Through pedagogy to safety:

a study to identify more productive pedagogies for teaching home

chemical safety education interventions to primary school children

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List of Abbreviations

Abbreviation	Full Text
UN	United Nations
ILO	International Labour Organisation
GHS	Globally Harmonised System for Classification and Labelling
OECD	Organisation for Economic Co-operation and Development
EU	European Union
RoSPA	Royal Society for the Prevention of Accidents
WHO	World Health Organisation
RAND	Research and Development
IFCS	Intergovernmental Forum for Chemical Safety
NGO	Non-Governmental Organisations
CEHAPE	Children's Environmental Health Action Plan for Europe
SPSS	Software Package for the Social Sciences
PASW	Predictive Analysis SoftWare
IQD	InterQuartile Deviation

Abstract

Globally, accidental chemical poisonings account for the deaths of more than 35,000 children below the age of 15 annually. Chemical poisonings also cause many more children to endure disease and disability. A new Globally Harmonised System for Classification and Labelling was being introduced through the United Nations at the time of the study. This replaces the many disparate systems in use around the world.

The aim of this study was to identify more productive methods for teaching home chemical safety interventions to primary school children aged 7 to 11 years old in order to increase their knowledge uptake and increase the retention of this knowledge. The new GHS hazard labelling system was applied to this.

The focal concept was the knowledge gained and knowledge retained with the variety of influences that affect the outcomes of learning. A Delphi survey was employed to elicit consensus of expert opinion of the design of the educational intervention. The design of the study was based on a non-equivalent groups, pre-test, post-test, follow-up test structure.

The quantitative part of this study demonstrated a larger gain in knowledge by the test school than by the control school from pre-test to post-test, but it is not clear whether this was due to the intervention or to regression. However, retention of knowledge gained was far superior for the test school and was the result of the intervention.

Children's misconceptions regarding the new hazard symbols were also elicited in the study, clarifying the task set for adults in teaching home chemical safety and mitigating the effect of cognitive dissonance.

Rather than any individual teaching method being superior to others, a blend of teaching styles and learning activities was the most effective. Children's capacity and resources for preventing injury are increased by strengthening their knowledge using comprehensive approaches.

Chapter 1: Introduction to the Study

1.1 Introduction

In my role as chemical safety adviser for a large multi-national pharmaceutical company I was responsible for training staff involved in using and distributing chemicals. This involved teaching people about the chemical hazard communication systems – chemical hazard labelling being the primary source of information in this case. I began to suspect that unless an individual's role involved chemicals, and therefore they would receive industry training, their knowledge of the chemical hazard communication system would either be non-existent or critically flawed. I instigated this research study to produce a more accurate view of the knowledge held by the general public regarding chemical hazard communication.

I started with a pilot study using environmental science students at the University of Salford. The results of this study demonstrated that public knowledge of chemical hazard labelling was extremely low and was, to some extent, flawed. This study showed that 42% of participants did not know to look for a hazard label on chemical containers. Another 17% of participants did not read the hazard label if they noticed it. There was also a misconception regarding the corrosive symbol by some participants which could lead to serious injury.

The lack of a forum for teaching adults about the chemical hazard labelling system would have led to major difficulties in conducting a research project like this one. However, children are at much greater risk of chemical harm than adults, as their small size and faster metabolism cause more rapid chemical absorption and distribution around the body. I decided, then, that children should be the focus of this study. This study also coincided

with the introduction by the United Nations of a new global chemical hazard labelling system (GHS) so that by the end of 2015 every country in the world would use the same chemical hazard labelling system. Consequently, I decided that this study would explore child interventions using the new GHS system.

This study was designed to identify more productive methods for teaching home chemical safety education interventions to primary school children. The study contributes to more effective chemical safety education teaching which leads to greater knowledge uptake and retention. This could, potentially, lead to a decline in the number of unintentional chemical injuries experienced by children each year.

1.2 The international context of child injury

Globally, child injuries are increasing and becoming a major public health concern. They contribute to all death rates from the age of one year until adulthood and are a significant area of concern. Millions of children endure the effects of non-fatal injuries, often with lifelong consequences, with many being left disabled. Hundreds of thousands of children are killed each year from injuries. There are well-established ways to reduce the severity and likelihood of these injuries, but political commitment to take action to prevent child injury and to raise awareness of the problem and its preventability has been lacking (World Report on Injury Prevention, 2008).

Most governments have ratified the International Convention on the Rights of the Child (United Nations, 1989). This convention enshrines the right of children to protection from injury and to have a safe environment. It further states that facilities, services and institutions should conform to established standards of responsible protection and care for

children. As children everywhere go about their daily lives they are exposed to risks and hazards and are therefore equally vulnerable outside these relatively controlled environments.

