goal setting and feedback; and
- No improvement in safety behaviour regarding the use of bamboo scaffolding was observed after introduction of goal setting and feedback.

The results showed that housekeeping behaviour deteriorated after removal of goal setting and feedback which suggests that behaviour-based safety management did improve positive behaviour. However, the results showed that, although behaviour-based safety management methods did improve some aspects of safety performance; the improvement was not universal across all observed behaviours.

Lingard and Rowlinson (1997) also found that *management commitment* had a strong influence on behaviour, consistent with the findings of Teo et al. (2000). The researchers noted that managers attended meetings on housekeeping; and subsequently, did not attend meetings on the subjects of both working at heights and access to scaffolding. Notably, housekeeping behaviours were found to improve, while working at heights and access to scaffolding behaviours did not. Lingard and Rowlinson (1997) suggest that the lack of commitment from managers, contribute to workers negative perception on the importance of behaviours relating to issues addressed in meetings where managers were not present. This finding is consistent with research by Lingard, Cooke and Blismas (2012) who found that operatives perceptions of managers commitment to safety, have a considerable influence on positive safety behaviour within an organisation.

Furthermore, Lingard and Rowlinson (1997) found that operatives perceived the safety standards proposed for working at heights and access to scaffolding were contrary to project performance goals and thus, not possible to achieve. This is consistent with research by Ajzen (2006) who found that the behaviour is influenced by beliefs about issues that may facilitate, or impede, the performance of behaviour.

2.4.3 Summary of Attitudes and Behaviours in the Construction Industry

Overall, a large body of research suggests that there is a link between attitudes and behaviour towards C&D W management (Table 2.1). For example, research by Begum et al. (2009) revealed a correlation between C&D contractors' positive attitudes toward waste management and satisfactory C&D W management behaviours, which is consistent with Ajzen's (1993) theory of planned behaviour. According to Kulatunga et al. (2006), the main cause of the generation or mismanagement of C&D W is the behaviour of the construction workforce. Kulatunga et al. (2006) cites a potential coupling of behaviours and attitudes, which is again consistent with Ajzen's (1993) theory of planned behaviour. More specifically, results indicate that operatives' positive or negative attitudes towards C&D W management influence how they behave (i.e. how they practice waste management procedures). However, this speculation is counter to what Kulatunga et al. (2006) actually found. That is, though the operatives possessed positive attitudes towards waste minimisation and management, they also exhibited a lack of effort in practicing (i.e. behaving) good waste management and minimisation procedures.. Thus, it is reasonable to suggest that empirical research has established that there was potentially some variable(s), apart from attitude, that impacted operatives' behaviour. Notably, one potential variable cited by Begum et al. (2009) as impacting C&D W management attitudes and behaviours is C&D W management-related beliefs.

Table 2.1: Research Suggesting a Link between Attitudes and Behaviour

Ajzen (1985; 1993; 2001)	An attitude is an evaluative view, which is either, positive, neutral or negative, that an individual has towards an object or a *behaviour*.
Yang & Yoo (2004)	Attitude consists of both affective and cognitive components. The affective component refers to the degree of which an individual likes the object of thought, while the cognitive component refers to an individual's specific beliefs about/related to the object.
Chau & Hu (2001); Luarn & Lin (2005)	Attitude refers to an individual's positive or negative evaluative affect about performing a particular behaviour.
Eagly & Chaiken (1993); Tian-Cole & Cromption (2003)	Attitude is a psychological tendency expressed by evaluating a particular object, ideal or entity with some degree of favour or disfavour.
Dawes & Smith (1985); Garling, Gilholm & Garling (1993)	An attitude is an evaluative response to some object which disposes a person to behave in a certain way toward it.
French et al., (2005)	Attitude refers to emotions and drives engendered by the prospect of performing a behaviour.

2.5 Waste Management Beliefs

Though research in C&D W management cites beliefs about waste management as an important factor affecting operatives' C&D W management practices (e.g. Lingard, Graham & Smithers, 1997; Teo et al., 2000; Teo & Loosemore, 2001), there is a lack of research that actually examines *beliefs* as an independent variable. This may be, in part, due to the variance throughout C&D W literature, in the interpretation of the word *belief.* For example, Teo and Loosemore (2001) identify *beliefs* as a cognitive dimension of attitude, similar to *knowledge.* Conversely according to Ajzen's theory of planned behaviour (1985; 1993; 2001), beliefs are a separate construct to attitudes, given that attitudes are more commonly associated with an affective construct

(i.e. emotions and feelings) than cognition. Another disparate characterisation is provided by Lingard and Rowlinson (2007) who classify *beliefs* as a *perception* which directly determine behaviour. Due to such variance in definitions, for the purposes of this research, the simplified conceptualisation provided by Schwitzgebel (2006) will be utilised, wherein a belief refers to a premise, or set of premises that an individual holds to be true.

According to theory of planned behaviour (Ajzen, 2006), behaviour is guided by beliefs, specifically: beliefs about the consequences of a behaviour; beliefs about the expectations of others (with respect to a specific behaviour); and beliefs about factors that may facilitate, or impede, the performance of a behaviour. In turn, certain beliefs will produce a positive (or negative) attitude. This is consistent with Lingard and Rowlinson (1997) who also found that negative beliefs had a negative effect on behaviour. This is important to consider with respect to C&D W management practices, as research indicates that if operatives believe that they have little control over waste management performance, or that their contribution will not be valued, behaviour will reflect these beliefs (Lingard, Graham & Smithers, 1997). In addition, research indicates that operatives possess the underlying belief that people in managerial roles have greater responsibilities than those in more technical roles for ensuring that C&D W is managed appropriately (Teo et al., 2000).

Notably, a belief is a cognitive construct and likewise, is informed by either knowledge, or by a lack of knowledge (Ajzen, 2001). Figure 2.3 provides a visual interpretation of the influence of beliefs and knowledge on attitudes and behaviour described in Ajzen (2001). Furthermore, cognitive substitution occurs when there is a lack of knowledge

concerning a particular topic. In such instances, an individual may fill this void with a belief (Kahneman, 2011). Hence, given the influence of knowledge on beliefs and subsequently, attitudes and behaviour, it is also important to consider knowledge as a human factor potentially influencing C&D W management.

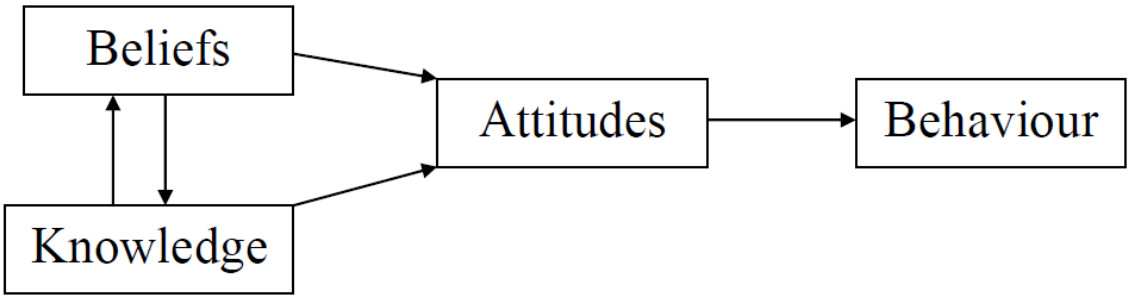


Figure 2.3: Influence of Beliefs and Knowledge on Attitudes and Behaviour (adapted from Ajzen, 2001)

2.6 Waste Management Knowledge

Knowledge, Attitudes, Skills and Aspirations (KASA) control behaviour and, moreover, the ability to modify behaviour (Bennett, 1975; Purcell & Magette, 2010). Purcell & Magette, (2010) found that deficiencies in the understanding, or *comprehension* of good Biodegradable Municipal Waste (BMW) management procedures will negatively affect the ability to appropriately manage waste, with respect to participating in reduction, re-use and recycling of materials; and also the quantity of waste reduced, re-used or recycled.. Thus, as this finding is consistent with research by Ajzen (1985; 1993; 2001), it is reasonable to suggest that behaviour, in addition to attitudes, is dictated by one's existing knowledge. For example, research by Maycox (2003) revealed that though behaviour is critical to minimising waste, there are other significant, more primary barriers, such as a lack of knowledge concerning waste practices. Likewise, according to Kulatunga et al. (2006), there has been a lack of education (e.g. onsite) surrounding

waste minimisation practices, which has obstructed proper waste management practices in the C&D industry. However, though many in the field acknowledge the importance of C&D W management knowledge and training (Begum et al., 2009; Kulatunga et al., 2006; Maycox, 2003; Taylor et al., 2011), neither the effects of operatives' C&D W management knowledge on related attitudes and behaviours, nor their relationships have been explored in the literature. Thus, future research is necessary to investigate both these effects and relationships. Given that the primary goal of the current research is to examine the effect of waste management training on individual's knowledge of waste management practices and the subsequent effect that knowledge may have on attitudes and behaviours (as well as beliefs and motivations towards waste management), the focus of the current discussion now turns to a presentation of both research and theory on knowledge (i.e. in training/learning settings).

2.6.1 Learning & Knowledge

In order to develop a training intervention for C&D W management, the expansion of knowledge in C&D W must be a primary focus. Thus, the approach to knowledge presented in this thesis is taken from a training/educational perspective. Bloom's taxonomy of learning objectives was developed for the purposes of improving training and education (Bloom, 1956). Bloom's taxonomy of educational objectives consists of six major categories of thought; the first two of which are relevant to this discussion of knowledge. The first category refers to *knowledge*. This includes:

(1) The knowledge of specifics (e.g. facts);

(2) The ways and means of dealing with specifics (e.g. procedures); and

(3) The abstract nature of some information (e.g. abstract concepts).

This may also include knowledge of specific terminology, facts, conventions, patterns, classifications, criteria, methodologies, principles, generalisations, theories and structures; and the ability to remember, or recall, this knowledge on demand. The second category of thought, *comprehension*, is the ability to understand or grasp the meaning of this information.

Anderson and Krathwohl (2001) revised Bloom's taxonomy by making a number of changes. The involvement of an increased dependence of thought processes on knowledge in the revised taxonomy is both the most important difference between these taxonomies and the most relevant with respect to this discussion. Specifically, in Bloom's taxonomy, knowledge encompassed both knowledge of different forms of facts, procedures and abstract concepts, as well as the ability to remember facts, procedures and abstract concepts (Krathwohl, 2002). In the revised taxonomy, knowledge is described as a separate dimension (Krathwohl, 2002; Moseley et al, 2005), while the ability to remember is described as a separate thinking process. Anderson and Krathwohl made this decision to highlight their belief that cognitive processes (e.g. remembering and understanding) act on knowledge in their own right (Figure 2.4). Furthermore, the addition of this new knowledge component is an important feature of Anderson and Krathwohl's (2001) revised taxonomy because it also includes an additional knowledge component not included in Bloom's original taxonomy: metacognitive knowledge; which in this context refers to strategic knowledge, knowledge about thinking processes and tasks, and self-knowledge (Anderson & Krathwohl, 2001). Simply, metacognition refers to thinking about thinking

(Flavell, 1976; 1979) and it includes various dispositions and motivations towards thought and knowledge-based tasks.

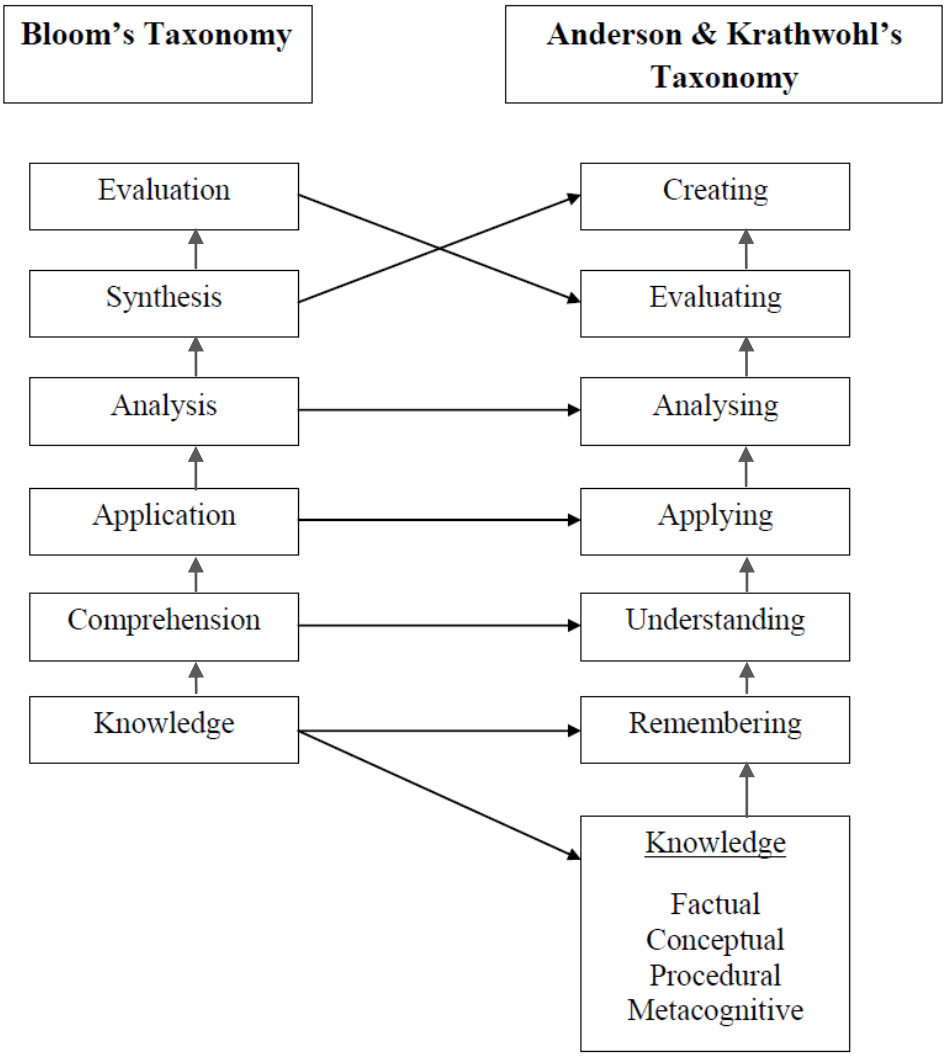


Figure 2.4: Bloom's Taxonomy and Anderson and Krathwohl's (2001) Revision

Notably, another recent taxonomy, Marzano's (1998; 2001) taxonomy of learning objectives, was developed in light of a large scale meta-analysis of research conducted on training/educational interventions. This taxonomy provides further, empirical, support for the models discussed above, given the inclusion within the taxonomy of (under the broad category of the *cognitive system*) the processes of *knowledge retrieval*

(i.e. memory/recall); *comprehension* (i.e. knowledge representation); and *knowledge utilisation* (i.e. decision-making, problem-solving, investigation and experimental enquiry); as well as a *metacognitive system*, which acts as a self-regulatory processor, for example, with respect to motivation, attention, attitudes, beliefs and the interaction of such processes (Marzano, 1998; Moseley et al., 2005).

To clarify, metacognition can be described as the processes associated with the active self-monitoring, consequent self-regulation and orchestration of knowledge concerning one's own thinking (Boekaerts & Simons, 1993; Brown, 1987; Demetriou, 2000; Flavell, 1976; Ku & Ho, 2010). In the context of research on training, metacognitive self-regulatory functions of thinking often refer to the motivation to learn and think and to consider relevant knowledge during specific tasks. Specifically, motivation refers to one's own 'personal drive' to think or act in a certain manner and the extent to which they are willing to perform, consistent with this 'personal drive' (Valenzuela, Nieto & Saiz, 2011). For example, motivation to learn and think may include the motivation to control learning beliefs, regulate effort and seek help (Pintrich et al., 1991). This will be an important perspective to consider in discussion of the rationale for the current research in the following chapter.

2.6.2 Knowledge & Memory

According to the taxonomies provided above, knowledge should be conceptualised as both the ability to remember information and as an information storage centre (e.g. for facts, procedures and events; Bloom, 1956; Anderson & Krathwohl, 2001). In order for information to be stored as knowledge, a number of processes must first take place, (e.g. the active processing, encoding and storage), so that an individual may remember that

information. According to Broadbent (1958) and Miller (1956), a limited amount of information is held in short-term storage (i.e. working memory; Baddeley 1986; 2000) after it is actively processed (e.g. such as during training). After manipulation of that information within short-term storage, it can be transferred into permanent, long-term storage, where it becomes knowledge (Baddeley, 2000; Craik & Tulving, 1975; Baddeley & Hitch, 1974; Broadbent, 1958*).* Notably, the effective transfer of information from short-term storage to long-term memory dictates what will be remembered (Baddeley, 2000; 2002; Tulving & Thompson, 1973; Tulving, 1984). Thus, it must be a goal for any training programme to ensure this transfer. This can be achieved through the presentation of well organised knowledge (i.e. toolbox training) aimed at facilitating the construction of schemas.

2.6.2.1 Schemas

Whereas, short-term storage (i.e. working memory) can store a limited amount of information for a short amount of time, long-term memory (LTM) is an area of memory that allows comparatively permanent storage of information. For example, the following areas of LTM sore the following categories of information:

- Semantic LTM stores facts (e.g. Elvis Presley was a famous singer);
- Episodic LTM stores events (e.g. the storming of the Bastille occurred on July 14th 1789); and
- Procedural LTM stores procedures (e.g. making a cup of coffee).

(Tulving, 1984).