From the age of 1 year, injuries play an increasing part in the deaths of children globally as demonstrated in Figure 1.
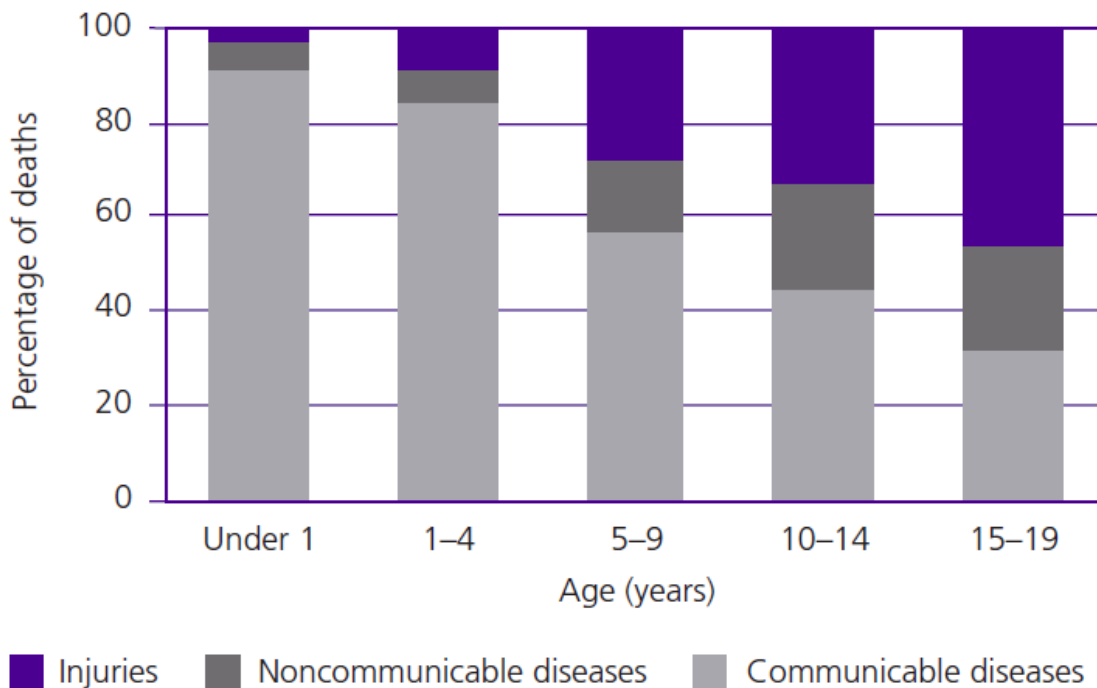
Figure 1. Main causes of death among children, World, 2004 (WHO, 2008)

1.3 The international context of child chemical injury

In 1994 all stakeholders concerned with the good supervision of chemicals formed a coalition called the Intergovernmental Forum on Chemical Safety (IFCS). This body was founded on the key principle of the complete and candid involvement of all associates. It forms an international arena for stakeholders such as governments, organizations – provincial, national, international, labour associations, scientific organisations, industry groups, representatives of civil society and public interest associations. These meet to provide advice and guidance, collaborate, make proposals and appraise progress

(Michaelidou, 2007). The roles of the IFCS are advisory and consultative and incorporate the following:

- The promotion of stronger national chemicals management coordination mechanisms;

- To identify the co-operative action priorities and facilitate this co-operation;

- To promote technical cooperation and information exchange;

- Produce recommendations for concerted international strategies;

- Scientific understanding gap identification;

- Evaluation of progress on agreed recommendations and actions;

- Relevant on-going activities effectiveness reviews;

- Chemical safety advice to governments;

- To promote co-operation between non-governmental and governmental organizations.

(IFCS, 2010)

In its Bangkok symposium in November 2003, and reaffirmed in its Austrian symposium in June 2007, the IFCS encouraged stakeholders and governments to "take action on children's health and chemical safety" and to adopt recommendations to guide the work (Michaelidou, 2007). It declared that there were three foundations for sustainable development: environment, society and economy, and, at the heart of sustainable development, children. It also declared that the economic and social costs were unacceptable: the enormous burden of direct medical expenses, keeping parents from work in order to nurse their sick children, and the emotional toll on families and communities that childhood illness, disability and death take (Michaelidou, 2007).

IFCS appealed to the United Nations, governments, NGOs, multi-interest economic organizations, the public and professionals: parents, teachers, nurses, physicians and others, declaring that all stakeholders have a responsibility to take action to lessen the sources of chemical hazard and to stop child exposure (Michaelidou, 2007). In the same declaration, IFCS reiterated that, when considering the safety of children, assessment should be made relative to chemical exposures that could develop during adolescence, childhood, infancy, gestation and preconception. It asserted that national appraisals ought to ascertain priority concerns requiring action and establish a foundation for the development of an action plan to focus on these priorities. The model ought to be established on the principles of prevention, precaution, and integration, and should aim for the maximum synergy of objectives, encourage participation of all sectors, have multi-sector activities and targets, and have links to related policies and commitments (Michaelidou, 2007).

In summary, the IFCS recommendations were that much more emphasis should be placed on data collection with a uniform classification system, and that more research should be encouraged both to produce less injurious chemical products and to increase the efficacy of child chemical safety interventions. More education and training should be encouraged, and regulators should take actions to prevent and reduce exposure.

IFCS promoted four distinct types of education that could assist in the identification and reduction of chemical risks:

- Training and educating children and parents regarding common chemical risks and approaches to safeguard their families and themselves;

- Educating child care professionals, teachers and others with accountability for the safety of children to teach and practice stratagems to reduce or prevent exposures;

- Increasing the appreciation of lawmakers and politicians, and educating governmental regulators to create and instigate effectual regulations and laws to safeguard children;

- Educating local health officials and health care providers to comprehend, identify, and prevent harm from chemicals

(IFCS, 2010).

Launched in 2004, being a World Health Organization regional office for Europe initiative, the Children's Environment and Health Action Plan for Europe (CEHAPE) has been agreed by all 53 WHO European Region member states including the UK. The fundamental objective of CEHAPE was to provide the benefits of chemicals in the safest way possible, being particularly cautious in protecting children of all ages and developmental stages from harmful exposures.

From birth to eighteen years of age, approximately 33% of the total disease burden in the European Union can be ascribed to unhealthy and unsafe environments (Valent et al., 2004). This investigation also established that unhealthy and unsafe environments were located both within home environments and in the broader community, resulting in considerable economic and social costs. Approximately 17% of the overall disease burden and death is attributable to injuries alone and constitutes the primary reason for mortality in this age range. In some countries, however, this prevalence can be as great as one third (Valent et al., 2004).

An international programme to increase children's environmental health (CEH) was

demanded by the IFCS which coordinated the 'Busan Pledge for Action on Children's

Health and the Environment' (IFCS, 2009) shown in figure 2. It called on WHO to develop

and support the programme and examine and report on its development regularly.

> "We pledge to develop a global plan of action to improve CEH, monitor and report on progress, and we urge W.H.O. and its partners to facilitate the development of this plan in collaboration with all relevant agencies.
> We will implement activities in close interactive partnerships with governmental and non-governmental organizations, centres of excellence, academia, professional bodies, educators and other sectors.
> We commit to take CEH issues to the consideration of the higher authorities in our respective countries and to the attention of the international agencies concerned about children's health and the environment and the needs for green growth and sustainability."

Figure 2. The Busan Pledge for Action on Children's Environmental Health
(IFCS, 2009)

1.3.1 Global Plan of Action

WHO (2010) replied with its 'Global Plan of Action for Children's Health and the

Environment' maintaining that its comprehensive objective was to establish healthy, clean

and safe environments to allow children to grow in good health and develop their full

potential, and also to contribute to the progress of societies both socially and

economically. There are five main domains of work incorporated in the Global Plan of

Action for Children's Health and the Environment in order to attain this objective:

1. awareness raising and education

2. advocacy

3. clinical service delivery

4. collaborative research

5. data collection and analysis.

The fact that children are not just small adults was re-affirmed by WHO, however they also

stated that there was an enduring lack of appreciation of this fact. Particular consideration

needs to be given to lessening their episodes of exposure in the community, at school and at home since they are especially susceptible to environmental hazards (WHO, 2010). There is an obligation to inform providers and effectively enlighten parents, children, key stakeholders and members of the community, regarding the significance of children's health and the environment (WHO, 2010).

It is necessary for injury interventions to be accurately assessed for their efficacy as countries face numerous competing priorities. However, much more knowledge has now been assimilated regarding the prevention of child injury and death than has been acted upon. The potential that exists for preventing injuries and saving lives continues to be elucidated by new research which also continues to highlight the scale of the problem (WHO, 2010).

Type of injury sustained	Rate per 100,000 population	Proportion of all unintentional injuries (%)
All fractures	837.9	32.4
Intracranial injury – short term	419.4	16.3
Open wound	316.9	12.3
Poisoning	282.4	10.9
Burns <20%	152.7	5.9
Internal injuries	129.3	5.0
Injuries to eyes	34.3	1.3
Sprains	33.7	1.3
Injured nerves – long term	26.1	1.0
Other dislocation	24.1	0.9
Intracranial injury – long term	21.0	0.8

Table 1. Nature of unintentional injuries sustained by children under 15 years of age, World, 2004 (WHO, 2008)

Poisonings account for a considerable proportion of these injuries. This data includes burns from fire but it excludes chemical burns from materials that are corrosive and injuries caused by more insidious chemicals such as carcinogens, as shown in table 1.

For example, in the UK alone, more than 28,000 children every year require hospital intervention for chemical poisoning (RoSPA, 2002). Household chemical products (consumer products) are implicated in almost all poisoning accidents.

Poisonings in the UK are the third most common injury to children up to the age of 14 years old, as demonstrated in figure 3. Globally, accidental poisonings account for more than 45,000 deaths of children below the age of 15 annually (WHO, 2010). Moreover, chemical poisonings or continual exposure to chemicals in the environment cause a great many more children to endure disease and disability (Michaelidou, 2007).

Admissions to hospital by age and cause

Number of admissions
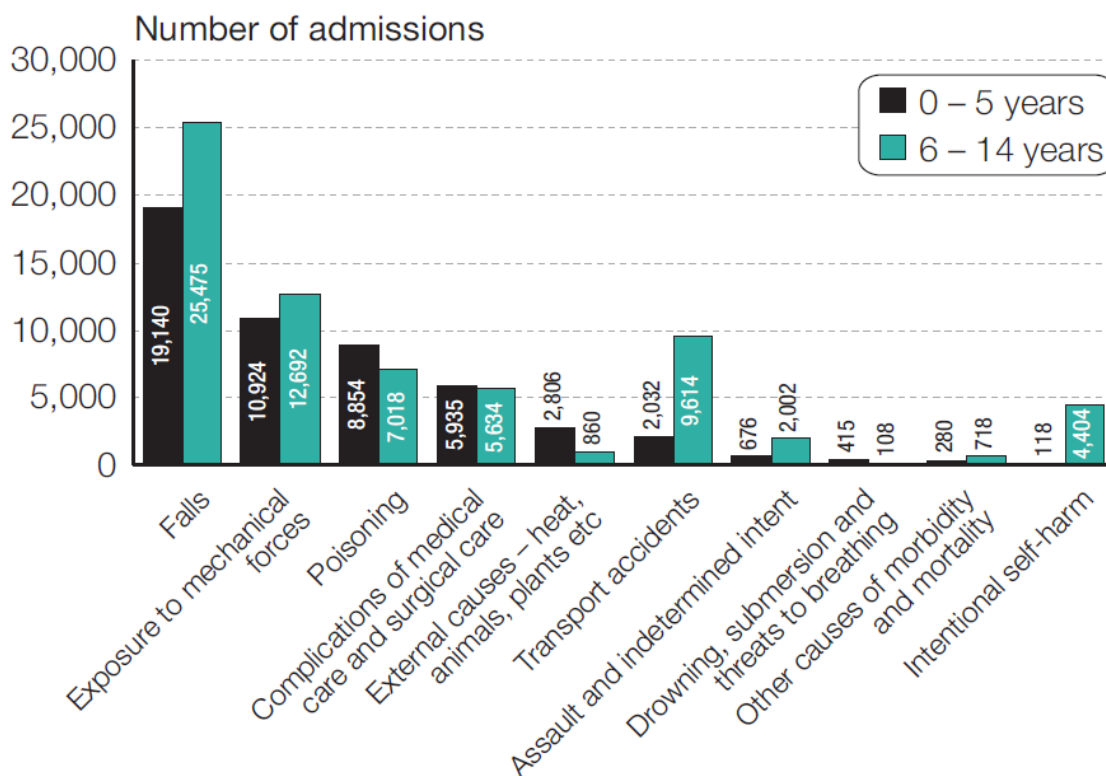
Figure 3. Breakdown of unintentional injury across the 0-14 age group resulting in admission to hospital in the UK in 2005/06 (Hospital Episode Statistics (HES), 2007)

1.3.2 Children's susceptibility to injury

As children grow older a substantial change occurs in their cognitive and physical abilities, activities, degree of dependence and risk behaviours (Agran et al., 2001; Agran et.al., 2003; Flavin et al., 2006; Pruss-Ursun and Corvalan, 2006; Schwebel and Gaines, 2007; Towner et al., 2008). Their wish to experiment and their innate curiosity develop faster than their capacity to understand or respond to danger (Bartlett, 2002).