The eventual possibility of information being stored in LTM is improved when it is organised into a schema (i.e. a grouping of knowledge which has been assembled from

previous experience, for example, stereotypes, beliefs, attitudes and expertise). The schema acts as a plan that guides the successive processing of information. Consider the following as an example of a functioning schema; imagine each and every piece of available information (i.e. knowledge) as a brick. In this example, a schema is represented by the house which was built from similar, related bricks. For schemas to be constructed properly, the information which is used to eventually form the schema must be understood. Simply, in order to build knowledge, new information must be comprehended.

Schemas are also important to consider in the context of this research given that they are representations of knowledge and understanding that have been assembled from previous experience. This suggests that knowledge construction and knowledge application will be highly influenced by the level of expertise (e.g. level of education or years working on site) held by individuals receiving training. For example, in research by Chi, Glaser, & Rees (1982), two groups with different levels of expertise (novice and expert) were asked to categorise 24 physics problems based on their similarities. Both groups identified approximately the same number of categories. However, qualitative analysis revealed that novices categorised the problems according to the following:

- By the objects referred to in the given problem (e.g. a spring);
- Specific physics 'terminology' (e.g. friction); or
- The interaction or configuration of various objects (e.g. a block on an inclined plane).

Conversely, it was found that experts categorised the problems according to the law of physics which governed each problem. The findings revealed that the expert solution

methods (Figure 2.5 provides an example of one such solution) were more advanced. Furthermore, the expert solution reflected a more abstract understanding than novice solutions (i.e. which largely focused on concrete aspects of the problem). Consequently, Chi, Glaser & Rees findings are notable, in the context of the current research, as they indicate that an individual's existing schemas, knowledge or expertise, determines the manner in which a given task (e.g. waste management) is performed. Thus, expertise in C&D W management, has a substantial influence on the manner in which information (i.e. knowledge for that topic) is retrieved and, subsequently, applied.

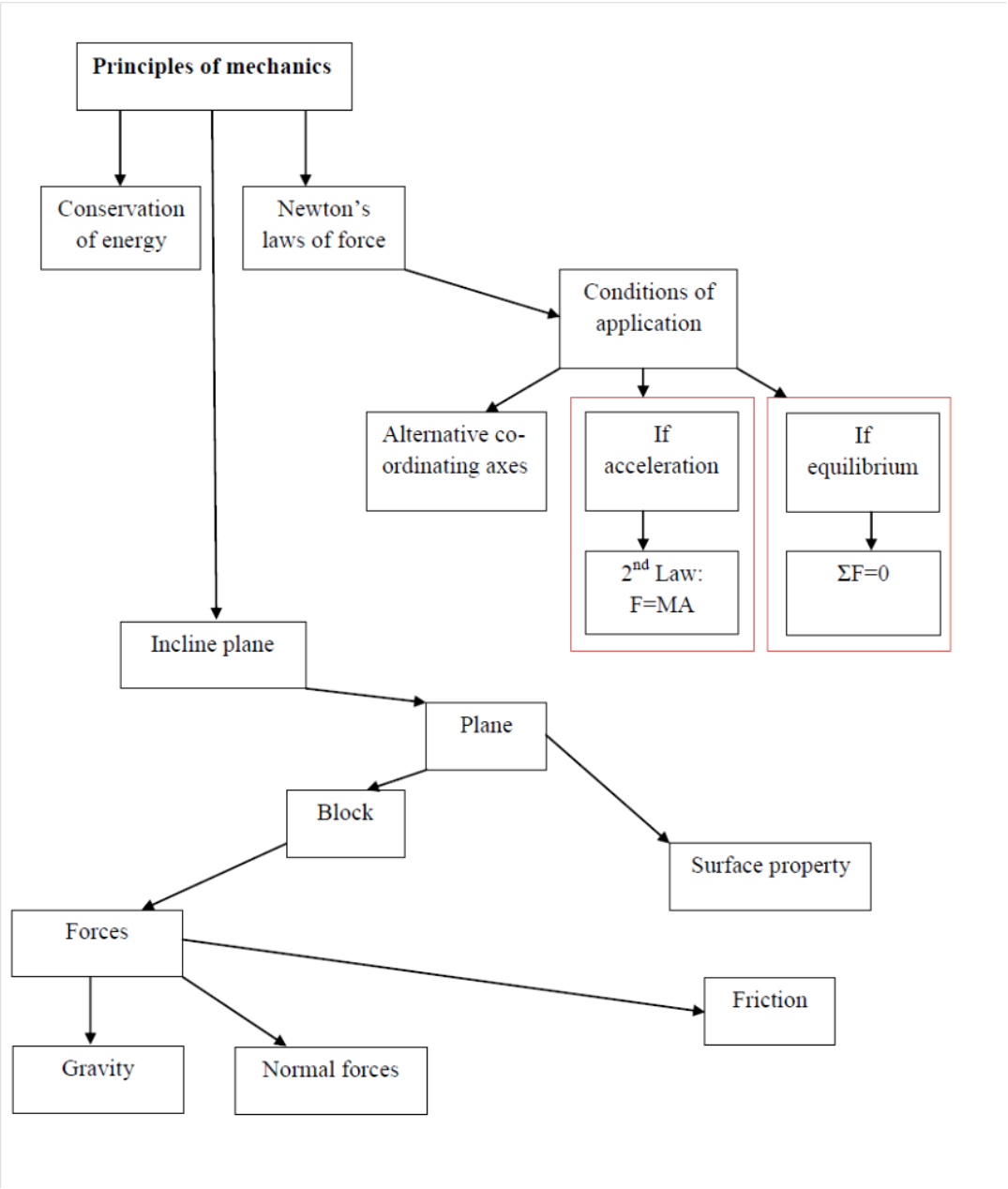


Figure 2.5: Expert Schema for Principles of Mechanics (Chi, Glaser & Rees, 1982)

2.7 Knowledge Management in Construction

Though there are many definitions of KM available (e.g. Scarborough et al. 1999; Klynveld Peat Marwick Goerdeler. (KPMG) 1998; Davenport & Prusak 2000), one of the most widely used is provided by Webb (1998) who defines knowledge management as:

"The identification, optimisation, and active management of intellectual assets to create value, increase productivity and gain and sustain competitive advantage."

Webb (1998)

In recent years, the area of knowledge management (KM) in construction has received much interest from large, geographically dispersed companies that acknowledge the necessity for their employees to be able to access information, regardless of location (Carrillo & Chinowsky, 2006).

Furthermore, KM has become more attractive due to the assertion that implementation can lead to improved business performance through, revenue growth, reduced design times and client and personnel satisfaction (Carrillo & Chinowsky, 2006). According to Robinson et al. (2005), learning and knowledge sharing is necessary, particularly, in order to encourage continuous company-wide improvements. This, in turn supports competition among construction organisations. Moreover, the implementation of KM is even more important within large construction companies, as, due to size, it is often more difficult to ascertain "who knows what".

Due to the nature of the construction industry, each project is unique (i.e. with respect to location, employees, building methods, weather conditions and design differences). Thus, employees are required to find out "who knows what" and to communicate "lessons learned" in a short space of time (Carrillo & Chinowsky, 2006). Furthermore, researchers such as Kulatunga et al. (2006), Batayneh et al. (2007) and Jaillon et al. (2008) have identified pre-planning (i.e. before commencement of construction activities) as an area of elevated importance with respect to reducing construction

wastes. Pre-planning provides an opportunity to plan and implement objectives related to recycling, identify waste streams and identify procedures for handling, recycling and disposing materials. In order for guidelines (e.g. regarding handling, recycling and disposing materials) developed during pre-planning to serve any useful purpose, they must then be communicated to all personnel throughout the construction company.

Jashapara (2004) identified the many dimensions of knowledge management. Each element (e.g. culture, strategy, systems & technology and organisational learning) rely interdependently on each other, and also their implementation impact (i.e. facilitate or impede) knowledge management. Figure 2.6 highlights the many disparate fields which equally impact on knowledge management. For example, the organisational culture is equally as responsible for success as the quality of internal systems and technology. Thus, in order to optimise the effectiveness of a waste management training module on site, each of the elements outlined above must perform equally well. More specifically, in order to implement a C&D W training module on site, the organisational culture must first support the implementation of training. This can be displayed, for example, through the provision of adequate time for the training to occur. Secondly, there must be a strategy in place for operatives to receive this training (e.g. identification of who receives the training and identification of the optimal location wherein to provide the training). Suitable technology must be made available in order to provide the training (e.g. provision of an overhead projector in order to show presentations as opposed to displaying presentations on a laptop, which may be difficult to see if there are several personnel attending the training module). Finally, the correct information must be available to create useful training materials. That is to say, information provided in training materials must be in accordance with organisational objectives and goals and

not cause confusion for personnel by providing conflicting information. This is consistent with recommendations made in ISO 14001:2004, whereby environmental policies should not conflict with wider organisational policies.

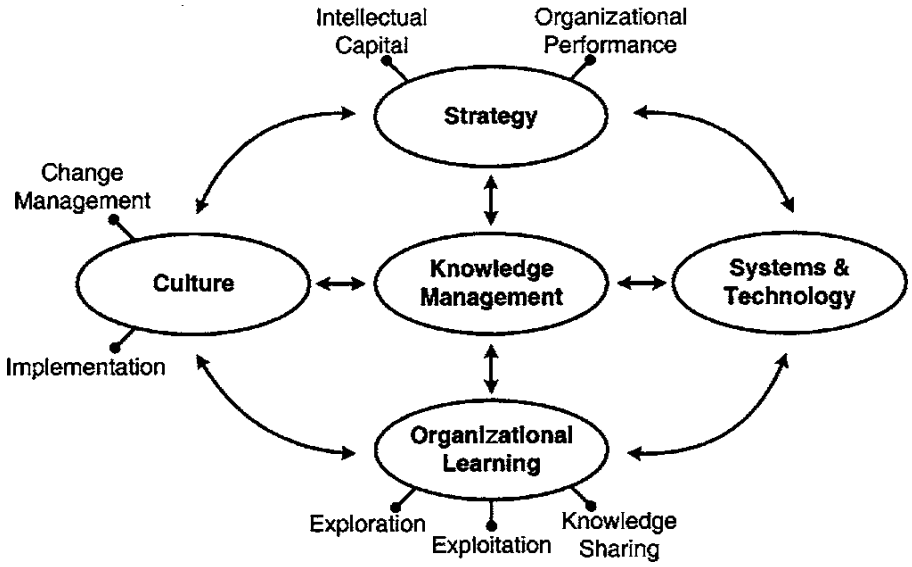


Figure 2.6 Dimensions of knowledge management (Jashapara, 2004)

In order to identify the main motivations for implementation of KM, Robinson et al. (2001) conducted a UK-based survey of construction and engineering firms, which identified the following:

- The requirement to support continuous improvement (92.5%);
- In order to share precious tacit knowledge (88.7%);
- So as to distribute the knowledge of best practices (86.8%); and
- To reduce the amount of rework (77.4%)

The need to encourage continuous improvement, sharing of tacit knowledge, dissemination of best practices and reduction of rework are also significant motivations for sharing knowledge within an organisation on effective C&D W management.

Significantly, Tiwana (2000) identified that Information Technology (IT) alone cannot be solely responsible for KM as it disregards the sharing of tacit knowledge. As such, the use of IT for the purposes of training may be optimised, providing that tacit knowledge is incorporated into the learning materials. The inclusion of tacit knowledge in training materials is highly important in the construction industry as information and knowledge is generally site specific (e.g. location of skips, quantity and type of skips, identification of waste collectors and identification of persons responsible for dealing with waste). Therefore, IT based C&D W training materials should be accessible to the relevant members of the organisation (e.g. SHE officer or Forman), and furthermore must allow for the updating of relevant information. In addition, IT based training which allows for the updating of information, can also provide a means of sharing information on methods which have been a C&D W management success, for use on future projects (Horton, 2000). For example, a particular method of segregating waste on site (e.g. provision of heavy duty bags at workspaces for waste segregation as a substitute for mini skips, which take up more space) may have proven successful in increasing C&D W recycling and therefore could be implemented on future projects. Inclusion of tacit knowledge such as this in IT based training materials, will allow for the sharing of useful knowledge throughout the whole organisation.

2.8 Chapter Summary

Overall, a large body of research has identified a lack of training as a major cause for operatives' poor attitudes, beliefs, knowledge, behaviours and motivation towards C&D W management (e.g. Begum et al., 2009; Teo et al., 2000; Teo & Loosemore, 2001; Lingard et al. 2000; McDonald & Smithers, 1998). However, there is a substantial gap

in the research which evaluates the effectiveness of training on influencing attitudes, behaviours, beliefs, knowledge and motivation towards waste management.

In the current chapter, attitudes, behaviours, beliefs, knowledge and motivation were discussed, in light of both existing conceptualisations and past research, given that they are the primary variables examined in this thesis. Furthermore, IT was identified as an effective method of sharing useful knowledge throughout the organisation. In the following chapter, these variables will again be discussed in order to make explicit the aims, hypotheses and the rationale for the current research.

CHAPTER 3

AIMS, HYPOTHESES & RATIONALE FOR THE CURRENT RESEARCH

3.1 Overview

Based on the review of literature presented in the two preceding chapters, a set of aims, hypotheses and a rationale are presented in the current chapter, in order to explain, in detail, the research conducted in this thesis.

3.2 Aims of the Current Research

C&D W and its management is one of many environmental concerns garnering attention within the construction industry, due to the increased awareness of environmental sustainability and perhaps equally, to the rising cost of landfill levies. However, despite these concerns, the construction industry remains "*notorious*" for (over) producing massive amounts of C&D W (Kwan et al., 2003). Likewise, the C&D industry is one of the largest waste producers in the Republic of Ireland. Thus, C&D W management has become a focus of both the engineering and construction industries in Ireland.

The common focus of research in this area has largely concentrated on existing frameworks regarding how C&D W management practices, procedures and relevant technologies contribute to:

(1) The generation of C&D W (Formoso et al., 1993; Bossink and Brouwers, 1996; Poon, 1997; Faniran and Caban, 1998);
(2) C&D W minimisation; and
(3) Resource optimisation (Osmani, 2012; Kulatunga et al., 2006).

However, significantly less focus has been paid to the potential effect of individual differences (e.g. knowledge, motivation, beliefs and attitudes) on C&D W management practices. This is interesting to consider as a common *attitude* in the industry has been that waste is accepted as an inevitable by-product of the C&D industry, with a strong *belief* that minimisation practices will not be able to completely eliminate the generation of C&D W (Teo and Loosemore, 2001). Thus, as discussed in the previous chapters, due to the lack of research conducted on knowledge, motivation, beliefs and attitudes towards C&D W management; and their relationships with waste management behaviours, specifically in Ireland, the current research aims to:

- Quantitatively examine the effects of a C&D W management 'tool-box-talk' training programme on C&D W management knowledge, while controlling for baseline motivation, beliefs and attitudes towards C&D W management.

- Quantitatively examine the effects of a C&D W management tool-box-talk training programme on motivation towards C&D W management, beliefs about C&D W management and attitudes towards C&D W management.

- Quantitatively examine the relationships among knowledge, motivation, beliefs and attitudes towards C&D W management.

- Quantitatively examine pre-existing differences in knowledge, motivation, beliefs and attitudes towards C&D W management resulting from age.

- Quantitatively examine pre-existing differences in knowledge, motivation, beliefs and attitudes towards C&D W management resulting from years working on-site/experience.

- Quantitatively examine pre-existing differences in knowledge, motivation, beliefs and attitudes towards C&D W management resulting from education.

- Quantitatively examine pre-existing differences in knowledge, motivation, beliefs and attitudes towards C&D W management resulting from position on-site.

- Qualitatively analyse the effects of a C&D W management tool-box-talk training programme on waste management behaviours.

- Qualitatively analyse site operatives' perceptions of the C&D W management tool-box-talk training programme training course, with specific focus on: the presentation and quality of the training sessions; the participants' experience of the training sessions; and the likelihood that the training will facilitate appropriate C&D W management practices in the future.

3.3 Hypotheses for the Current Research

Consistent with aims presented above, the main focus of the current research is to test six hypotheses:

(1) The ‘tool-box-talk’ intervention will significantly enhance site operatives’ (a) waste management knowledge, (b) motivation towards waste management, (c) beliefs about waste management, (d) attitudes towards waste management and (e) waste management behaviour.

(2) Knowledge, motivation, beliefs and attitudes towards waste management will all be significantly, positively correlated.

(3) Older site operatives (i.e. 34 and older) will score significantly higher on waste management knowledge than younger site operatives.

(4) More experienced site operatives (i.e. 15 years on-site or more) will outperform less experienced site operatives on waste management knowledge.

(5) Higher educated operatives (i.e. with at least an apprenticeship level of education or above) will outperform less educated operatives on waste management knowledge and also score significantly higher on positive attitudes, beliefs and motivation towards waste management.

(6) There will be a significant difference between position/trade groups (i.e. labourers, builder, plumbers, electricians and ‘others’) on pre-existing knowledge, motivation, beliefs and attitudes towards waste management.

3.4 Rationale for the Current Research

The first hypothesis is that the ‘tool-box-talk’ intervention will significantly enhance site operatives’:

(1) Waste management knowledge;

(2) Motivation towards waste management;

(3) Beliefs about waste management;

(4) Attitudes towards waste management; and

(5) Waste management behaviour.

With respect to the enhancement of knowledge, research indicates that training in a specific domain facilitates the schema-construction (i.e. the building of knowledge) for that domain, yielding domain-specific knowledge, or expertise (Pollock, Chandler & Sweller, 2002; Sweller, 2010). This perspective is consistent with research by Chi, Glaser and Rees (1982), Marzano (1998) and Sweller (1999). Furthermore, in research by Kulatunga et al. (2006), it was speculated that providing on-site waste management training to operatives might enhance their waste management knowledge and subsequently, their waste management practices.

As the tool-box-talk training will present information about waste management practices and specifically, both the financial and environmental costs of poor waste management practices (i.e. information which site operatives may not have previously known), it is hypothesised that learning such information may enhance positive beliefs and attitudes towards waste management, as well as the motivation to manage waste correctly, given that the benefits of appropriate waste management will be made explicit. That is, consistent with *theory of planned behaviour* (Ajzen, 1993; 2001), it is hypothesised that knowledge will inform beliefs and beliefs will inform attitudes – a perspective which is also consistent with research by Teo and Loosemore (2001). Furthermore, given the potential for increase in knowledge, as well as positive attitudes

and beliefs towards waste management, it is hypothesised that motivation will also increase over the duration of training. This hypothesis is consistent with research by Hattie, Biggs and Purdie (1996), which found a significant correlation between motivation and learning. In turn, it is hypothesised that with enhanced knowledge (Ajzen, 1993; Maycox, 2003) and motivation towards waste management (Hattie, Biggs & Purdie, 1996), alongside positive beliefs and attitudes towards waste management (Begum et al., 2009; Fabrigar, 2004; Herresman & Allwright, 2000; Kulatunga et al., 2006; Teo & Loosemoore, 2001; Teo et al., 2000), site operatives will exhibit more appropriate waste management behaviours (Bennett, 1975; Kulatunga et al., 2006; Purcell & Magette, 2010) at post-intervention assessment. Similarly, the second hypothesis is that that knowledge, motivation, beliefs and attitudes towards waste management will all be significantly, positively correlated, given the links among these variables discussed in past research (e.g. Ajzen, 1993; Begum et al., 2009; Marzano, 1998; Maycox, 2003; Pintrich et al., 1991; Purcell & Magette, 2010; Teo & Loosemoore, 2001; Teo et al., 2000).

The third hypothesis (i.e. older site operatives will score significantly higher on waste management knowledge than younger site operatives, but younger operatives will score significantly higher on positive attitudes, beliefs and motivation towards waste management than older operatives) and the fourth hypothesis (i.e. more experienced site operatives will outperform less experienced site operatives on waste management knowledge, but the less experienced operatives will score significantly higher on positive attitudes, beliefs and motivation towards waste management than older operatives) share the same rationale. Simply, it is hypothesised that older and more experienced site operatives will have greater waste management knowledge due to

having had more opportunities to engage in waste management procedures and have done so for a longer amount of time (i.e. as a result of expertise; Chi, Glaser & Rees, 1982). However, younger and less experienced site operatives will exhibit greater motivation and more positive beliefs and attitudes towards waste management, given that they have worked a larger proportion of their careers in which current (and arguably, stricter) waste management practices and procedures have been implemented. That is, as older and more experienced operatives may have potentially worked on-site during times in which waste management practices were less strict, they may not be as motivated towards waste management, or be as positive towards waste management (with respect to their beliefs and attitudes) as younger, less experienced operatives. These hypotheses are also consistent with research by Begum et al. (2009), which found that contractors with less experience in construction and who were typically younger in age, demonstrated more positive attitudes towards C&D W management practices than those who were older and more experienced.

The fifth hypothesis is that higher educated operatives will outperform less educated operatives on waste management knowledge and also score significantly higher on positive attitudes, beliefs and motivation towards waste management, given that their previous training/education and potential capacity for relevant information may have influenced their knowledge, motivation, beliefs and attitudes towards waste management prior to the administration of the intervention. Notably, this hypothesis is, to some extent, consistent with research by Begum et al. (2009) which found that a construction-related education had a significant, positive effect on waste management behaviours (i.e. which, given the rationale above, may be mediated by attitudes, beliefs, motivation and knowledge).

The sixth and final hypothesis is that there will be a significant difference between operatives of certain positions/trades on pre-existing knowledge, motivation, beliefs and attitudes towards waste management, given that operatives belonging to certain trades or who hold certain positions on-site are either held as contractually responsible for their own waste, or are considered as responsible for all waste on-site. That is, labourers are considered the primary 'care-takers' of on-site waste-management and electricians are responsible for the management and disposal of their own waste. Perhaps, as a result of being personally responsible for waste, it is in the interest of certain trades to be knowledgeable, motivated and positive (i.e. with respect to both beliefs and attitudes) towards waste management above and beyond other on-site personnel. Notably, this could also be, in part, due to the varying levels of education associated with specific positions/trades. That is, some workers on-site would have been required to go to trade school for their position (e.g. electricians and plumbers); thus, this hypothesis is made, in part, based on the same rationale as above – that is, consistent with research by Begum et al. (2009), construction-related education will have a significant, positive effect on waste management behaviour, mediated by knowledge, motivation, beliefs and attitudes.

In the following chapters, the methodology, results and discussion of empirical research will be presented, which examine the broad claim that C&D W management 'tool-box-talk' training can be used to enhance a range of outcomes, including knowledge, motivation, beliefs, attitudes and behaviour towards waste management. In Chapter 4, the methodology for the current research will be discussed in detail. This will be followed by the presentation of results in Chapter 5. Finally, Chapter 6 concludes the thesis by presenting a general discussion, in which results will be interpreted;

limitations of the current research will be discussed; and both broader implications of waste management training and future research will be recommended in light of theory, extant research and findings from the current research programme.

CHAPTER 4

MATERIALS & METHODS

4.1 Introduction

The current study employed a mixed-methods approach to data collection and analysis (i.e. both quantitative and qualitative data analysis). While both quantitative and qualitative research methodologies have their respective strengths and weaknesses, a mixed methods approach maximises these strengths, as the analysis and reporting of both sets of findings allows for clearer and more focused interpretations, given that results can be explained by multiple investigative perspectives. Simply, whereas the quantitative portion of the approach measures the magnitude and frequency of results, the qualitative portion of the study explores the meaning and understanding of these results (Creswell et al., 2011). Notably, this methodological approach is consistent with research by both Begum et al. (2009) and Teo et al. (2000).

4.2 Materials and Measures

A series of three 'tool-box-talk' videos was presented to site operatives via a laptop computer and a projector, as part of the waste management training intervention. The three tool-box-talks can be viewed by using the following hyperlinks:

(1) Tool-box-talk 1: "*Construction and Demolition Waste and the Environment"* http://youtu.be/8vLBTMqv90Y

(2) Tool-box-talk 2: "*Avoiding and Reducing Construction Waste: Part 1"* http://youtu.be/HkmiXms3Qjo

(3) Tool-box-talk 3: "*Avoiding and Reducing Construction Waste: Part 2"* http://youtu.be/_Ykat9toU7U

A course outline is presented in Table 4.1 and the complete lecture slides can be found in Appendix C. The tool-box-talks were developed based on the *WRAP Site Practice Course* (WRAP, 2012), WRAP's *Waste Recovery Quick Wins* (WRAP, 2007), WRAP's *Demolition: Implementing Best Practice* (EnviroCentre, Controlled Demolition & National Green Specification, 2005), the *HSE Waste Management Awareness Handbook* (HSE, 2011) and multiple Envirowise information sheets for site workers (e.g. Envirowise, 2009).

The tool-box-talks were voice recorded and dubbed over *Prezi*™ slideshows using *CamTasia*™ recording software. A male voice (i.e. Dr. Christopher Dwyer) was chosen to provide the over dubbing for the tool-box-talk videos. This was implemented as research by Menzel and Carrell (1999) found that students perceived greater learning from instructors of the same gender. Hence, a male voice was chosen as the intervention group contained solely male participants. Additionally, the researcher considered the use of an external voice (i.e. not the voice of the researcher administering the educational materials) in order to facilitate the improvement of the participants perceptions of the importance of the educational intervention.

Expertise knowledge of waste management was measured by a 15 item multiple choice question (MCQ) assessment developed by the researcher, based directly on the content of the tool-box-talk videos (i.e. developed based on the *WRAP Site Practice Course* [WRAP, 2012], WRAP's *Waste Recovery Quick Wins* [WRAP, 2007], WRAP's

Demolition: Implementing Best Practice [WRAP, 2005], the *HSE Waste Management Awareness Handbook* [HSE, 2011] and multiple Envirowise information sheets for site workers [e.g. Envirowise, 2009]; again see Table 4.1. for a breakdown of the topics covered within the assessment). Each question presented 5 possible solutions. Only one of the five options was correct for each question. The following is an example of a question from Form A of the knowledge assessment:

Before placing orders, it is important to _____.

(a) Measure up correctly
(b) Check that the supplier is a member of the ISCA
(c) Check that the supplier is a member of GUBU
(d) Double your measurements so that you don't run out of materials.
(e) Order the materials to arrive well in advance of when you need them

This question was developed based on the information provided in the slide presented in figure 4.1 (i.e. When placing orders, measure up correctly).

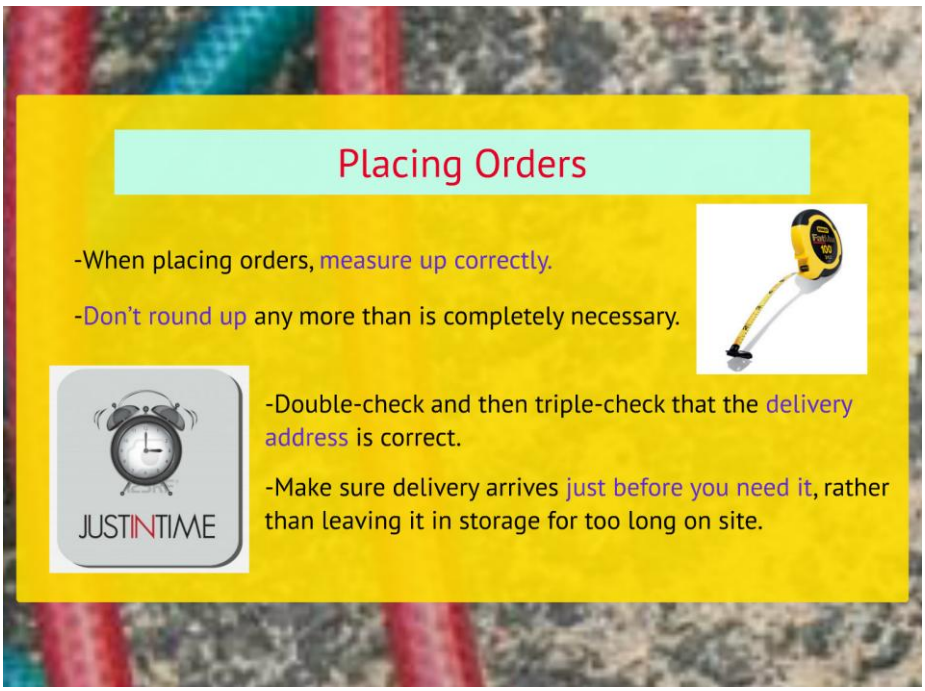


Figure 4.1: Slide 2 from Tool-box-talk 2: "Avoiding and Reducing Construction Waste, Part 1"

The following is a question from Form B of the knowledge assessment with a difficulty level which corresponds with the difficulty level of the question previously presented from Form A of the knowledge assessment:

When finished using solvents and cleaning fluids, which of the following will produce the least waste?

(a) Let them settle and reuse the clear solvent.
(b) Pour them down the sink
(c) Pour them down the toilet
(d) Put them in the skip
(e) Keep them safe by putting them in the general storage area

This question was developed based on the information provided in the slide presented in figure 4.2 (i.e. Let solvents and cleaning fluids settle so that they can be reused).

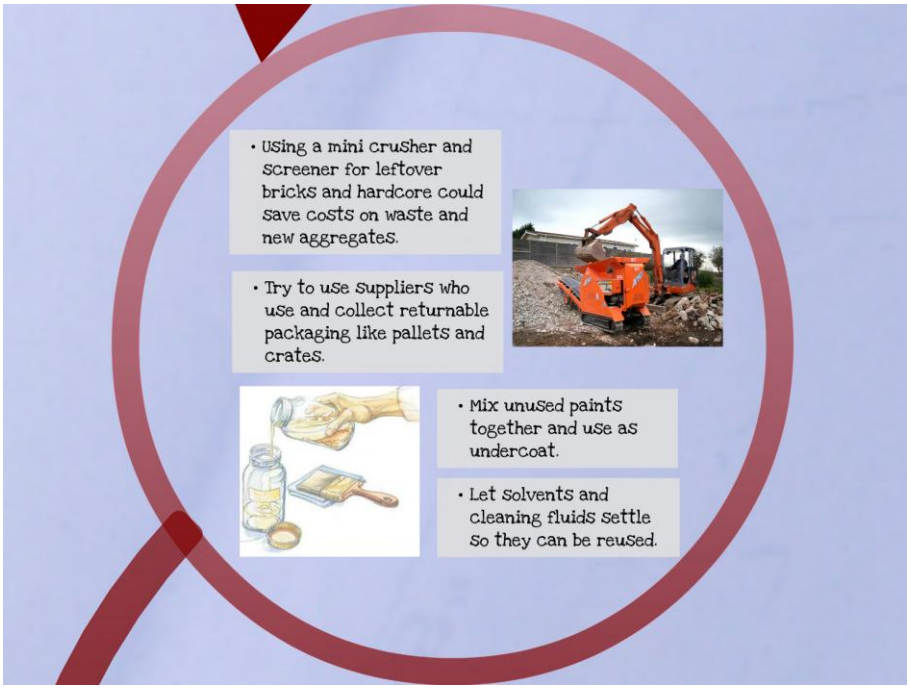


Figure 4.2: Slide 4 from Tool-box-talk 3: "*Avoiding and Reducing Construction Waste, Part 2*"

Two versions of the knowledge assessment (i.e. Form A and Form B) were developed and each participant completed each form once over the duration of the intervention (i.e. either as a pre-test or as a post-test).

A seven item 'attitudes towards waste management' scale and a six item 'beliefs about waste management' scale were adapted from research by Ajzen (1985; 1993), Begum et al. (2009) and Teo et al. (2000). Each item on each scale was responded to using a seven-point likert scale, a scale also used by Kualatunga et al. (2006). The internal consistency of the beliefs scale was identified. This refers to the inter-correlations among items within a scale. Thus, the internal consistency determines the scale's reliability with respect to its ability to measure the intended variable. More specifically, according to George and Mallery (2003) scales with a Cronbach's α of greater than 0.90 are excellent; 0.70-0.90 are 'good'; 0.60-0.70 are 'acceptable'. Though 0.50-0.60 are 'poor', they can still be used; whereas scales with a Cronbach's α of less than 0.50 are 'unacceptable'. Test reliability of the attitudes scale used in the current study was strong, with an internal consistency of Cronbach's $\alpha = 0.88$; and $\alpha = 0.62$ for the beliefs scale, which is also acceptable (George & Mallery, 2003).

Table 4.1: C&D W Management Training Course Outline

Class No.	Title	Content	Duration (m/s)
1	*Construction and Demolition Waste and the Environment*	• Addresses the question as to why minimise waste? • Displays the environmental benefits of waste reduction • Introduces the Waste Hierarchy and describes the requirements of the Waste Hierarchy • Describes the true cost of waste	7:30
2	*Avoiding and Reducing Construction Waste: Part 1*	• Describes methods for reuse of materials on site • Identifies wastes worth segregating for reuse or recycling • Describes correct disposal of waste on site, including good skip management practices • Identifies different waste types including, identification of hazardous wastes • Addresses canteen waste • Addresses landfill tax	8:20
3	*Avoiding and Reducing Construction Waste: Part 2*	• Illustrates appropriate storage of materials on site • Explains the importance of pacing orders correctly • Describes the correct procedures when receiving deliveries • Identifies methods of good materials handling • Reiterates the importance of reducing waste when using materials	8:54

Motivation towards C&D W management was measured by a customised questionnaire, adapted from the *Motivated Strategies for Learning Questionnaire* (MSLQ; Pintrich et al., 1991). The version of the MSLQ used in this current study consisted of 9 items, each of which was responded to using a seven-point likert scale (1 = strongly agree, 7 = strongly disagree). Three adapted sub-scales from the MSLQ were also used in this study, including motivation towards: *effort regulation* (i.e. the motivation to control both effort and attention when confronted with distractions and uninteresting tasks); *help-seeking* (i.e. participants' motivation to seek assistance and support from others when it is necessary); *control of beliefs* (i.e. participants' beliefs that their efforts to manage waste will result in positive outcomes). Internal consistency for sub-scales used in the current study range from $\alpha = 0.52 – 0.69$ (Pintrich et al., 1991). The assessment packets (i.e. the knowledge, motivation, beliefs and attitudes scales) administered to participants can be found in Appendix D.

Observed behaviour was assessed qualitatively by the researcher. The researcher examined, recorded and photographed the quantity and proportion of materials put in skips, as well as the composition of materials in skips. A skip observation sheet was developed based on the Kelly and Hanahoe (2009) skip audit sheets. The skip observation sheet was used to record the initial impression of the quantity, type and compaction level of waste in skips (see Appendix E for a full skip audit of the five days of behavioural observation). Subsequently, away from the work site, the researcher further analysed the materials visible in each skip (within the photographs). This further analysis was implemented using the criteria set out in the skip audit sheets and assessed the approximate percentage of materials incorrectly disposed of in each skip. The researcher employed a colleague from the MSc in Environmental Systems (i.e. William

Burke) to do the same, in order to avoid researcher bias. The secondary adjudicator was chosen based on his educational qualifications (i.e. BSc Hons. in Construction Management). Such qualifications provide the secondary adjudicator with expertise in the area of construction and as an extension of this, construction materials. These credentials were considered by the primary researcher to be satisfactory, in order to provide a second expert observer of skip contents. The secondary adjudicator was also blind to what day the photo was taken (i.e. before or after the training intervention), in order to eliminate any bias towards the potential success or failure of the training intervention. Inter-observer reliability (i.e. agreement between observers on the percentage of inappropriately skipped materials; see Bailey & Burch, 2002) was 0.94. These ratings are provided in Chapter 5, underneath each photograph that presents an evaluated skip. Notably, other observed behaviours were noted and included in the analysis (e.g. storage practices). Behaviour was observed for three days prior to the training intervention and for two days following the training intervention. The duration of each observation period (i.e. once per day on-site) was approximately one and one–half hours.