The effect of hazardous chemicals is far greater on children since their metabolism and behaviour differ from those of adults. This causes the risk to be significantly greater, compared to adults, relative to chemical hazards (Children's Environmental Health Network, 2005). In particular, children are more susceptible because their immune, digestive, nervous, reproductive and respiratory systems are developing and changing rapidly. This transformation produces periods of vulnerability. If children are exposed to hazardous chemicals at these times this could give rise to permanent damage even though the same exposure to a fully developed adult system could result in insignificant or complete lack of damage (Children's Environmental Health Network, 2005). Specifically children's capability to metabolise, detoxify and eliminate chemical substances from the body varies greatly from that of adults (Srinivasan et al., 2003), and the faster metabolism in children accelerates their absorption of toxins (Moyers, 2001). Children also have a much longer time period in which to acquire long-term medical conditions activated by childhood exposure to chemicals. For example, carcinogens and teratogens can take many years for their effects to become apparent (Landrigan and Garg, 2002).

1.3.3 Environment

For children, the possibility of unintentional poisoning is greatest in the home and its surroundings as this is the place where the largest amount and most varied selection of

hazardous chemicals reside. Children will explore in and around the home as they are naturally curious. This results in millions of calls being made to poison control centres, also known as poison information centres, around the world each year. The inadvertent consumption of various types of household product causes many thousands of children to be admitted to emergency departments each year. It is possible to prevent the vast majority of these unintentional poisonings (WHO/UNICEF, 2008).

1.3.4 Types of chemical hazard

The definition of a chemical hazard is any chemical substance, or mixture of substances, that can cause harm to people or the environment (WHO, 2012). The hazardous effects of chemicals can be divided into two main effect categories. These are immediate or acute effects, after a single exposure, and chronic effects, usually after repeated exposures. If injury occurs after a short duration exposure, or instantaneously after exposure, the chemical is defined as acutely hazardous. However if adverse outcomes, for example impairment of the reproductive system, damage to the nervous system, damage to the immune system, cancer, etc., occur after repeated or constant low level exposure to the chemical over a significant period of time, this is defined as a chronic hazard (WHO, 2012).

The types of chemical hazards are (ILPI, 2009):

Corrosive

A chemical that, following a period of exposure, causes irreversible alterations in, or visible destruction of, living tissue, at the site of contact. It can also corrode inorganic materials such as metals.

Long Term Poison

These types of chemicals can cause harm over a long period of time ranging from many months to decades. They include:

Carcinogens - cancer inducing compounds or substances.
Mutagens - cell mutations may occur in exposed individuals which may cause cancer or cause an adverse mutation to occur in later generations.
Teratogens - These chemicals can generate foetal defects in pregnant women.

Acute Poison

A substance that if absorbed, inhaled or ingested can destroy life or severly injure health. The terms 'poison' and 'toxic' are used interchangeably. All chemicals can be considered as 'poisons' or 'toxic' and, if they access the body in sufficiently large quantities by absorption, inhalation or ingestion, are able to produce injury to some degree. Therefore to produce a useful definition toxic chemicals are defined by dosage. The definition of acute toxicity ranges from extremely toxic, highly toxic and toxic depending on this dosage.

Flammable

A substance possessing the property to burst into flames, if exposed to other heat sources such as flames, heat or sparks. The definition of 'flammable' depends on the flash point of the chemical, which is determined by testing. There are four main categories of flammable chemicals. These are aerosols; gases; liquids and solids and the flammability ranges from extremely flammable, highly flammable and flammable depending on the testing results.

Dangerous for the Environment

If the chemical can present a delayed or immediate danger to one or several constituents of the environment such as fish, plants, birds and other aquatic life, it is considered as dangerous for the environment.

Other Hazards

For example:

- irritants to the skin
  - A non-corrosive chemical which, at the site of contact with living tissue, causes an inflammatory effect, by chemical action, which is reversible.
- sensitizers
  - A chemical which causes the development of an allergic reaction in normal tissue which occurs after several exposures

(ILPI, 2009)

Some particularly common hazardous chemicals found in the home environment are listed in table 2 along with their hazard types.

Product	Main ingredients	Hazards
Toilet bowel cleaners	Hydrochloric acid Sodium bisulphate Phenol Oxalic acid 5-dimethyldantoin	Corrosive - corrodes mouth and stomach; corrosive to skin. Can damage liver and kidney; causes eye and respiratory tract irritation; can depress the central nervous system; category 1B carcinogen
Bleach	Sodium hypochlorite solution	Corrosive to skin, lining of mouth, throat and nose; fumes irritating to respiratory tract and eyes.
Anti-freeze	Ethylene glycol	Can be toxic if swallowed. Can cause damage to the kidneys, brain and heart.
Insecticides	Carbamates and Organophosphates	Can cause nausea, headache and dizziness. Category 1B carcinogen.
Dishwashing detergents	phosphates plus anionic, cationic and non-ionic solutions	Causes skin irritation.
Windscreen washer fluid	Ethylene glycol Methanol	Inhalation can lead to lung disease. Ingestion can cause blindness. Can damage the kidneys, nervous system and liver.
Oven cleaners	Potassium hydroxide or Sodium hydroxide	Can be fatal if swallowed. Extremely corrosive will burn eyes and skin.

Table 2. Examples of hazardous household products and their hazards (The Cleveland Clinic Foundation, 2010)

1.3.5 Household chemicals

The main contributory factor causing unintentional injuries in children are chemicals found within and around the home and to which children have access. Exposure to some cleaning agents will result in slight injury, however some consumer chemicals such as

ammonia, dishwasher detergents and bleach can cause severe tissue damage. In developed countries these types of chemicals are found in the majority of homes (Taft et al., 2002; Gupta et al., 2003; Scott et al., 2005; Bataineh, 2007).