A *HTC Wildfire S*™ media device with recording capability was used to record the focus group interview as an MP3 audio file. The following set of semi-structured questions were used to direct the focus group discussion:

(1) What did you think of the tool-box talks/training?

(1a) What did you think about the content of the training

(1b) What did you think about the technology e.g. visuals and sound

(1c) Do you feel you learned anything?

(1d) Do you feel that you know more now than before the training?

(2) Do you feel that you were already managing site waste materials correctly before the training?

(2a) Have you noticed any difference in your ability to manage site waste materials since completing the training module?

(3) Do you think further training in waste management would be helpful?

(3a) Do you think you receive enough training?

(4) Do you think the current level of waste production is a problem for the construction sector?

(5) Do you feel that you encounter problems when attempting to dispose of site material?

(5a) What kind of problems do you encounter?

(6) What do you think are the major causes of waste production on construction projects?

(7) Do you think that waste can ever be eliminated from the construction process?

(7a) If no, do you think that waste could be reduced to a bare minimum?

(7b) If yes, how do you think this could be done?

(8) Do you think waste management, prevention and minimisation are important issues to consider?

(9) Do you feel it's your responsibility to properly manage waste on site?

(9a) Is there anyone else who shares this responsibility?

(10) Do you think that your workmates think that you should manage waste materials correctly?

(11) If you require help when dealing with waste on site, who would you most likely ask for help?

This method is consistent with research by Begum et al., (2009) who utilised a structured, verbal questionnaire survey in order to interview a random sample of construction contractors.

4.3 Participants

Participants (N=19; 10 in the training group, 9 in the control; all male) were employees of BAM Building Ltd., Galway, aged between 18 and 49 years. The initial pre-test sample size (N= 34) was decreased by an attrition rate of 44 per cent. The attrition may have resulted from the occurrence of a fault with the crane on the day of post-testing, in which many operatives were forced to skip lunch and aid in fixing the difficulties associated with the crane, as according to the SHE officer, 'all hands were on deck'. Attrition may also have occurred as a result of some participants, who completed pre-testing, no longer being on-site at the time of post-testing. Another possible reason for the small sample size was that recruitment for voluntary participation took place during site operatives' lunch/break-time and thus, operatives may have been reluctant to participate as this would impinge on their breaks.

Participants in the focus group (N = 5) were site operatives who took part in the training group and completed both pre-and-post-testing. The breakdown of site operatives' positions is presented in Table 4.2.

Table 4.2 Breakdown of site operatives' positions

Position	N
Builders	2
Electricians	3
Fitters	2
Labourers	4
Plumbers	4
Others	4

4.4 Procedure

BAM Building Ltd., specifically project manager, Liam Croke, was contacted for research recruitment and established a suitable visitation schedule for the researcher. The project consists of the construction of two buildings namely, Merlin Woods Primary School and Coláiste Mhuirlinne/ Merlin College Post-Primary School. The address of the project is Merlin Woods, Doughiska, Galway, Ireland. The estimated value of the project is €10,423,140. A point of contact was made on Day 1 of the observation (i.e. July 19th, 2013); namely, Vera Kilgallon, the Safety, Health and Environmental (SHE) officer for the site.

The study took place over the duration of five weeks. Pre-intervention behavioural observation began on Friday, July 19th and resumed in Week 2 (i.e. on July 23rd and

24th). During behavioural observation, the primary researcher examined and recorded waste management, waste disposal and storage practices on site. In Week 3, the intervention began. On Monday, 29th July, 34 site operatives (including electricians, plumbers, labourers and builders) were administered measures which assessed knowledge, motivation, beliefs and attitudes towards C&D W management.

Notably, two forms of the knowledge assessment were developed for the current study, both consisting of 15 MCQs (all of which provided 5 possible solutions, with only one of which being correct). All 30 items developed (i.e. the sum of the 15 items from each of the two assessments) were piloted on six site operatives that were not from the BAM site. The pilot session was carried out on operatives who were not from the BAM site in order to avoid reducing the sample size. A small sample size was of concern to the researcher as participation of operatives in the study was voluntary. The site operatives used for piloting were acquaintances of the researcher and completed pilot testing via email. Test-takers from the pilot testing session found the assessments to be fair. However, some minor modifications were made to the phrasing of questions on the knowledge assessment in order to make them more easily understood by site operatives.

The researcher compared the scores from the pilot testing with a difficulty ranking previously developed for each item. Using both measures, the researcher split the 30 items into two separate, though reasonably similar tests (i.e. with respect to difficulty). Nevertheless, a cross-over repeated measures approach was utilised for administration of the assessment. That is, half the site operatives completed Form A as the pre-test and Form B as the post-test, and the other half of site operatives took Form B as the pre-test and Form A as the post-test. This design automatically corrects for any differences in

difficulty between the two forms (Hitchcock, 2004). In addition, given that test-takers would not be encountering any of the same questions from one testing-time to the next, this design also eliminated the potential for any practice effects. Furthermore, neither basement effects (i.e. extreme low scoring; e.g. less than chance – in this context, 3/15 correct), nor ceiling effects (i.e. extreme high scoring), were observed in the resulting data analysis as mean scores ranged from a minimum of 5.2 to a maximum of 9.3.

After completion of the pre-intervention assessments, participants were randomly allocated to either the training group or the control group. Those who participated in the training group received three 'tool-box-talks' - one each day for three days. The 'tool-box-talks' were designed to teach C&D W management procedures according to the WRAP framework (again, see the *Materials and Measures* section) and presented educational/training information about:

- C&D W management;
- Why C&D W should be managed correctly; and
- Procedures for how to conduct C&D W management appropriately.

The duration of the tool-box-talks ranged between seven-and-a-half and nine minutes, so as to not to lose the attention of the participating viewers, given that research indicates that didactic presentations (such as those used in the current research) which last longer than 15 minutes can substantially decrease attention to the source of instruction (Wankat, 2002). Those allocated to the control group did not attend any 'tool-box-talks'.

The tool-box-talks began on Tuesday, 30th of July and ended on Thursday, 1st August. Following completion of the training intervention, participants were again administered measures which assessed knowledge, motivation, beliefs and attitudes towards C&D W management. Again, those who received Form A at pre-testing were administered Form B at post-testing and vice versa.

The researcher returned to site on Monday, August 12th and conducted a follow-up, semi-structured focus group interview, in order to elicit a deeper understanding of the quantitative results. Five site operatives participated in the focus group interview. After completion of the interview, all participants were debriefed and thanked. Also on August 12th, the first post-intervention behavioural observation took place, followed by the second and final behavioural observation on Wednesday, August 14th. During both days of post-intervention behavioural observation, the researcher again examined and recorded waste management, waste disposal and storage practices on site. Following completion of the behavioural observation, the researcher thanked her point of contact, Vera Kilgallon (the site Safety Health, and Environmental officer) for her help and support.

Notably, data collection was conducted in an anonymous and confidential manner. This was accomplished by instructing site operatives who completed the assessment and questionnaire packet to provide an arbitrary participant identification number/group of letters to ensure anonymity and confidentiality during coding. In order to ensure that participants did not receive the same assessment at post testing, identification numbers/groups of letters were recorded on the front of the appropriate post testing assessment. Participants were then instructed to retrieve the blank post test assessment

with their identification number/group of letters, from a pile laid out on a table. This was done while the researchers' back was turned in order to further maintain confidentiality. Results from the assessments were subsequently, inputted and analysed using the Statistical Package for the Social Sciences (SPSS), according to the design procedure outlined above. Interview transcripts (i.e. the qualitative data) were interpreted through thematic analysis.

4.5 Design and analysis

4.5.1 Quantitative data analysis

With respect to the quantitative analysis in the current research, a series of independent samples t-tests was conducted in order to examine potential differences between groups (i.e. derived from demographics, including age, years working on-site/experience and education) on C&D W management knowledge, motivation, beliefs and attitudes towards C&D W management. A t-test is a statistical test which is used to assess the difference between two sets of data. Specifically, the test assesses the means, standard deviations, t-statistic, t-distribution and degrees of freedom to determine a *p* value, or probability (Field, 2013). Given that a t-test is used to test the null hypothesis, if the p value is lower than .05, there is a significant difference between the two sets of data. The independent samples version of the test refers to the assessment of a single variable separated by some grouping criterion. In the current research, independent samples t-tests were used to assess, for example, the performance of knowledge (i.e. the single variable) according to condition (i.e. control group performance v. training group performance); and in another t-test, according to time (i.e. performance at time 1 v. performance at time 2).

An ANOVA is similar to a t-test, but instead of assessing the difference between two sets of data, an ANOVA is used to determine the differences among three or more sets of comparable data. The ANOVA produces an F-statistic. This refers to the ratio of the variance calculated among the means to the variance within the samples (Field, 2013). Simply, an ANOVA is a test of the hypothesis that the variation is no greater than that due to normal variation of performance and error in the subsequent measurement. That is, much like a t-test, ANOVA tests the null hypothesis and as such, if the p value yielded is lower than 0.05, there is a significant difference among the multiple sets of data. Hence, a series of 2 (time: pre-and-post-testing) x 2 (condition: training group and control group) mixed analyses of variance (ANOVAs) was also conducted in order to examine the effects of the C&D W management training programme. This is consistent with research by Teo et al. (2000) who conducted an ANOVA in order to investigate the external and internal influences on operative's attitudes. In the current study the ANOVA was done with respect to both time and condition, on motivation, motivation sub-scales, attitudes towards C&D W management and beliefs about C&D W management.

Pearson correlations were also conducted in order to examine the relationships among C&D W management knowledge, motivation, beliefs and attitudes towards C&D W management. A correlation refers to the statistical relationship, either positive or negative, between any two variables. Pearson's correlation coefficients, or simply Pearson's correlations, are a commonly used method of assessing correlation. The correlation analysis yields an r value between +1 and −1, where +1 is a total positive correlation, 0 is no correlation, and −1 is a negative correlation. Much like the other

statistical tests discussed, correlations also yield a p value. If the p value yielded is lower than 0.05, then the two variables are significantly correlated.

Finally, with respect to the quantitative approach to the data analysis, a 2 (time: pre-and-post-testing) x 2 (condition: training group and control group) mixed analysis of covariance (ANCOVA) was conducted. The ANCOVA was carried out in order to examine the effects of a C&D W management training programme, with respect to both time and condition, on C&D W management knowledge, while controlling for baseline motivation, beliefs and attitudes towards C&D W management. An ANCOVA is the same as an ANOVA, but with the addition of one or more covariates. A covariate is a secondary variable that is included in the analysis to control for change or influence on the dependent variable (i.e. the primary outcome measure). Simply, an ANCOVA is used to determine the differences among three or more sets of comparable data, while simultaneously, statistically controlling for variability of other measured variables (i.e. the covariates). For example, in the ANCOVA used in the current research, the dependent variable was knowledge; and motivation, beliefs and attitudes were covariates.

4.5.2 Qualitative data analysis

As part of the mixed-methods approach to data analysis in the current study, qualitative data analysis was also conducted. Behaviour was observed by the primary researcher for three days prior to the training intervention and for two days following the training intervention. The primary behaviour observed and analysed was the disposal of materials on-site (i.e. what materials were segregated into which skips). Other observed

behaviours, that may have an effect on site waste production, were noted and included in the analysis.

After completion of the waste management training intervention, a semi-structured focus group interview was also conducted with five participants, in order to investigate their perceptions of the training course, with specific focus on:

- The presentation and quality of the training sessions;
- The participants' experience of the training sessions; and
- The likelihood that the training will facilitate appropriate C&D W management practices in the future.

Notably, the focus group was also conducted in order to elicit a deeper understanding of the quantitative findings. Similar to research by Teo et al. (2000), significant findings from the survey-based research informed the development of a retrospective focus group interview. The interview transcript (see Appendix F) was examined using thematic analysis.

Results from both the quantitative and qualitative data analyses are presented in the following chapter. The interpretation of these results and the implications of these findings are discussed in Chapter 6.

CHAPTER 5:

RESULTS OF THE QUANTITATIVE, QUALITATIVE AND OBSERVATIONAL DATA ANALYSES

5.1 Overview

The aim of the current chapter is to present the results from the current research. Specifically, the quantitative, qualitative and observational data analyses will be presented.

5.2 Quantitative Data Analysis

Means and standard deviations for scores on knowledge, overall motivation, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, beliefs and attitudes towards C&D W management are presented in Table 5.1. Table 5.2 presents an analysis of variance (ANOVA) summary for all dependent variables (i.e. outcome measures) included in this study. Table 5.3 presents inter-correlations between all outcome measures included in this study.

5.2.1 Group differences in Knowledge, Motivation, Attitudes and Beliefs

A 2 (time: pre-and-post-testing) x 2 (condition: training group and control group) mixed analysis of covariance (ANCOVA) was conducted in order to examine the effects of a waste management training programme, with respect to both time and condition. This was conducted while controlling for baseline motivation, beliefs and attitudes towards waste management. Preliminary analysis indicated that for motivation (F [1, 14] = .994, p = .336), beliefs (F [1, 14] = .920, p = .354) and attitudes (F [1, 14] = .123, p = .731),

the relationship with knowledge did not differ significantly as a function of the training condition. That is, change in knowledge was not accounted for by motivation, beliefs or attitudes.

Results from the mixed ANCOVA revealed a significant effect of time (F [1, 17] = 12.84, p = 0.002, partial η^2 = 0.43), in which knowledge scores significantly increased from pre-to-post-testing. There was no effect of condition, though a trend towards significance was observed (F [1, 17] = 3.10, p = 0.097), in which those in the training group scored higher than those in the control group. There was also a significant time x condition interaction effect (F [1, 17] = 14.31, p = .001, partial η^2 = 0.46), whereby the benefits of training were greater at the post-testing (Figure 5.1).

Table 5.1: Descriptive Statistics from the Mixed ANCOVA

		Pre-Test		Post-Test	
	N	*M*	*SD*	*M*	*SD*
Knowledge					
Training Group	10	5.20	1.55	9.30	2.31
Control Group	9	6.00	2.60	5.89	1.36
Overall Motivation					
Training Group	10	45.40	7.57	44.00	6.11
Control Group	9	40.89	8.38	47.56	11.52
Help-Seeking					
Training Group	10	14.20	2.30	13.70	2.63
Control Group	9	12.00	2.83	13.44	3.50
Control of Beliefs					
Training Group	10	15.90	3.35	15.10	2.81
Control Group	9	14.89	3.66	16.22	4.74

Table 5.1: Descriptive Statistics from the Mixed ANCOVA (Cntd,)

		Pre-Test		Post-Test	
	N	*M*	*SD*	*M*	*SD*
Effort Regulation					
Training Group	10	15.30	5.03	15.20	4.44
Control Group	9	14.00	4.50	17.44	4.13
Beliefs					
Training Group	10	26.60	4.25	30.30	5.36
Control Group	9	29.00	3.87	31.89	4.51
Attitudes					
Training Group	10	24.50	12.78	40.80	5.61
Control Group	9	31.44	9.25	37.11	10.83

As a result, post hoc analyses were conducted via a series of paired samples t-tests, which examined the differences between pre-and-post-test knowledge scores for both conditions. Differences between the training and control groups' pre-test knowledge scores, as well as their post-test scores were also analysed. With respect to pre-testing, there was no significant difference between groups on knowledge (t = .83, df = 17, p = .420). This indicates that the two groups were well matched. At post-testing, the training group scored significantly higher than controls on waste management knowledge (t = -3.86, df = 17, p = .001, two tailed, d = 1.80). The paired samples t-tests further revealed that those who participated in the training group scored significantly higher on post-testing compared with pre-testing on knowledge (t = -7.24, df = 9, p < .001, two tailed, d = 2.08). There were no significant differences between the pre-and-post-testing knowledge scores of participants in the control group.