1.3.6 Morbidity

The vast majority of global data collected concerns mortality; non-fatal outcome data are not usually collected in most countries. Some countries record and collate data from specialized surveillance systems (such as the National Poison Data System in the United States) or national poison control centres. However, the main problem encountered is the variety of classification systems used which makes comparing poisoning incident rates between countries very difficult.

A number of high-income countries publish data regarding hospital admissions for poisoning incidents. Again, comparison of these results is limited by admission criteria differing between urban and rural settings as well as between countries. For example, in Australia hospital admission rates for child poisoning have been consistently lower in urban areas than in rural areas for many years. This has been attributed to the fact that doctors in rural areas may be more cautious and therefore are more inclined to admit children to hospital even when this may be unnecessary. The hazardous chemicals involved are the same in both rural and urban cases (O'Connor, 2005).

1.3.7 The cost of poisoning-related injury

In middle and low income countries very little research has been undertaken relative to the cost of child poisonings. However, in one South African study the estimated direct hospitalization costs due to paraffin poisoning alone totalled at least US$1.4 million per

year (Danseco et al., 2000). This study showed that the average cost of treatment was US$1060 per patient (Malangu et al., 2005).

The South African findings that child poisonings and their management are especially costly were confirmed by data from the United States (Finkelstein et al., 2007). Data for the year 2000 showed that for children under 15 years of age there were 219,000 poisonings in total, 14,000 of which resulted in hospital admission, and 141 of which were fatal. This study also estimated that the lifetime cost of poisonings in this age group was US$400 million, and that 9% of this cost was for medical treatment. Taking into account medical costs, lost earnings and lost quality of life, a conservative estimate suggests that each case of poisoning costs US$1,780 on average (Faelker et al., 2006).

1.3.8 Limitations of data

Injury statistics should be viewed with caution. These statistics are compiled centrally from many national systems around the world. There are various ways of gathering child poisoning data, including mortality data, surveillance systems, hospital admissions and discharge records, enquiries to poison control centres, and emergency department records. Globally, though, there is limited data on the types of chemicals that result in child poisoning and death. Under-reporting and under-recording of child poisoning incidents is substantial. Since poisoning is not usually a notifiable condition, few countries maintain records on these events. The counting or reporting of child poisonings is not guaranteed even where surveillance systems exist. For example, if those affected are not taken to a health care facility, or even if they seek medical help, the wrong cause may be attributed if the symptoms are similar to another condition and if the child does not admit to taking the chemical. The medical worker may not identify the chemical agent that is involved correctly

even when poisoning is correctly diagnosed. Coding problems can also have a negative effect on child poisoning data. The categorisations used by systems can vary and may skew the results either way. For example, the NEISS injury surveillance system used in the United States collects data only from people treated in accident and emergency departments and does not include outpatient departments, general practitioner treatment or children that are not treated at all.

Moreover, systems use different variables and fields of varying lengths. This leads to incomplete records or sometimes absence of information in a particular field. Descriptions are not standardised, which can lead to the wrong categorisation.

There can also be major gaps in the statistics caused by countries not collecting injury data. For example, the UK decommissioned the HASS (Home Accident Surveillance System) in 2002, and this system has not been replaced. Since this date the UK has not been submitting injury data to European and UN surveillance systems.

1.3.9 Risk factors

The risk of child poisoning, as with other injuries, is affected by child related factors, the environment and the chemical. These factors are highly dependent on the context and are interrelated. The development of interventions to prevent injury is dependent on an understanding of these factors.

1.3.10 Child-related factors

Age

There is a strong association between poisoning and age. Age determines the physiology, behaviour and size of the child, each of which will influence the types of exposure and

outcome (Centers for Disease Control and Prevention, 2006). Children are particularly susceptible to the unintentional ingestion of household chemicals, especially chemicals in liquid form (Manzar et al., 2010).

Gender

The risk of poisoning is usually reported to be much greater in boys than girls (Soori, 2001; Fernando, 2002; Malangu et al., 2005). However, some studies show no difference between boys and girls (Abu-Ekteish, 2002; Lifshitz et al., 2003; Wani et al., 2004).

Poverty

Socioeconomic status is strongly associated with deaths and injury from poisoning, both between and within countries (Turrel and Mathers, 2001). King et al. (1996) conducted a study in the UK which showed that the risk of death from poisoning amongst children in more affluent areas were three times less than amongst children from poor socioeconomic backgrounds. The cause of this seems to be that people from poor backgrounds tend to live with limited and inadequate storage space to keep hazardous chemicals away from children.

1.3.11 Characteristics of the agent

The nature of the chemical is also important. Liquid chemicals have a much greater incident rate relative to solid chemicals (Center for Disease Control and Prevention, 2006a). Powdered chemicals, such as laundry detergents, are much harder to swallow than liquid chemicals, as they will stick to the mucosa of the mouth. Furthermore, powdered chemicals will tend to produce a burning sensation and so tend to limit the amount of solid ingested. Regrettably, anti-caking agents are now being added to powdered chemicals which will make ingestion easier because it will increase the ease of flow.

The attractiveness to children of a hazardous chemical depends on its physical appearance. Characteristics such as colour, size and texture all play a part in attracting the child who may then handle and ingest the chemical. A study by Brok et al. (2009) defined certain characteristics relative to the attractiveness to children. They showed that liquids were more attractive than solids and clear liquids were more attractive than dark liquids. Small solids were more attractive than large solids.

1.3.12 Storage and access

Chemicals in the home that are within reach of children are the most obvious risk factor for ingestion. By law in most countries, hazardous chemicals are usually marked with warning labels which usually have visual warning symbols on them. For example, the skull and cross bones symbol indicates toxicity. However, it is unlikely that children will recognise the meaning of these hazard symbols unless they have been taught to do so (Smithson et al., 2011). It is highly likely that children will misunderstand these symbols, leading to more injuries. Warning labels may even attract children, because of these misunderstandings and the eye- catching nature of the labels (Smithson et al., 2011). Being understood is absolutely crucial for warning label effectiveness (Smithson et al., 2011).