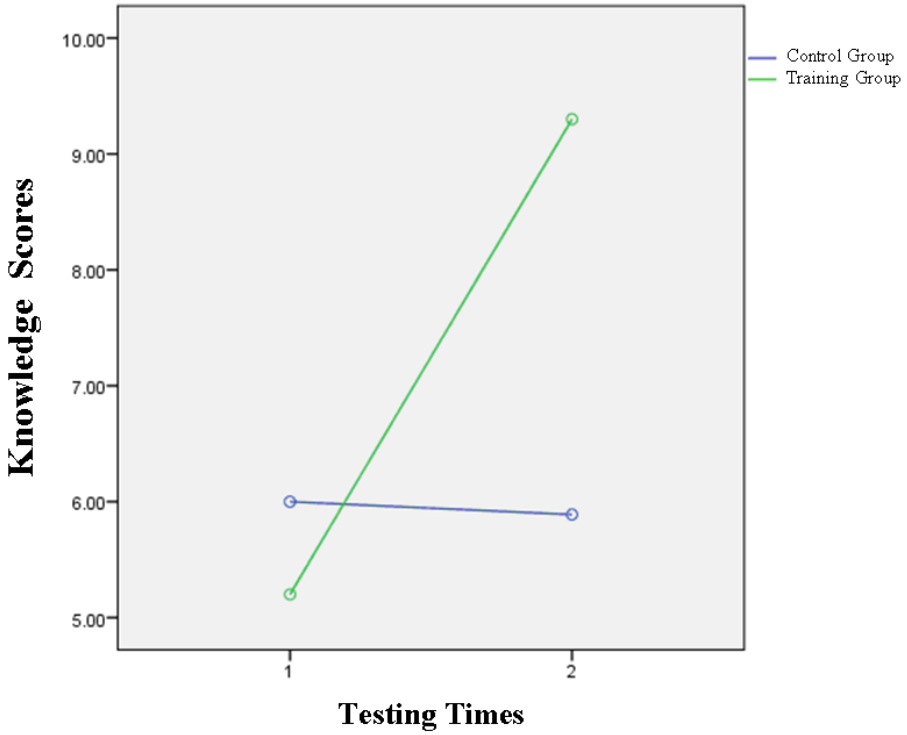


Figure 5.1: Pre-and-Post-test Knowledge Performance in Training and Control Groups

Table 5.2: Summary of ANOVA results

	Df	df (error)	*F*	*p*	Partial η^2
Knowledge					
Condition	1	17	3.10	.097	.15
Time	1	17	12.84	.002	.43
Condition x Time	1	17	14.31	.001	.46
Overall Motivation					
Condition	1	17	.30	.865	.00
Time	1	17	.90	.356	.05
Condition x Time	1	17	2.12	.164	.11
Help-Seeking					
Condition	1	17	1.72	.208	.09
Time	1	17	.28	.606	.02
Condition x Time	1	17	1.17	.295	.06
Control of Beliefs					
Condition	1	17	.01	.954	.00
Time	1	17	.04	.851	.00
Condition x Time	1	17	.58	.457	.03
Effort Regulation					
Condition	1	17	.08	.780	.01
Time	1	17	1.76	.203	.09
Condition x Time	1	17	1.97	.178	.10
Beliefs					
Condition	1	17	1.73	.206	.09
Time	1	17	5.24	.035	.24
Condition x Time	1	17	.08	.781	.01
Attitudes					
Condition	1	17	.27	.611	.02
Time	1	17	10.89	.004	.39
Condition x Time	1	17	2.55	.129	.13

A series of 2 (time: pre-and-post-testing) x 2 (condition: training group and control group) mixed analyses of variance (ANOVAs) was also conducted in order to examine the effects of both time and condition on motivation, motivation sub-scales, attitudes towards waste management and beliefs about waste management. Results from the

ANOVAs revealed a significant effect of time on beliefs (F [1, 17] = 5.24, p =0 .035, partial η^2 = 0.24) and attitudes (F [1, 17] = 10.89, p =0 .004, partial η^2 = 0.39), both of which increased in positivity over time; however, there were no effects of condition, no interaction effects, nor any other significant effects.

5.2.2 Correlations

At pre-testing, there was a significant, positive correlation between overall motivation and all motivation sub-scales: motivation towards help-seeking (r = 0.65, p < 0.001), motivation towards control of beliefs (r = 0.64, p <0 .001) and motivation towards effort regulation (r = 0.72, p <0 .001). There was a significant, positive correlation between overall motivation and positive beliefs about waste management (r = 0.39, p <0 .05); between motivation towards control of beliefs and positive beliefs about waste management (r = 0.53, p < 0.01). Also at pre-testing, knowledge was significantly, negatively correlated with age (r = -0.37, p <0 .05) and years on-site/experience (r = -0.38, p <0 .05).

At post-testing, there was a significant, positive correlation between overall motivation and only one motivation sub-scale: motivation towards effort regulation (r = 0.61, p <0 .05). There was a significant, positive correlation between motivation towards control of beliefs and positive attitudes towards waste management (r = 0.64, p <0 .05); and between positive beliefs and attitudes towards waste management (r = 0.76, p < 0.01). Furthermore, age was significantly, positively correlated with years on-site/experience (r = 0.90, p < 0.001). Again, the full set of correlations is presented in Table 5.3.

Table 5.3: Correlations (Pearson's) Among Outcome Variables at Pre-testing (below diagonal) and Post-testing (above diagonal).

	1	2	3	4	5	6	7	8	9	10
1. Knowledge	-	.38	.25	-.05	.38	.26	.07	-.30	-.28	-.16
2. Overall Motivation	.18	-	.53	.52	.61[1]	.33	.44	-.15	-.24	.02
3. Help-Seeking	.11	.65[3]	-	.36	-.13	-.05	.05	.06	-.01	.36
4. Control of Beliefs	.06	.64[3]	.29	-	-.24	.64[1]	.61	.38	.44	.28
5. Effort Regulation	.17	.72[3]	.20	.06	-	.05	.03	-.49	-.60	-.38
6. Attitudes	.19	.29	.35	-.28	.40	-	.76[2]	.31	.46	.17
7. Beliefs	-.05	.39[1]	-.17	.53[2]	.32	-.06	-	.02	.20	.10
8. Age	-.37[1]	.25	.01	.10	.31	-.16	.17	-	.90[3]	.08
9. Experience	-.38[1]	.20	-.18	.14	.32	-.33	.29	.90[3]	-	.16
10. Education	.07	.08	-.04	.20	.01	.07	.19	.08	.16	-

Significance levels [1] = *p* at the 0.05 level; [2] = *p* at the 0.01 level; [3] = *p* at the 0.001 level.

5.2.3 Differences in Knowledge, Motivation, Attitudes and Beliefs based on Demographics

Further quantitative analysis was conducted in order to examine any pre-existing differences in knowledge, motivation, beliefs and attitudes towards C&D W management resulting from demographics.[3] Groups were determined based on age, on-site experience, education and position on-site. With respect to age, in order to ensure a similar sample size in each group; and given that the mean age was just over 33 years, the sample was divided into two groups. The two groups were:

(1) Those *34 or above* (N = 15) and

(2) Those *below 34* (N = 19).

[3] Due to a diminished small sample size, such analysis was not possible for post-training data.

A series of independent samples t-tests was conducted in order to examine the effects of age on knowledge, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, overall motivation, beliefs and attitudes towards C&D W management. Results revealed that older participants (i.e. 34 or above) scored significantly higher on motivation towards effort regulation than younger participants (t = -2.34, df = 30.33, p = 0.026, two tailed, d = 0.78). There were no other significant differences based on age. Means and standard deviations are presented in Table 5.4.

Table 5.4: Descriptive Statistics for Age

	N	*M*	*SD*
Knowledge			
Below 34	19	6.05	2.15
34 or Above	15	5.47	2.56
Overall Motivation			
Below 34	19	43.68	7.45
34 or Above	15	46.60	6.27
Control of Beliefs			
Below 34	19	16.16	3.70
34 or Above	15	15.73	3.15
Help-Seeking			
Below 34	19	13.11	3.05
34 or Above	15	13.33	2.16
Effort Regulation			
Below 34	19	14.42	4.79
34 or Above	15	17.53	2.92

Table 5.4: Descriptive Statistics for Age (Cntd.)

	N	*M*	*SD*
Attitudes			
Below 34	19	29.32	12.17
34 or Above	15	24.93	7.46
Beliefs			
Below 34	19	28.74	4.53
34 or Above	15	28.07	4.76

With respect to on-site experience, in order to ensure a similar sample size in each group; and given that the mean for years on-site/experience was approximately 14 years, the sample was divided into two groups (N = 17 for both): *More Experienced* (15 years on-site or more) and *Less Experienced* (i.e. less than 15 years on-site). A series of independent samples t-tests was conducted to examine the effects of experience (i.e. years on-site) on knowledge, overall motivation, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, beliefs and attitudes towards C&D W management. Results revealed no significant differences between more experienced participants and less experienced participants on knowledge, attitudes, beliefs, motivation or any motivation sub-scale. Means and standard deviations are presented in Table 5.5.

Table 5.5: Descriptive Statistics for Experience

	N	*M*	*SD*
Knowledge			
Less Experienced	17	6.29	2.11
More Experienced	17	5.29	2.47
Overall Motivation			
Less Experienced	17	43.24	7.72
More Experienced	17	46.71	5.93
Control of Beliefs			
Less Experienced	17	15.59	3.48
More Experienced	17	16.35	3.43
Help-Seeking			
Less Experienced	17	12.94	3.19
More Experienced	17	13.47	2.07
Effort Regulation			
Less Experienced	17	14.71	4.88
More Experienced	17	16.88	3.46
Attitudes			
Less Experienced	17	30.06	12.57
More Experienced	17	24.71	7.22
Beliefs			
Less Experienced	17	27.88	3.82
More Experienced	17	29.00	5.28

With respect to education, in order to ensure a similar sample size in each group; and given the prevalence of participants who completed at least an apprenticeship, the sample was divided into two groups. The two groups were:

(1) Those who completed an apprenticeship (N = 14) and

(2) Those who *did not* complete an apprenticeship (N = 19).

A series of independent samples t-tests was conducted to examine the effects of education (i.e. apprenticeship completion) on knowledge, overall motivation, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, beliefs and attitudes towards C&D W management. Results revealed no significant differences between those who completed an apprenticeship and those who did not on knowledge, attitudes, beliefs, motivation or any motivation sub-scale. Means and standard deviations are presented in Table 5.6.

Table 5.6: Descriptive Statistics for Education

	N	*M*	*SD*
Knowledge			
Apprenticeship	14	6.43	2.41
No Apprenticeship	19	5.42	2.24
Overall Motivation			
Apprenticeship	14	45.93	6.87
No Apprenticeship	19	44.37	7.39
Control of Beliefs			
Apprenticeship	14	16.86	3.42
No Apprenticeship	19	15.53	3.37
Help-Seeking			
Apprenticeship	14	13.07	2.23
No Apprenticeship	19	13.37	3.04
Effort Regulation			
Apprenticeship	14	16.00	4.30
No Apprenticeship	19	15.47	4.48

Table 5.6: Descriptive Statistics for Education (Cntd.)

	N	*M*	*SD*
Attitudes			
Apprenticeship	14	24.36	7.00
No Apprenticeship	19	28.47	11.43
Beliefs			
Apprenticeship	14	29.36	5.30
No Apprenticeship	19	27.68	4.08

Finally, with respect to position, in order to ensure a similar sample size in each group; and given the percentage of participants who work in certain fields, the sample was divided into five groups. The five groups were as follows:

(1) Labourers (N = 4);

(2) Plumbers (N = 5);

(3) Builders (N = 3);

(4) Electricians (N = 9); and

(5) Others (e.g. fitters, woodworkers, crane operators, plasterers, etc.; N = 12).

A series of ANOVAs was conducted to examine the effects of work position/trade on knowledge, overall motivation, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, beliefs and attitudes towards C&D W management. Results revealed no significant effect of position on

knowledge, attitudes, beliefs, motivation or any motivation sub-scale. Means and standard deviations are presented in Table 5.7.

Table 5.7: Descriptive Statistics for Position/Trade

	N	*M*	*SD*
Knowledge			
Labourer	4	4.25	3.20
Plumber	5	6.20	1.79
Builder	3	5.33	1.53
Electrician	9	7.22	2.44
Other	12	5.33	2.06
Overall Motivation			
Labourer	4	43.50	4.80
Plumber	5	42.40	8.65
Builder	3	44.33	3.06
Electrician	9	50.56	5.05
Other	12	42.67	7.61
Control of Beliefs			
Labourer	4	15.00	2.71
Plumber	5	14.40	4.67
Builder	3	15.67	1.53
Electrician	9	18.11	3.37
Other	12	15.75	3.14
Help-Seeking			
Labourer	4	11.75	1.89
Plumber	5	12.80	3.03
Builder	3	14.00	2.00
Electrician	9	15.11	2.26
Other	12	12.33	2.74
Effort Regulation			
Labourer	4	16.75	2.50
Plumber	5	15.20	4.76
Builder	3	14.67	3.79
Electrician	9	17.33	4.12
Other	12	14.58	5.05

Table 5.7: Descriptive Statistics for Position/Trade (Cntd.)

	N	*M*	*SD*
Attitudes			
Labourer	4	29.75	3.20
Plumber	5	31.60	12.93
Builder	3	18.33	7.51
Electrician	9	26.00	11.12
Other	12	26.33	9.30
Beliefs			
Labourer	4	28.25	4.11
Plumber	5	31.80	4.66
Builder	3	28.33	2.51
Electrician	9	28.89	5.30
Other	12	26.67	4.44

However, a trend was observed in which electricians scored higher, on average (though non-significantly), than participants from other fields on all outcome measures with the exception of positive attitudes. As a result, in order to further investigate this trend, a further series of independent samples t-tests was conducted to examine the effects of work position (i.e. in this context, being an electrician or not being an electrician) on knowledge, overall motivation, motivation towards control of beliefs, motivation towards help-seeking, motivation towards effort regulation, beliefs and attitudes towards C&D W management. Means and standard deviations are presented in Table 5.8. Results from the t-tests revealed that electricians scored significantly higher than non-electricians on knowledge (t = -2.19, df = 31, p = .036, two tailed, d = .83), overall motivation (t = -3.08, df = 31, p = .004, two tailed, d = 1.28), motivation towards help-seeking (t = -2.66, df = 31, p = .012, two tailed, d = 1.07) and motivation towards control of beliefs (t = -2.21, df = 31, p = .035, two tailed, d = .85).

Table 5.8: Descriptive Statistics for Electrician Comparison

	N	*M*	*SD*
Knowledge			
Electrician	9	7.22	2.44
Non-Electrician	24	5.33	2.11
Overall Motivation			
Electrician	9	50.56	5.05
Non-Electrician	24	42.96	6.70
Control of Beliefs			
Electrician	9	18.11	3.37
Non-Electrician	24	15.33	3.16
Help-Seeking			
Electrician	9	15.11	2.26
Non-Electrician	24	12.54	2.54
Effort Regulation			
Electrician	9	17.33	4.12
Non-Electrician	24	15.08	4.34
Attitudes			
Electrician	9	27.00	11.12
Non-Electrician	24	26.00	9.62
Beliefs			
Electrician	9	28.89	5.30
Non-Electrician	24	28.20	4.47

5.3 Qualitative Data Analysis

5.3.1 Observed Behaviour

Behaviour was observed for three days prior to the training intervention (i.e. July 19th, 23rd and 24th) and for two days following the training intervention (i.e. August 12th and 14th). The primary behaviour observed and analysed was the disposal of materials on-site (i.e. what materials were segregated into which skips). Quantities, types and compaction levels of waste within the skips were recorded on skip audit sheets (Appendix E). Other observed behaviours, that may have an effect on waste production, were noted and included in the analysis. The duration of each observation period (i.e. once per day on-site) was approximately one and one–half hours.

Though approximately 80 individual worked on-site each day, only 10 of these workers took part in the training regime (i.e. 12.5%). As a result, it is difficult to attribute observed differences in behaviour (e.g. changes) from pre-to-post-intervention to the 'tool-box-talk' training itself. However, given that: the four labourers on-site were the primary 'care-takers' of waste-management (i.e. according to the Safety, Health & Environmental [SHE] Officer, Ms. Vera Kilgallon); and all four labourers participated in the training intervention, variance in behaviour attributed to the training intervention warrants additional weight.

5.3.1.1 Pre-Intervention Observed Behaviour

Day 1: Mini skips were dispersed throughout the worksite (Photographs 5.1 and 5.2), with one mini skip per floor. The staff was required to place one type of waste in each skip; which, when full, was then lifted by the crane down to the large skip area. However, as there is only one skip per floor, all skips were observed to contain mixed

waste. The researcher was informed that, often, this would then be further segregated at the large skip area by a labourer, if one was available.

Photograph 5.1: Day 1. Mini Skip A

Photograph 5.2: Day 1. Mini Skip B

In addition, one wheelie bin was observed at the entrance to the secondary school, which was signposted as ‘general’ (i.e. mixed) waste. However, it was observed to primarily contain recyclables (i.e. cardboard and plastic) and some metals (Photograph 5.3). It was not made clear as to why a wheelie bin was provided, instead of a mini skip. The wheelie bin was full to the point where waste was stacked beside the bin on the ground.

Also on Day 1 of observation, four large skips were in operation (i.e. Metal waste, mixed waste and two timber skips; see Table 5.9 for Day 1 skip audit). The skips were not identifiable by either colour-coding or by signage. However, the researcher was advised that it was assumed that site personnel would recognise the correct skip based

on its' shape (Photograph 5.4). This is not an ideal practice as new personnel on site may not be aware of the skip's intended purpose/contents, especially when empty.

Photograph 5.3: Day 1. General Waste Wheelie Bin

Photograph 5.4: Day 1. Large skip area - approximately 4% (Metal); 14% (Mixed); and 5% (Timber) non-compliance

Table 5.9: Day 1. Results of skip audit

Skip Type	Average Estimated % of Non-Compliance
Mixed	14
Timber	5
Metal	4

A considerable amount of large materials were stored outdoors at the rear of the site (Photograph 5.5). These were kept out of the way of site traffic and in their original packaging. This form of storage is acceptable; however, such a large quantity of stored materials on site may be subject to damage from site vehicles or possibly vandalism. The BAM site in question does not have a plastic packaging 'take-back scheme' organised with any of their distributers; which, if implemented, would cut down on plastic waste being placed in mixed waste skips when 'recyclables' skips are not available. However, they do collect wooden pallets (Photograph 5.6) which are then taken back by the brick and block suppliers.