1.3.13 Educational approaches

Behavioural change will not necessarily be the end result when education is the only intervention used. The result of educational approaches is that the child needs to take action each time they encounter a hazardous chemical. Consequently education is regarded to be an active intervention (Runyan, 2003; McClure et al., 2004). The use of educational interventions to reduce child chemical injury is open to question. Non-intentional ingestion of hazardous chemicals has not been reduced significantly as a result

of educational campaigns in isolation (Wallack, 2000; Schwebel et al., 2009). This might be due to the efficacy of educational interventions being dependent on the actions, efforts and beliefs of the children who are targeted by the education (Runyan, 2003). A systematic review by Kendrick et al. (2008) revealed that although home safety education interventions improved prevention stratagems, it was unclear whether there was an impact on injury prevention rates. However Runyan (2003) showed that if the education was particularly specific and targeted injury education, especially when there was a need for new information, this could be effective. However, many studies support injury education as a useful component of prevention programmes, especially when used in combination with passive stratagems to prevent poisoning (Morrongiello and Kiriakou, 2004; Nixon et al., 2004; Beirens et al., 2006).

No research has been undertaken to evaluate the methods used in the teaching of these educational interventions. Therefore, to dismiss the educational aspect of injury prevention may be discarding a potentially effective way of preventing injury which, if the efficacy of these interventions could be increased, could contribute significantly to a reduction in childhood injuries. If just the basics of hazardous chemical labelling could be taught effectively, so increasing the knowledge and retention of the hazard communication elements, this could significantly contribute, together with passive stratagems, to a fall in chemical injury rates amongst children.

1.3.14 Parental Supervision

In the home the parents or guardians are usually nearby but engaged in household tasks. Consequently it is not practical to have continuous direct supervision of children even though this would reduce children's access to hazardous chemicals. This is especially the

case in poorer households where there may be more competing household tasks and where there are likely to be more children to be supervised. Morrongiello and Kiriakou (2004) have shown that parents or guardians take fewer precautions against child poisonings if these precautions involve more effort or if they involve changes in behaviour.

1.3.15 Product hazard communication

Product hazard labelling is based on the tenet of the consumer's right to know the inherent dangers of a chemical. This concept is important and widely supported by many governments, agencies and organizations, and is enshrined in law for most countries. Industry has supplementary references of information, for example, safety data sheets and shipping papers, which enhance product safety information and allow the correlation of risk to the hazard information supplied. Public consumers, however, depend exclusively for information on the product label which details the hazardous effects that a chemical product can have.

1.4 Timing of GHS implementation and of the study

Between 2008 and 2015 the world is changing over to one system of chemical classification and labelling. This new system will replace all the current disparate systems used around the world. The GHS was initiated at the 1992 United Nations 'Earth Summit' in Rio de Janeiro. Many international organisations including the ILO, OECD and the United Nations have worked for more than a decade on GHS, resulting in this international convention providing a basis for a globally accepted system to address the hazard classification of chemicals and corresponding labels. GHS is encompassed in what is commonly known as the 'purple book' - the first revised edition of which was published by the United Nations in July 2005. This book details the classification criteria and hazard

label elements that are to be used throughout the world. The target audiences are those concerned with the manufacture, distribution and supply of chemical products, together with emergency responders, consumers and workers (United Nations Sub-Committee of Experts, 2001).

The new GHS system is designed to take account of:

- the requirement to safeguard confidential business information and to assist international free trade;

- the obligation to protect the safety and health of the environment and target audiences;

- compatibility with existing systems and international instruments;

- consumer's entitlement to know the true identity of the chemicals they use and the hazards associated with them;

- the consideration of risk when communicating to particular target audiences;

- the requirement for a system which takes into account developing country's needs, is simple, easy to apply and effective;

- use, for all hazards covered by the GHS, of harmonised hazard classification criteria;

- the completeness of information, its comprehensibility and accuracy;

- the varied scenarios where hazardous chemicals are encountered by target audiences;

- the requirement for guidance;

- the role that training and education needs to play.

(United Nations Sub Committee of Experts, 2001)

As Cotton (2002) of the UK Department of Trade and Industry put it, "Without education, even the best designed label will be ineffective". This comment has been supported by the United Nations and many other agencies.

1.4.1 Changes that GHS will introduce

The new GHS includes the following elements:

- Globally harmonised classification criteria for mixtures and substances relative to their physical hazards, environmental hazards and health hazards; and

- Globally harmonised hazard communication components, together with hazard labelling requirements.

(United Nations sub committee of Experts, 2001)

Although a number of elements of the existing classification systems will be incorporated into GHS, they will look different and the terminology used will be different. In Europe, for example, diamond shaped pictograms with a red border will replace the current orange background pictograms. Risk phrases will be replaced by Hazard statements and Safety phrases will be replaced by Precautionary statements (UK Health and Safety Authority, 2003). An example is given in figure 4 where the Saint Andrews cross and the indications of danger, in this example 'Irritant', is replaced by the exclamation mark with the signal word 'Warning' and the Risk phrases are replaced by the Hazard statements (UK Health and Safety Authority, 2003). Another example is shown in figure 5 where the indication of danger pictogram, in this example 'Toxic' with the skull and cross bones symbol, and the Risk phrases will be replaced by the 'Health hazard' pictogram together with the signal word 'Danger' and the hazard statements (UK Health and Safety Authority, 2003).

1.5 Statement of the Problem

Addressing the problem through education of adults would be difficult since no single forum exists for their education in this area. Since it is young children that are most at risk, it seemed appropriate to target children directly through a teaching intervention at school

about chemicals found in the home and their associated hazards.

Current EU LABEL	GHS LABEL
✖	❗
Irritant	Warning
Risk of serious damage to eyes	Causes serious eye irritation

Figure 4. Example of a change in irritant chemical communication from EU to the new GHS system (UK Health and Safety Authority, 2003)

Current EU Label	GHS label
☠	☠
Toxic	Danger
May impair fertility	May damage fertility or the unborn child.