Photograph 5.5: Day 1. Storage of large materials

Photograph 5.6: Day 1. Storage of pallets for collection

Waste timbers, which were deemed by site personnel to be reusable, were also stored in piles outdoors (Photographs 5.7 and 5.8). However, these were not stored in a formal, organised manner, which may cause issues when attempting to find the correct length and/or grade of wood required. As a result, it may be easier for a site worker to obtain a new piece of material in order to avoid wasting time searching for the correct piece. Furthermore, no criteria were officially specified on site as to what would constitute reusable wood. Therefore, the types of timber kept for reuse were entirely dictated by each worker's own judgement. In this context, the quantity of timber kept for reuse could vary widely from person to person, depending on their personal attitude (i.e. whether it is positive or negative towards materials' reuse).

With respect to observation of behaviour in the indoor storage areas, lighting was provided; however, the bulbs were broken (Photograph 5.9). Also, breakable materials (e.g. Perspex sheeting) were left in the walkway, on the floor, in front of shelving. This may have lead to breakages due to materials being stood on by site personnel attempting to get closer to the shelving.

Photograph 5.7: Day 1. Storage of reusable timber A

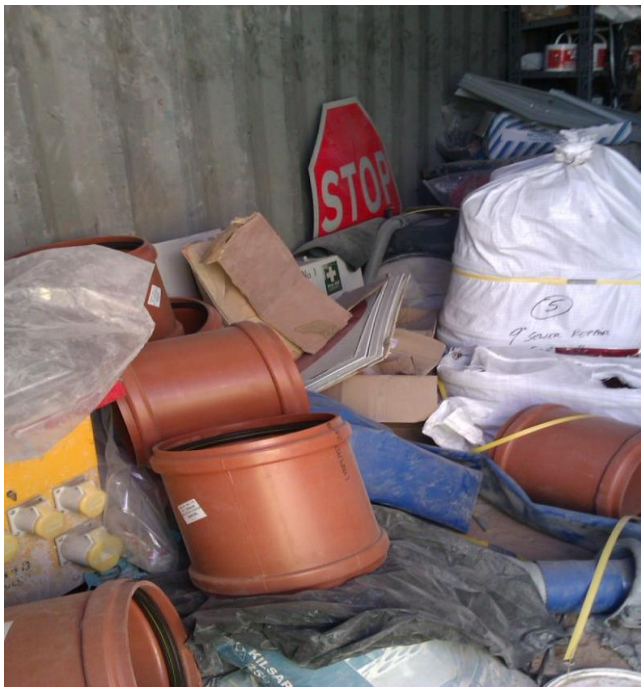
Photograph 5.8: Day 1. Storage of reusable timber B

No organisation system was in place to arrange any of the materials stored on shelves in the storage area (Photograph 5.10). Many boxes of nails, screws, bolts, etc. were left open with their contents strewn across the shelves, which could lead to these materials being lost or just not being used as they would not be easily transported to the work area without their packaging.

Photograph 5.9: Day 1. Indoor storage area,no lighting and materials stored on the ground in the walkway

Photograph 5.10: Day 1. Shelf storage

A large amount of unorganised materials were also stored haphazardly in unordered piles on the floor of the indoor storage area (Photograph 5.11). This may cause the materials to become lost. It may also cause damage to the materials, which would then end up as waste.



Photograph 5.11: Day 1. Indoor storage area, materials stored in unordered piles

In another section of the indoor storage area, many of the storage shelves were broken, which could subsequently collapse and damage materials stored on them or under them (Photograph 5.12). Much of the store room did not have shelving available for storage and thus, materials were stored on the ground in the walkways. Materials were piled precariously, which could eventually fall and break, or cause damage to other materials, such as the paint tins on the ground below them. Paint tins were observed stored on the ground, where they could be easily kicked or damaged by falling materials. This could cause wastage of the paint tins' contents and also, damage to other materials in the store room.

Photograph 5.12: Day 1. Indoor storage area with materials piled in the walkways

Chemicals were stored in a locked, indoor area. However, the shelf in the storage area was broken. As a result, it was susceptible to falling or collapsing and subsequently, causing the chemicals to spill (Photograph 5.13). This could further result in chemical damage to materials stored in close proximity to the storage area. Also, chemical spills may cause unwanted environmental damage.

Photograph 5.13: Day 1. Storage of chemicals

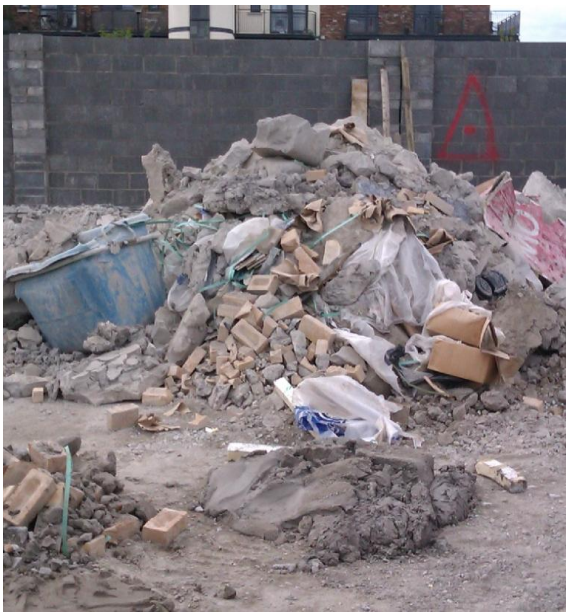
Day 2: Mini skips were observed in situ, at work areas. The skips should have contained segregated materials. However, they were still being used as mixed skips (Photograph 5.14). Table 5.10 presents a skip audit for Day 2.

Photograph 5.14: Day 2. Segregated mini skips used as mixed skips

Table 5.10: Day 2. Results of skip audit

Skip Type	Average Estimated % of Non-Compliance
Mixed	50
Metal	5
Timber (A)	5
Timber (B)	10

A pile of inert waste, containing plastic and cardboard elements, was observed. This pile was to be separated out and then crushed using a mini crusher for reuse elsewhere on site (Photograph 5.15). In addition, non-permanent skip signage was observed - lying against the side of the skips (Photograph 5.16). These could easily fall over and/or not be replaced after skips are emptied/removed from site. Also, colour-coding of the signage would have been preferable as this may provide ease of identification for site personnel who are non-English speaking, or who have difficulty reading.



Photograph 5.15: Day 2. Pile of inert material

Photograph 5.16: Day 2 Poor signage – approximately 50% non- compliance

Furthermore, a metals skip was observed with signage stating ‘steel skip’ lying against it (Photograph 5.17). The skip contained primarily metal, with a small amount of cardboard and plastic. However, the metal contained in the skip was not solely steel, as a large quantity of aluminium was observed (Photograph 5.18). The observer was informed by the SHE officer that the intended use for the skip was containment of ‘mixed metals’ therefore; more appropriate signage would read ‘mixed metals’ if mixed metals were indeed the intended contents.

Photograph 5.17: Day 2. Metal skip signage

Photograph 5.18: Day 2. Metal skip – approximately 5% non-compliance

A full timber skip was observed, which was in the process of being collected by the permitted collector (Photograph 5.19). Furthermore, an unmarked skip was observed which contained both timber and insulation materials. The observer was informed by a member of site personnel that this skip was intended for timber only (Photograph 5.20).

Photograph 5.19: Day 2. Full timber skip (A)– approximately 5% non-compliance

Photograph 5.20: Day 2. Timber skip B containing timber and insulation materials – approximately 10% non-compliance

Glass and windows were stored in the centre of a busy turning area in between the two schools. This may have lead to breakages due to being hit by site traffic. Plastic

packaging was retained on some of the glass materials. However, not all glass materials were protected with plastic packaging, which may have lead to damage from the elements or ‘scrapes-and-scratches’ (Photograph 5.21).

Photograph 5.21: Day 2. Glass and windows storage

In addition, aluminium roofing materials were stored indoors overnight and each day the required amount was brought out. During the day, these were stored on hangers, in grouped lengths (Photograph 5.22). Notably, a similar strategy could have been implemented for the reusable wood.

Photograph 5.22: Day 2. Aluminium roofing materials

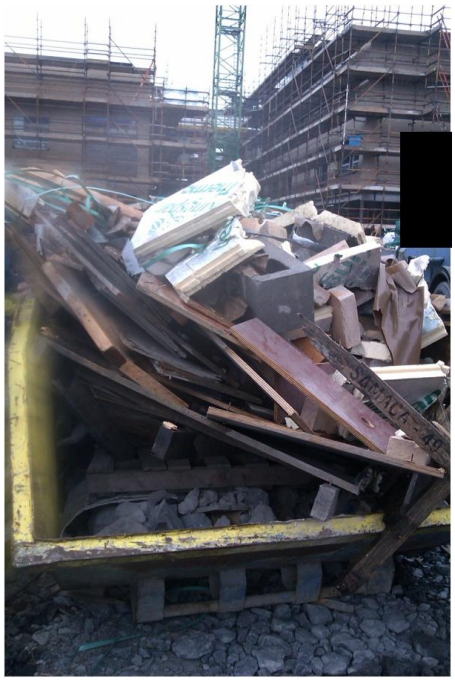
Day 3: A mini skip containing mixed materials (i.e. metal, cardboard and plastic) was observed (Photograph 5.23). The skip's intended purpose was for segregated waste. Similar to Day 2, on Day 3, all of the skip signage was observed lying against one skip (i.e. the timber skip), which could cause confusion as to the contents of the skips (Photograph 5.24). There is some evidence of this confusion in that, a large portion of the timber skips contained incorrect materials. That is, one timber skip was observed containing a large portion of mixed and recyclable waste (i.e. insulation, cardboard, plastic strapping, bricks and concrete blocks; see Photograph 5.25); and another large timber skip was observed containing some metals (Photograph 5.26). Table 5.11 presents a skip audit for Day 3.

Photograph 5.23: Day 3. Mini segregated skip containing non-segregated waste

Photograph 5.24: Day 3. Skip signage

Table 5.11: Day 3. Results of skip audit

Skip Type	Average Estimated % of Non-Compliance
Timber (A)	50
Timber (B)	4
Mixed	4



Photograph 5.25: Day 3. Timber skip A containing mixed waste – approximately 50% non-compliance. Site worker omitted for purposes of privacy.

Photograph 5.26: Day 3. Timber skip B containing some metals – approximately 4% non-compliance

A mixed skip was observed with recyclable materials such as plastic and timber which should have been segregated out (Photograph 5.27). A second mixed skip was in the process of being replaced and as a consequence was empty on Day 3 of the observation (Photograph 5.28). The metals skip was also empty on Day 3.

Photograph 5.27: Day 3. Mixed skip containing recyclable materials - approximately 4% non-compliance

Photograph 5.28: Day 3. Empty mixed skip 2. Site worker omitted for the purposes of privacy.

The indoor storage room was observed again on Day 3. The lighting had not been fixed and materials were still being stored in the walkways, on the ground, blocking easy access to storage shelves (Photograph 5.29). Furthermore, dissimilar materials were still stored in the indoor storage area in stacked piles (Photograph 5.30).

Photograph 5.29: Day 3. Indoor storage area A

Photograph 5.30: Day 3. Indoor storage area B

5.3.1.2 Post-Intervention Observed Behaviour

Day 4: A mini rubble bin was observed containing a small portion of metal and some plastic (Photograph 5.31). Signage on skips was found to be either completely missing or lying on the ground (Photograph 5.32). A skip containing solely plastics was observed on site which previously had not been present (Photograph 5.33). Table 5.12 presents a skip audit for Day 4.

Photograph 5.31: Day 4. Mini rubble bin

Photograph 5.32: Day 4. Skip signage.

Photograph 5.33: Day 4. Recyclables skip

Table 5.12: Day 4. Results of skip audit

Skip Type	Average Estimated % of Non-Compliance
Metal	7
Timber	0
Mixed	10

The metals skip was observed containing a small amount of timber and some plastic (Photograph 5.34). Notably, though there was not a large quantity of non-compliant materials in the skip, it was still an increase in non-compliance based on what had previously been observed (i.e. in pre- intervention observations). In addition, the timber skip had recently been emptied, though nevertheless, the contents (albeit few) were observed to be 100 per cent compliant (Photograph 5.35).

Photograph 5.34: Day 4. Metals skip – approximately 7% non-compliance Site worker omitted for the purposes of privacy.

Photograph 5.35: Day 4. Timber skip – 0% non-compliance

The mixed skip was observed containing plastics and timber which should have been recycled (Photograph 5.36). However, the recyclables skip was observed to be full (Photograph 5.37), which could have accounted for this incidence of non-compliance. Also, as the timber skip had just been emptied, it is possible that the timber was placed in the mixed skip at a time in which the timber skip was full. However, if this was the case for both plastic and timber, then given the protocol on this particular BAM site, perhaps the plastic and timber should have been left in a mini skip, in order to be appropriately segregated at a later time.

Photograph 5.36: Day 4. Mixed skip – approximately 10% non-compliance

The indoor storage area was revisited during the post-intervention observation. The lighting had been fixed and the quantity of materials on the floor was reduced. However, there were still materials on the ground that prevented ease of access to shelving (Photograph 5.37).

As previously observed, the precariously stacked pile of miscellaneous materials had been reduced in height. However, these materials were still stored *on top* of a storage box, as opposed to *in it* or on shelves. The walkway had also been slightly cleared. Paint tins, which had been stored on the ground (where they could be kicked or knocked over and subsequently, cause spillage), had been removed and placed securely on shelving (Photograph 5.38).

Photograph 5.37: Day 4. Indoor storage Area A

Photograph 5.38: Day 4. Indoor storage Area B

Day 5: Four large skips were in operation on Day 5 (i.e. the second day of post-intervention observation); namely, a 'metals skip', two 'mixed waste' skips and a 'recyclables' (i.e. plastics and cardboard) skip. One of the mixed waste skips was originally intended for timber; however, due to lack of signage, one member of site

personnel mistook the timber skip for a mixed waste skip. As a result, there was no timber skip in operation on site (Photograph 5.39). Furthermore, the mixed waste contained both timber and plastics, which could have been recycled. Table 5.13 presents a skip audit for Day 5.

Table 5.13: Day 5. Results of skip audit

Skip Type	Average Estimated % of Non-Compliance
Timber	95
Recyclables	3
Metals	4
Mixed	60

Photograph 5.39: Day 5. Skip intended for timber but containing mixed waste - 95% non-compliance

A recyclables skip was observed containing primarily plastic and cardboard; however, a portion of the skip also contained metals and mixed waste (i.e. insulation and partially empty pots; see Photograph 5.40). The skip was located quite a distance away from the other large skips and there was no signage on the skip to identify its intended use. In addition, the metals skip (Photograph 5.41) was observed containing a small amount of timber, plastic and plastic strapping. The approximate quantity of non-compliant materials in the skip had not changed from the observation two days prior (i.e. on Day 4). The skip signage was also missing.

Photograph 5.40: Day 5. Recyclables skip containing metals and mixed waste - 3% non-compliance

Photograph 5.41: Day 5. Metal skip containing wood, plastic and plastic strapping - 4% non- compliance

The main mixed skip was observed containing a very large quantity of plastic (Photograph 5.42), which would normally have been acceptable; however, due to the presence of a half empty recyclables skip on that day, the plastics would have been

better placed in the recyclables skip. Some metals were observed in the mixed waste skip, which was located directly beside the metals skip. Some timber was also present in the mixed skip; however, there was no timber skip present on that day (again, one member of site personnel had mistaken the timber skip for a mixed waste skip); therefore, there was nowhere else to place the timber.

Photograph 5.42: Day 5. Mixed waste skip - 60% non-compliance

Overall, the level of non-compliance was low across all observation days, in comparison with the researcher's experience on other construction sites. This may potentially be due to influence/encouragement from upper site management, who were anticipating the arrival of the visiting researcher. That is, reduction in waste may have been established in the immediate days prior to site visitation. Nevertheless, the

presence of segregated skips, such as on this particular BAM site, fosters the process of waste segregation and hence, landfill waste reduction.

With respect to waste segregation, the first day of observation was by far the most successful; again, however, possibly due in part to managements' expectation of the observer's arrival on site. However, successful waste management practices declined over the coming observation days. Particularly, Days 2-4 (i.e. the first two days occurring prior to the intervention and the latter occurring post-intervention) had a higher frequency of non-compliance than on Day 1. On Day 5 (i.e. the second and final day of post-intervention observation) the lowest level of compliance with correct C&D W management practices. For example, a lack of skip identification inevitably lead to one site worker mistaking a timber skip for a mixed waste skip (in which a sizeable amount of mixed waste was disposed), which lead to no timber skip being available on that day; and hence, a greater amount of waste going to landfill. Cumulatively, compliance with skipping materials correctly was superior at pre-intervention observation in comparison with post-intervention observation.

However, there is a caveat to this recommendation – that being the restriction of site operatives to manage waste correctly as a result of 'oversights' made by upper management. For example, as in the previous example (i.e. regarding the Day 5 observation), though the presence of skip identification (i.e. the clear display of skip signage adjacent to the corresponding skip) declined over the duration of behavioural observation days (which is likely to have accounted for an increase in non-compliance with correct C&D W management practices), this aspect of site practice is the responsibility of site management and *not* that of site workers. In addition, site procedure states that personnel are required to segregate waste at their workspace,

accomplished by filling a mini skip with one type of waste, waiting for it to be emptied and then filling it with a different type of waste. However, this did not occur in practice, nor was it likely to occur as personnel are also required to clear their workspace as they go, due to health and safety constraints (i.e. stockpiling of waste materials is discouraged as they are possible trip hazards). Thus, it appears that conflicting site objectives were restricting operatives from managing site waste correctly with respect to mini skip segregation.