Figure 5. Example of a change in long-term toxic chemical communication from EU to the new GHS system (UK Health and Safety Authority, 2003)

However, since GHS was a new hazard communication system, and teaching about chemical hazards found in the home had not been addressed widely in schools before there was a gap in knowledge about how to proceed.

1.6 Aim of the study

The study aim was to identify more productive methods of teaching home chemical safety interventions to primary school children, aged 7 to 11 years old, in order to increase their knowledge uptake and increase the retention of this knowledge using the new GHS chemical hazard warning system.

1.7 Intervention Design

The main focus of the research was the knowledge gained and knowledge retained with the variety of influences that affect the outcomes of learning. The intervention design is shown as a schematic in figure 6.

1.7.1 Health Education Intervention

Generally health education is defined as – "An educational programme directed to the general public that attempts to improve, maintain, and safeguard the health of the community" (Mosby's Dictionary, 2008). In this case the health education intervention was directed at primary school children.

1.7.2 Intervention being taught - Chemical Safety

The intervention was aimed at primary school children age 7 to 11 years old. It used the new GHS chemical hazard communication system. This system includes signal words, pictograms, and text describing the hazards.

1.7.3 Existing Knowledge

The existing knowledge of the pupils defined the base level from which the Impact assessment measured the increase in knowledge uptake. It also took into account crucial misconceptions.

1.7.4 What pupils were expected to learn

- To understand that a communication system exists
- To understand the meaning of specific words for example, Harm, Hazard, Precaution.

- To understand the basic meaning of hazard words for example Toxic, Corrosive, Dangerous for the environment.

- To understand the effect of each hazard

- To identify the pictograms and relate to the associated hazard word

- To become aware of places in the home where hazardous chemicals might be stored.

1.7.5 Delphi survey

The Delphi survey method was used as an instrument to gain the opinions of specialists in the domain of education to propose a more effective learning experience for the children.

1.7.6 Educational Method

This focused on the manner in which a more effective teaching and learning environment could be implemented and how the selection, organisation and presentation of course material could lead to an injury prevention intervention having a greater efficacy. The Delphi survey was designed to address each of these areas so as to improve the knowledge uptake and retention.

1.7.7 Impact Evaluation

The Impact evaluation evaluated the programme's success in attaining the required changes in targeted mediators - in this case knowledge within the targeted group.

1.8 Research question

Can more productive methods for teaching home chemical safety education interventions to primary school children be identified which will lead to greater knowledge uptake and

retention?

1.9 Research Objectives

1) To evaluate the teaching and learning method, identified by use of a Delphi survey, by comparison with a traditional teacher centred approach using chemical safety interventions to primary school children. The evaluation is based on:

- whether this method has increased the knowledge uptake

- whether this method has increased the knowledge retention

2) To identify and correct any misconceptions and resolve any cognitive dissonance which may prevent or hinder assimilation of new concepts.

Figure 6. Intervention design
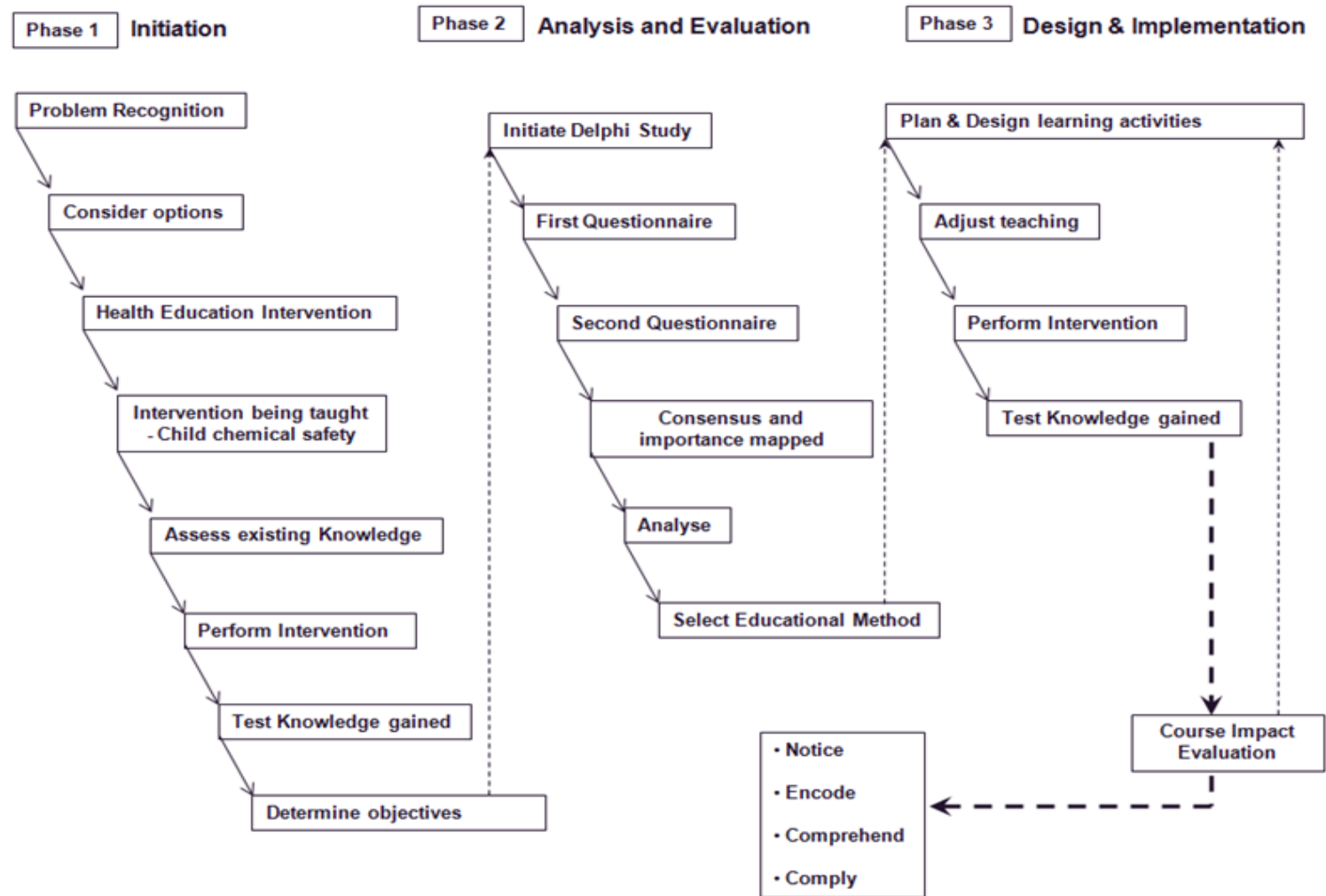
Chapter 2: Literature Review