Furthermore, during observation, a lack of availability of segregated mini skips (i.e. no more than one mini skip was made available at a time on each floor) resulted in all mini skips being utilised as mixed skips. Though mini skips are frequently, further separated by labourers into the main skips, it is not likely that this will occur, particularly if all labourers are occupied elsewhere (as is often the case on this site; please see *Focus Group Results*); and/or if an empty mini skip is required elsewhere on the worksite. Notably, it is the responsibility of upper management to provide adequate skips for site personnel; and thus, the training intervention would have no effect on this aspect of behaviour, given that: (1) this is not an outcome attributed to site operatives (i.e. it is not the responsibility of site operatives to organise skip logistics) and (2) upper management did not take part in the training intervention.

Across the five days of site visitation, storage areas were observed, as improper storage of materials can lead to waste creation. On observation days prior to the training intervention, the storage areas were observed to contain many incidences of incorrect storage practices (e.g. see Day 1 above). However, during post-intervention behavioural observation, the storage areas exhibited a marked improvement. This change was fully attributed to a member of site personnel (i.e. operatives were not instructed to do this) -

showing personal initiative by means of tidying the store area and replacing broken lighting. This behaviour is consistent with the quantitative results above, specifically those which indicate enhanced knowledge, positive beliefs and positive attitudes towards waste management – which is reasonable to suggest, given that correct storage of materials was included in the training materials (i.e. Video 2 - *Avoiding and Reducing Construction Waste: Part 1*).

There was also a noticeable improvement on the compliance of the contents of the mixed waste skip during post-intervention observation. Though this may have been due to the training received by site operatives, it may also have resulted from the presence of a recyclables skip on Day 4. The presence of the extra recyclables skip clearly aided mixed waste reduction.

In conclusion, the results of the behavioural observation indicate that many incidences of non-compliance could be greatly reduced through the provision of segregated mini skips on the worksite and through an improvement in main skip identification. In both cases, upper management, rather than site personnel, would be responsible for the incorrect practices of waste management, as a result of not having procedures implemented that facilitate correct waste management practices. Thus, the results of the behavioural observation analysis suggests that, when excluding incidences of poor waste management practice attributable to upper management, site operatives exhibited a marked improvement in behaviour towards waste management.

5.3.2 Focus Group

After completion of the waste management training intervention, a semi-structured focus group interview was conducted with five participants, in order to investigate their perceptions of the training course, with specific focus on the presentation and quality of the training sessions, as well as the participants' experience in the training sessions and the likelihood that the training will facilitate appropriate waste management in the future. The interview transcripts were examined using thematic analysis. Overall, there were five themes identified:

(1) The quality of the waste management training;
(2) The perceived futileness of waste management training;
(3) Perceived restrictions to waste management;
(4) The possibility of waste reduction; and
(5) The varying perceptions of those who 'clean' on-site.

With respect to the first theme, focus group participants responded favourably to the training course and the quality of the training materials, referring to them as "good" (participant EM) and "informative" (participant IM). According to EM, "[the training] makes you think about [waste management], definitely." IM continued:

"*the visuals where good enough, when you're watching it was easy to understand, you know, it was practical and easy to understand*".

(Participant IM)

IM also agreed that he learned something from the training session. However, participants noted that though the training sessions were of good quality and could be helpful, what the training presented might not necessarily be practical. For example, IM stated "Some of it would [help sorting waste on-site]…some of it would be practical and some of would be impractical, like." EM agreed and followed-up:

"Yes, some of it, yes, in an ideal world you would be able to do all that but, going on, if you're working for a sub-contractor and a lot of it is 'get stuff done' and you can't."

(Participant EM)

EM has indicated that in an ideal world, waste management would be conducted correctly; however, if one's boss wants that individual to complete the task they've been asked to do, as opposed to taking care when managing waste, then one will do what the boss has instructed them. EM continued that the training was not:

"necessarily [stating the obvious] – because, there were certain bits that you could look at… if you could, you would do more. [The training] makes you think about [managing waste properly], but only for what we are doing now - it's just that we are able to use some things".

(Participant EM)

EM has further indicated that waste management is possible on-site, but that there are many restrictions to it; and as a result, training was perceived as somewhat futile.
The perceived futility of waste management training was the second theme identified in this analysis and was a sentiment supported by all participants who stated:

"I don't think further training would be helpful".

(Participant QM)

"*[training is] not going to make an impact*".

(Participant EM)

IM indicated that the problem with training is that it must be implemented properly and must be consistent with the instructions that they are given on-site.

"I did [find the training informative], but it all has to be done by a process. You know, everything has to be done step by step, if you want to [do it right]. You see, it has to be implemented, there's no point training everyone and then saying just use that skip there."

(Participant IM)

This statement suggests that one major restriction to proper management of waste is that of being given orders from those in higher authority which contradict correct waste management procedures. Notably, following on from the previous quote, participants often alluded to the availability of only one skip at a time throughout the focus group interview, for example:

"*Everything in the one skip*!"

(Participant FM)

Moreover, when asked if people would begin to manage waste properly if everyone was to be provided waste management training, IM responded:

"*some people would but some people won't bother*".

(Participant IM)

Another participant added the following:

"[perhaps it's about] *work ethic*".

(Participant QM)

The third theme identified in the focus group interview was the perception of restrictions to waste management; that is, many protocols associated with waste management were deemed impractical. For example:

"*Let's say right now, the fellow I work for now, we have stacks and stacks of timber and for him to bring that all up to Donegal again and I don't even know if he has a job to go. He's going to have to pay for somewhere to store that and he's going to think, 'is that going to pay for me to bring all that stuff up to Donegal?'*"

(Participant EM)

When asked if all that timber will be dumped, the participant responded:

"Well, a lot of it will, Id' say."

(Participant EM)

The same participant supported his statement by providing the following information:

"…to drive down from Donegal, get a truck to drive down from Donegal then you take a day of wages and then you drive back up again and and then it sits there and its not been used and it goes rotten anyways; and sure, it's no good to anyone then and then it eventually gets dumped again then."

(Participant EM)

Again, the impracticality of managing materials correctly, indicates the participants' perception of waste management training's futility. IM asks EM

"Well is it financially viable to transport it?"

(Participant IM)

The perceived impractical nature of waste management is again noted by one participant:

"In an ideal world you would be able to do all that. I mean… but, going on… if you're working for a sub-contractor and a lot of it is 'get stuff done' and you know, you can't.

(Participant EM)

Another restriction identified was the feasibility of 'cleaning'. According to IM:

"If you are, like, put in to clean a room, you can't be jumping in three, two skips, like. And then the foreman goes, like, 'empty this skip out of timber".

(Participant IM)

EM supported the statement made by participant IM with the following:

"Well that's it like, I mean basically you are told to clear an area and we come back and it's like well where is it, do you know, and like you have your job to get a room cleared like do you know, so am, there isn't enough area to be going…"...

(Participant EM)

IM interjected, in reference to his own work space:

"There isn't enough area to segregate [in] an area".

(Participant IM)

This dialogue indicates that the limited amount of space available at work areas restricts appropriate waste management, in that there is not enough room available to properly segregate materials and ensure that they're 'skipped' properly. The participants indicated that, often, there is only enough room to drop one skip into the work area with the crane, which is then used for all materials. When asked if someone comes in and then separates the materials out of the skip, a participant responded:

"No, I'd say it goes out to the landfill and then they separate it".

(Participant QM)

Not only does this statement indicate that no further effort is made to segregate materials after they have been skipped; it also indicates that there is a lack of both knowledge and care regarding what happens to the skipped waste.

One participant summarised the restrictions to waste management by stating:

"It's space, time and organisation"

(Participant IM)

This statement indicates that there is not enough of the three to make waste management feasible. This is consistent with one participant's assertion:

"I mean, if you could … if you had more time, you would be able to … hopefully, you could do a bit more."

(Participant EM)

Though this statement indicates that time is a restriction, it also indicates what can be construed as an implicit desire to actually manage waste properly. This possibility is to some extent consistent with the fourth theme identified in the focus group interview (i.e. the possibility of waste reduction).

Though the focus group participants stated that they did not think that waste could ever be eliminated completely from the construction process; according to IM:

"It could be reduced an awful lot."

(Participant IM)

It is at this point in the interview that EM tells the anecdote about the man he works for and his drive to Donegal – equating the impractical nature of waste management with a missed opportunity to reduce waste. The participants reiterated that waste reduction on-site is possible, but is often impractical. Notably, when participants were asked about how waste could be reduced, they joked about the possibility of individual, personalised fines. Joking aside, this was an interesting solution as all participants acknowledged this suggestion, indicating that perhaps some form of negative reinforcement may facilitate a reduction in waste.

The fifth and final theme identified in the focus group interview was the perception of those who 'clean' on-site. Though EM has expressed favour upon managing waste correctly in his statements throughout, IM presents a negative perspective on those who 'clean'. For example:

"Let's say you're a chippy and you're chipping that wall there and a man sees you going around cleaning the whole time, he's going to say, 'Sure, what's that fellow at? Sure, that fellow is a waste of time, get rid of him'. Sure, if he sees you going around stacking timber, you would go missing like, wouldn't you? Let's say you came in and you were really environmentally conscious and you were working for a sub-contractor and you were going around the whole time cleaning and that - you would be back on the dole."

(Participant IM)

IM has expressed a negative outlook on those who 'clean' and indicates that it is the individual's job to complete the task they were hired to do, rather than 'clean'.

However, IM fails to recognise that is the responsibility of all on-site personnel to 'clean' up after themselves. This notion is consistent with EM and FM who mention that when "down tools" is called, everyone should contribute to 'cleaning'. IM further rationalised his perspective when he stated

"Years ago, when there was rakes of lads, people on the sites, there was probably more work, you would have labourers cleaning up there the whole time. Nowadays, you don't have that, there are no free labourers on the site now… Everyone is here probably doing what they're doing, twice the work they were doing years ago. Years ago, you would have labourers on every floor of the building, and now, there are no labourers"

(Participant IM)

This allusion to how things were 'years ago' indicates that IM feels that waste management is not his responsibility; but rather, that of labourers. He further indicates that perhaps, the waste management process would work better if people were hired for that task specifically, but is dismissive towards it as he has indicated that no one will pay for it (i.e. alluded to in his comment above about "years ago"). He stated:

"If you walk into a room... if someone dropped a skip into that room, to clean that room, there is timber and ply wood. You put it all in that skip and then bring the whole lot down and tip it into the big skip and that's it done - the job is done. But, if you were to go segregating it, you would have to have two lads there the whole time just going around cleaning!"

(Participant IM)

IM further indicates that waste management is a full-time job in its own right and that it is not his responsibility, but that of some other 'lads'.

Again, though EM has expressed favour upon managing waste correctly in his statements throughout, he initially answered the question of whether he takes waste management as his personal responsibility with the following statement:

"No, not really, no."

(Participant EM)

When asked who they felt was responsible for waste management on-site, participants named multiple people, including labourers, the safety officer and those who are:

"environmentally conscious".

(Participant IM)

These responses indicate a lack of willingness on the part of the participants to take personal responsibility for their own waste management behaviours.

Overall, the focus group interview yielded five major themes:

(1) The quality of the waste management training;
(2) The perceived futileness of waste management training;
(3) Perceived restrictions to waste management;
(4) The possibility of waste reduction; and

(5) The varying perceptions of those who 'clean' on-site.

Results revealed that though the participants thought the training provided to them in the current study was "good", "easy to understand" and "informative", they did not think it would be helpful, because it would be too difficult to implement, given that what the training presents as appropriate waste management protocol is contradictory to the site practices they indicate are imposed on them. Furthermore, the participants question the financial viability of managing waste correctly and deem it impractical. They further suggest that they are restricted from managing waste correctly (in the event that they wished to do so), by space, time and organisation. Finally, results indicate that though participants feel that waste can be reduced on-site, they fail to see waste management as their own personal responsibility. To conclude the qualitative analysis of the focus group interview is an appropriate statement:

"It probably isn't right – all the waste. But, unless there is an overall reform of how it is, we can't change it really."

(Participant IM)

5.4 Conclusion

The current chapter presented the results from the quantitative, qualitative and observational data analyses. The interpretation and discussion of these results will follow in the next and final chapter.

CHAPTER 6

DISCUSSION

6.1 Introduction

This chapter presents a general discussion of the research conducted in this thesis, with a specific focus on interpreting the findings related to the effects of C&D W management training on waste management knowledge, motivation toward waste management, beliefs about waste management, attitudes towards waste management and observed waste management behaviour. This will be followed by a discussion of the limitations of the current study and potential, future research that may be conducted in order to further examine the effects of waste management training on waste management knowledge, motivations, attitudes, beliefs and behaviours. Next, broader implications for the use of waste management will be discussed, followed by a general summary and conclusion

6.2 Interpretation of Results

The overall aim of the current programme of research was to evaluate the use of waste management training on waste management knowledge, motivations, attitudes, beliefs and behaviours. The overall findings indicate that waste management training (i.e. tool-box-talks focused on presenting information about waste management and teaching waste management procedures) is an efficacious method of enhancing waste management knowledge and behaviour. However, findings suggest that there was no effect of waste management training on motivation, beliefs or attitudes towards waste management.

Specifically, the aim of the current research was to test six hypotheses.

With respect to the first hypothesis, results revealed a significant time x condition interaction effect, in which that those who took part in the waste management training intervention significantly outperformed those in the control group from pre-to-post-testing on waste management knowledge. The results indicate, simply, that the training intervention was successful in enhancing waste management knowledge. This finding is consistent with research by Begum at el. (2009), which also found beneficial effects of that construction-related education. This finding is also consistent with past research on training (in general) and the development of expertise (e.g. Chi, Glaser & Rees, 1982; Marzano; 1998; Pollack, Chandler & Sweller, 2002). Specifically, research suggests that training in a specific domain facilitates the schema-construction (i.e. the building of knowledge) for that domain, yielding domain-specific knowledge, or expertise (Pollock, Chandler & Sweller, 2002). Thus, the results from the current research indicate that the waste management training facilitated operatives' schemas-construction for C&D W management facts and procedures – represented as waste management knowledge.

Notably, results were somewhat counter to the hypothesis based on Ajzen's (1993; 2001) *Theory of Planned Behaviour* - that an increase in knowledge would yield increases in positive beliefs and attitudes. That is, there was no significant effect of training on beliefs, attitudes or motivation from pre-to-post-testing. However, there was an effect of time on both beliefs and attitudes towards waste management, in which positive beliefs and attitudes about waste management increased over-time (i.e. accounted for by *both* the control and training groups). This is an interesting finding, given that, though it was hypothesised that the training group would exhibit enhanced

positive beliefs and attitudes towards waste management from pre-to-post-intervention testing, the control group was not provided any treatment that would warrant an increase in positive beliefs and attitudes. It is possible that, following the initial testing session (i.e. the first meeting between site operatives and the researcher), site operatives were prepped or encouraged, in some manner, by the SHE Officer to exhibit a more positive disposition towards managing waste correctly (i.e. for purposes of maintaining a positive perception of BAM construction on the part of the researcher). Subsequently, such a positive disposition may have been reflected in the manner in which operatives responded to the post-test beliefs and attitudes scales.

On the other hand, the increase in positive beliefs and attitudes may have possibly been the result of the Hawthorne effect (i.e. observer effect), in which participants (i.e. in both groups or perhaps in the control group only) modify their performance (in this context, attitudes and beliefs), simply as a result of knowing that they are being examined and not as a result of any other experimental manipulation (e.g. being provided or not being provided a training intervention). This modification of performance could have been implicit or intentional. It is worth noting that, if this finding is a result of an observer effect and if it was localised to the control group only, then this would provide some support to suggest that those in the training group may have potentially exhibited enhanced positive beliefs and attitudes towards waste management as a result of the training. Unfortunately, however, there are many ‘if’s in this speculation, which is also not readily testable.

Another possible explanation for the enhanced positive beliefs and attitudes of the control group is that of a potential John Henry effect[4]. However, this would require that controls were aware that some of their peers had received training, which is possible given that participants all worked together on the same site and have numerous opportunities each day to socialise and speak with one another.

With respect to waste management behaviour, the results of the behavioural observation analysis indicated that, when excluding incidences of poor waste management practice that are attributed to upper management (i.e. a behavioural anomaly also identified in research by Teo et al., 2000; Teo & Loosemore, 2001), site operatives exhibited a marked improvement in behaviour towards waste management over the duration of the intervention. This finding suggests that the training provided, and perhaps the knowledge gained) accounted for at least some variance in behaviour; and thus, in addition to successfully enhancing waste management knowledge over time, there is some evidence to support the indication that waste management training also positively influences waste management behaviour. However, it is also possible that behaviour improved from pre-to-post-intervention as a result of increases in positive beliefs and attitudes towards waste management over the same duration. Notably, both of these interpretations are consistent with Ajzen's (1985; 1993; 2001) Theory of Planned Behaviour. Nevertheless, given the significant interaction effect of time x condition on knowledge, it seems likely that training accounted for at least some positive variance in behaviour.

[4] The John Henry effect is a condition in which controls perform better (i.e. in this context score higher) as a result of recognising that they're in a control group, or to a lesser extent, recognise that they're performance is being compared with something else; and subsequently, trying harder in order to overcome the disadvantage of being in a control group.

These recommendations (i.e. with reference to improved behaviour from pre-to-post-intervention) are made with the caveat that certain behaviours associated with poor waste management practice are excused as a result of responsibility. That is, the results of the behavioural observation also indicated that many incidences of non-compliance could be greatly reduced through the provision of segregated mini skips on the worksite and through an improvement in main skip identification; in which cases, upper management, rather than site personnel, would be responsible for the incorrect practices of waste management. To clarify, through the onsite observation, upper management were identified as responsible for many of the incorrect waste management practices, as a result of not having procedures implemented that facilitate correct waste management practices. This indication is further consistent with findings from the focus group interview. For example, the group indicate that in order for waste management training to make a difference to waste management behaviours, it must be implemented properly and must be consistent with the instructions that they are given on-site:

"It all has to be done by a process. Everything has to be done step by step, if you want to [do it right]. It [proper C&D W management] has to be implemented, there's no point training everyone and then saying just use that skip there."

(Participant IM)

Also consistent with onsite observation regarding the use of a limited amount of mini skips, was the frequent repetition of the following statement:

"*Everything in the one skip*!"

(Participant FM)

This is further elaborated upon as IM indicated, in reference to available space at his own work area:

"*There isn't enough area to segregate [in] an area*"

(Participant IM)

Furthermore, the group implied that often, there is only enough room to fit one skip at their work space, which is then used for all materials. Such restrictions to correct waste management practices were identified by both the behavioural observation and focus group participants. Matters pertaining to the availability of skips are also not attributable to site operatives, given that such logistics are not their responsibility. Thus, it is both fair and reasonable to suggest that certain poor waste management practices observed should not count against the site operatives' behaviour. Thus, taking this into account, site operatives exhibited an improvement in behaviour towards waste management over the duration of the intervention. Again, this finding is consistent with research by Teo and Loosemore (2001) who found that that, operatives' ability to implement good waste management practices were often hindered by management, through a lack of dedication to the problem of waste reduction. This is also consistent with research by Lingard and Rowlinson (1997) who found that, operatives' perception of managerial commitment produced improvements in operatives' behaviour.

With respect to the second hypothesis, results revealed that at pre-testing, overall motivation was significantly correlated with all motivation sub-scales, which comes as no surprise, statistically, given that a third of the motivation scale consisted of each of the three sub-scales (i.e. the overall scale comprised the three sub-scales). Overall

motivation was also significantly, positively correlated with positive beliefs about waste management, as was motivation towards control of beliefs. As hypothesised, these results indicate that the more motivated a site operative is to manage waste correctly, the more likely they are to hold positive beliefs about waste management and vice versa. Interestingly, the correlation between positive beliefs about waste management and motivation to control beliefs indicates that the more positive a site operative's beliefs are about waste management, the stronger their beliefs that their efforts to manage waste will result in positive outcomes.

At post-testing, only motivation towards effort regulation was significantly (positively) with overall motivation. This may have been a result of motivation generally increasing over time for the control group and decreasing over time for the training group, albeit non-significantly. However, it is worth noting that these null-effects of correlation may have been the result of a statistical anomaly, given the small sample size at post-testing. That is, there may not have been enough power to yield significance between overall motivation and the remaining two sub-scales, as a result of the attrition from pre-testing. However, consistent with the hypotheses outlined in this research, there was a significant, positive correlation between beliefs about waste management and attitudes towards waste management. Interestingly, whereas motivation to control beliefs was not correlated with positive beliefs towards waste management, as it was at pre-testing, it was significantly correlated with positive attitudes towards waste management at post-testing, indicating that that the more positive a site operative's attitudes are, or the more positive they feel about waste management, the stronger their beliefs that their efforts to manage waste will result in positive outcomes. This notion is consistent with the significant correlation observed above between beliefs and attitudes.

With respect to the third hypothesis, though there was no significant difference between older and younger participants on pre-existing knowledge towards waste management, results revealed that age was significantly, negatively correlated with pre-existing knowledge. This result suggests, contrary to hypotheses above, the older the site operative, the less they know about managing waste on-site correctly. Results also revealed that older participants (i.e. 34 or above) scored significantly higher on motivation towards effort regulation than younger participants, indicating that perhaps older operative are more conscious of conserving their energy for 'getting the job done', as opposed to simultaneously managing waste correctly (see the focus group results), than are younger operatives. Unsurprisingly, age was also significantly, positively, correlated with years on-site/experience, indicating the more years one has worked on-site, the older they are. With respect to years on-site and the fourth hypothesis, there was no effect of experience on knowledge, motivation, beliefs or attitudes towards waste management. However, like age, experience was negatively correlated with knowledge, consistent with the rationale presented above, with regards to age. This may also reflect the possibility for changing protocols in waste management 'over the years' to confuse or confound what experienced site operatives thought they already knew. Notably, this correlational finding is also consistent with research by Begum et al. (2009), which found that lower levels of experience increased consciousness of waste management practices.

Findings from the current study did not support the fifth hypothesis, nor were they consistent with research by Begum et al. (2009), as results revealed that there was no effect of education (i.e. those who completed an apprenticeship vs. those who did not complete an apprenticeship) on pre-existing waste management knowledge, motivation,

beliefs or attitudes. With respect to the sixth and final hypothesis, though there was no significant effect of position held/trade on pre-existing waste management knowledge, motivation, beliefs or attitudes, a trend was observed in which electricians scored higher, on average, than operatives from other fields on all outcome measures with the exception of positive attitudes; and thus, further analysis was conducted and revealed that electricians scored significantly higher than non-electricians on waste management knowledge, overall motivation and two motivation sub-scales (i.e. help-seeking and control of beliefs). Though one of the first possible explanations for these findings would generally be linked with level of education and/or having completed an apprenticeship, such speculation would be inaccurate, given the null effects of education presented above. However, given that the electricians on-site are held personally accountable for their own waste management (i.e. it is their responsibility to remove their own waste from site and have it disposed), then it seems reasonable to suggest that it would have been in their own interest to educate themselves (i.e. prior to the intervention) on waste management procedures, as mismanagement of waste could potentially result in personal fines. Accordingly, the desire to avoid fines for the mismanagement of waste would also account for their significantly higher motivation to manage waste correctly. The suggestion of financial incentives, or in this context, the avoidance of financial punishment, is also consistent with the findings that though effects were observed for knowledge and motivation, there were no effects of trade (i.e. being an electrician vs. non-electricians) on attitudes or beliefs. That is, if electricians' avoidance of financial punishment is the driving force for behaviour, then it doesn't matter how they feel about managing waste management or even what they believe about managing waste, but rather, what they know about doing it correctly (i.e. to avoid losing money) and whether or not they are motivated to do so.

Results from the focus group indicated that participants thought the training intervention was “good”, “easy to understand” and “informative”, which are largely consistent with the quantitative findings that the training intervention significantly enhanced waste management knowledge. Nevertheless, results from the focus group also indicated that participants thought that, regardless of the quality of the training, it would not be helpful, due to the many restrictions (e.g. “space, time and organisation” [IM]), placed on them by higher management, they feel would impede the implementation of the procedures taught within the training. This finding is consistent with research by Kulatunga et al (2006), which found a lack of available time was a main impediment to implementation of good waste management practices. This finding is further consistent with research by Teo et al. (2000) and Teo and Loosemore (2001), which found that operatives’ ability to manage waste was: obstructed by a deficiency in higher management, through lack of commitment to plan waste reduction (Teo et al., 2000); and hindered by a lack of dedication from management (Teo & Loosemore, 2001).

Finally, results indicated that though participants feel that waste can be reduced on-site, they fail to see waste management as their own personal responsibility. This finding may possibly reflect the trade of the focus group participants. That is, no labourers participated in the focus group. This is notable because on the BAM site examined, according to the on-site SHE Officer, labourers are the primary ‘care-takers’ of waste-management. Thus, if the focus group participants view labourers as the ‘care-takers’ of waste management (as participant IM explicitly states on multiple occasions), then it comes as reasonably unsurprising that non-labourers would view waste management as not being their own personal responsibility. Notably, an electrician (participant EM) provided an exception in the sample of focus group participants. Participant EM did not

strongly oppose personal responsibility of waste management – an individual, who unlike other focus group participants, would be directly responsible for his own waste management. For example, according to EM, when "down tools" is called, everyone should contribute to 'cleaning'.

Overall, a number of interesting findings were observed in the current study. The main findings from the current research indicated that though that the tool-box-talk training had no effect on motivation, beliefs or attitudes towards waste management, the 'tool-box-talk' training significantly enhanced knowledge towards waste management. Results also revealed a positive variance in behaviour towards waste management from pre-to-post-intervention assessment, perhaps to some extent, as a result of the tool-box-talk-training. Finally qualitative data analysis from the focus group interview yielded five major themes:

(1) The quality of the waste management training;
(2) The perceived futileness of waste management training;
(3) The perceived restrictions to waste management;
(4) The possibility of waste reduction; and
(5) The varying perceptions of those who 'clean' on-site.

Furthermore, though participants feel that waste can be reduced on-site, a majority fail to see waste management as their own personal responsibility.

6.3 Limitations & Future Research

Though the current research produced a number of interesting findings, there were two limitations that warrant consideration. One limitation was the small sample size, which may have decreased the power of the statistical analysis; thus, making it more difficult to identify significant effects when comparing groups on motivation, beliefs and attitudes, particularly at post-testing (i.e. as a result of a further decrease in sample size due to attrition). For example, from a pool of approximately 80 potential participants, only 34 completed pre-testing and subsequently, only 19 completed post-testing, yielding an attrition rate of 44 per cent from pre-to-post-testing. The attrition may have resulted from the occurrence of a fault with the crane on the day of post-testing, in which many operatives were forced to skip lunch and aid in fixing the difficulties associated with the crane, as according to the SHE officer, 'all hands were on deck'. Attrition may also have occurred as a result of some participants, who completed pre-testing, no longer being on-site at the time of post-testing. Another possible reason for the small sample size was that recruitment for voluntary participation took place during site operatives' lunch/break-time and thus, operatives may have been reluctant to participate as this would impinge on their breaks.

In order to overcome problems of attrition, future research might aim to implement and evaluate tool-box-talk training in the context of a mandatory course, as opposed to a voluntary course (as employed in the current study). By making such a training intervention mandatory (on the part of site management), attrition would have been significantly reduced and perhaps, as a result of increasing the statistical power associated with a larger sample size, there may have been a better chance of detecting a

significant effect of training on motivation, beliefs and/or attitudes towards waste management.

Another limitation of the current study was the manner in which observed behaviour was assessed. Observed behaviour by the researcher was deemed the most accurate method of assessing behaviour as it would allow for the researcher to quantify specific behaviours, such as correct/incorrect waste disposal practices. Though other methods of assessing behaviour exist, particularly self-report measures (such as those used in research by Teo & Loosemore, 2001), many are limited in that they are taking the word of the test-taker that they do indeed behave in a certain manner, in specific contexts. Thus, it is a more accurate and valid method of assessing behaviour to observe and quantify behaviours as they occur.

However, given that approximately 80 individual worked on-site each day, only 10 of these workers took part in the training regime (i.e. 12.5%). As a result, it is difficult to attribute observed differences in behaviour (e.g. changes) from before the training and after the training to the training intervention itself. However, given that: the four labourers on-site were the primary 'care-takers' of waste-management (i.e. according to the on-site SHE Officer, Ms. Vera Kilgallon); and all four labourers participated in the training intervention, variance in behaviour attributed to the training intervention warrants additional weight. Despite warranting additional weight, however, results and subsequent recommendations pertaining to the training intervention's effect on observed behaviour must be interpreted with caution.

In addition, though it was originally planned that the researcher would both qualitatively record *and* quantify behaviours, such as counting the amount of times materials were

correctly/incorrectly skipped and counting the occurrences of violations against good waste management practices (e.g. incorrectly storing materials, incorrectly disposing of materials outside of skips, creating surplus waste, etc.), this proved infeasible due to both time restrictions and the fact that such data collection was to be collected by one person. With respect to time, the amount of observation was limited, as the researcher was restricted to site visitation and likewise, site observation, based on the availability of the SHE Officer, who was to escort the researcher at all times on-site. This allowed for only five days of observation. Approximately one and one-half hours were granted to the researcher to observe behaviour on each of the five days. Due to these time restrictions, it became difficult to observe the entirety of the site for any extended duration. This ability was further impeded by the fact that there was only one observer. For example, on Day 5, at the time the researcher was observing the main skips, it would be unknown if operatives were inappropriately skipping incorrect materials in the mini skips elsewhere on the work site. Moreover, the ability to witness the skipping of material, as it happened, was a rare occurrence.

Given the restrictions above, the methodology for quantitative analysis of behaviour was amended and the new criteria for behavioural measurement – product recording (i.e. the measurement of behaviour through the quantification of a tangible outcome; Marholin & Steinman, 1977) of incorrectly skipped materials became the sole measure of observed behaviour. The researcher both photographed the skips on-site and recorded their estimation of the quantity of waste in skips on skip observation sheets (Appendix E) as part of the qualitative data collection. Therefore, these materials were also used in the quantitative analysis of the contents of the skips. Notably, however, it was only feasible, time-wise, to photograph each skip on one occasion each day (i.e. when doing

the ‘rounds’ with the SHE officer). To reiterate, the researcher analysed the materials visible in each skip (i.e. both in person and again within the photographs) and assessed the approximate percentage of materials incorrectly disposed of in each skip. The primary researcher employed a secondary adjudicator to also analyse the materials within the photographs, in order to avoid researcher bias. Though the secondary adjudicator was also blind to what day the photo was taken, in order to eliminate any bias towards the potential success or failure of the training intervention, it remains that these approximate percentages of materials incorrectly disposed are arbitrary at best, as it was not possible to decipher the contents of the skip below the surface area. Thus, to ensure the integrity of the research conducted, quantitative analysis of observed behaviour was omitted and presentation of the percentages of non-compliance was confined to data tables and photograph descriptions of each skip in the preceding chapter.

As a result, despite having completed a full skip audit for the skips used on each of the observation days, formal analysis of behaviour was limited to qualitative analysis, only. Given that this analysis was originally designed to be, in large part, objective; and was conducted by the researcher alone (who tried their best to analyse the data 100% objectively), there remains the potential for subjectivity in the observations. As a result, though the qualitative analysis was intended as only one aspect of behavioural evaluation, the results are consistent with findings from the focus group data analysis; thus, results and subsequent recommendations pertaining to observed behaviour are worth considering, but must be interpreted with caution.

In order to overcome problems of measuring observed behaviour, future research might aim to employ a research team in order to simultaneously observe different aspects of

waste management behaviour in different site locations. This would maximise the amount of time a section of the site is observed. For example, two researchers might observe the main skips at one end of the site for one and one-half hours (i.e. the approximate amount of time granted to the researcher for observation by the SHE officer in the current study), while at the same time, two different researchers might observe the mini skips on the work site for one and one-half hours, as opposed to having one researcher try and observe all facets of site behaviour within the allotted one and one-half hours. Employing a research team would also decrease the potential for subjectivity in the reporting of behavioural observations. Again, for example, having two observers at each skip would allow for a cross-referenced rating of each observed behaviour. In addition, future research might also aim to video-record the main skips on site from the opening to the closing of each working day, in order to provide researchers with the ability to quantify each and every item of material that is skipped, thus providing a more reliable method of quantifying non-compliance than simply approximating the percentage of non-compliant disposal. One final recommendation, along similar lines, is that future research should aim to develop a method of quantifying potential effects (i.e. both positive and negative) of site management's influence on waste management procedures, for purposes of controlling for such a variable in future data analysis (e.g. the intervention of management on site operatives' behaviour prior to the arrival of the researcher in order to establish positive waste management practices 'just in time' and established logistics and practices that are contradictory to correct waste management practices, for example, having one mini skip available per floor and providing inappropriate signage). This notion is important to consider and investigate in future research given not only the findings in the current

research, but also in research by Teo et al., (2000) and Teo and Loosemore (2001), regarding higher management's potential impact on operatives' ability to manage waste.

6.4 Summary and Conclusion

In conclusion, results from the current research programme revealed that the 'tool-box-talk' training intervention significantly enhanced knowledge towards waste management. Results also revealed a positive variance in behaviour towards waste management from pre-to-post- intervention assessment. In addition, results revealed that there was no effect of the tool-box-talk training intervention on motivation, beliefs or attitudes towards waste management. However, there was an effect of time on both positive beliefs and attitudes towards waste management. Furthermore, there was no effect of age, years on-site/experience or education on waste management knowledge, overall motivation, beliefs or attitudes. However, there was an effect of position/trade on waste management knowledge, in which electricians scored significantly higher than non-electricians on waste management knowledge, overall motivation and two motivation sub-scales (i.e. help-seeking and control of beliefs).

Moreover, results revealed that overall motivation was significantly correlated with all motivation sub-scales at pre-testing, but only with motivation towards effort regulation at post-testing. Overall motivation was also positively correlated with positive beliefs about waste management at pre-testing, as was motivation towards control of beliefs. At post-testing, beliefs about waste management were correlated with attitudes towards waste management, as was motivation to control beliefs. Though age and years on-site/experience were both positively correlated with each other, they were both negatively correlated with pre-intervention knowledge. Finally, the main findings from the qualitative focus group interview indicated that though the participants rated the

tool-box-talk training favourably, they thought it would be too difficult to implement, given that what the training presents as appropriate waste management protocol is restricted by space and time and contradictory to the site practices they indicate are imposed on them.

In conclusion, consistent with reports which highlight the value of C&D W management training and likewise, C&D W management knowledge and behaviour (e.g. Begum et al., 2009; Kulatunga et al., 2006; Teo et al., 2000; Teo & Loosemore, 2001), the results of the current research suggest that waste management knowledge and behaviour can be enhanced by participating in 'tool-box-talk' waste management training. However, future research is necessary to further examine the effects of waste management training on associated knowledge and, particularly, waste management behaviour, as well as the relationships among these constructs; and the conditions that most positively affect waste management knowledge and behaviour, such as site management support.

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