2.1 Introduction

Given the varied nature of the elements contributing to the research topic, each with equally varied rates of knowledge-production and synthesis, the literature review was based partly on a 'state of the art' method (Grant and Booth, 2009) in which a range of current evidence is reviewed, usually with less emphasis on historical or previous literature, and usually with less emphasis on appraisal of older literature. The centrality to the study of a current major change in global policy (GHS) suggests that older literature may have less impact on outcomes, but may help to explain current directions and influences. However, in some fields, current knowledge and practice may be based on relatively older evidence.

The literature review is preceded by details of the search strategy. It then progresses to psychological factors of hazard communication in relation to the design of warnings and their perception. Educational methodologies are then explored including learning concepts and stratagems. The review then addresses health education stratagems and promotional techniques. A review of knowledge acquirement follows, considering the factors which affect knowledge retention and the organisation of memory. Finally, current educational stratagems are explored, reviewing successful and unsuccessful programmes.

2.2 Search strategy

2.2.1 Sources

Computerised databases were searched: JSTOR, MEDLINE and Elsevier Scopus. These databases include the vast majority of literature produced in the English language relating to health, education and science. The ACADEMIC SEARCH COMPLETE

database was used to widen the search to include relevant psychological and social science research. This combination of databases facilitated access to a comprehensive range of research literature in English. Manual searching of additional resources was undertaken, including website resources, national governmental and NGO reports. Grey literature in the form of postgraduate theses and other material was sought using GOOGLE and GOOGLE SCHOLAR.

Key words were employed and combined with Boolean logic operators AND, OR and NOT:

- Injury prevention AND Children NOT Intentional

- Chemical injury AND Children AND Education

- Safety intervention OR Injury prevention AND Education

- Education AND safety intervention AND Children

- Learning OR Education AND safety

- Learning AND Knowledge AND memory

- Delphi AND child intervention

- Dephi AND child injury prevention

The abstracts were read in order to facilitate the decision on whether to review the whole article.

2.2.2 Restrictions on the search

The inclusion criteria were:

- Published between 2000 and 2012 and written in English

- Included children under the age of 15

- Relates to unintentional injury prevention

- Relates to educational interventions

    Either:

    - o a primary intervention measure to prevent accidents occurring was described

    - o prevention or reduction of the severity of injuries was described as a secondary measure

    - o an intervention or prevention stratagem for chemical injuries was evaluated by the research

- At least one objective quantified outcome reported : education, changes in behaviour, attitude or knowledge, injury rates, public policy, frequency of injuries, community based interventions, safety interventions, community based interventions

- Relates to performed Delphi studies or the use of Delphi studies

The following were exclusion criteria:

- Studies published before 2000

- studies focused on intentional injury

- studies focused on environmental poisoning by virtue of pollution

Primarily research included in this review has been conducted from the year 2000 onwards. However some work has been included prior to this date if it was:

- Used as a theoretical foundation for later research or programme development;

- Is considered seminal;

- It was considered that the information was particularly useful to this study

- More up to date information was not found.

2.3 Psychological Factors

2.3.1 Psychology of the communication system

There is general agreement in the mass of studies analysing danger labels as to the function and broad requirements of warnings. Danger communication via labels ought to be designated only when, in product planning, there are circumstances where a danger cannot be entirely protected against or removed totally (Sanders and McCormick, 1993) and also where it is not evident to a particular portion of the end user community that there is a danger. For instance where it is essential for designers to apply warnings to advise users as regards safer conduct, the designers have the obligation to verify that all the warning components that are essential to promote conformity are included.

Hazard warning investigators broadly concur that warnings ought to be composed of five components (Spink et al., 2011): a danger statement; a signal word; a symbol(s); a consequences statement; directions for circumventing the danger. The signal word is an individual word whose purpose is to affirm the appropriate degree of danger but also to attract the end users attention. As well as presenting a signal word, it is essential that a warning states the characteristics of the danger and is also accompanied by a significant consequences declaration if the person does not conform. In the significant consequences declaration, both magnitude and probability ought to be specified (Sanders and McCormick, 1993), however some investigations have concluded that the magnitude statement is the chief indicator of conformity (Wogalter et al., 2002; van Duijne et al., 2008).

Subsequent to communicating information concerning the consequences and its danger, the warning should include directions towards safer conduct which an end user could

employ to mitigate the danger. A last vital planning consideration is that the danger warnings should be positioned so that they are easily accessible at the point that the end user will normally expect to meet the danger (Sanders and McCormick, 1993). Mayhorn (2005) proposed for groups that have reduced effective recall facility this form of warning position is especially significant. Whilst research might confirm the fact that effective warnings require the previously mentioned elements, the warning system as conceived by Rogers et al. (2000) demonstrates that innovative interventions may assist in the implementation of these elements.

A sort of naive absolutism has occasionally categorized the research literature. This is demonstrated by some of the questions posed by previous studies: "is it generally effective to display the message component of the hazard, the degree of danger, the required action, the injury result, or maybe some permutation of these?" When constructing a label this research is definitely of use, however taking into account the hazard or hazards, comprehension by the public of the hazard and associated actions, competition with other messages, space considerations, the hazard's conspicuousness on the product container, and other numerous elements, then the issue changes to what information produces the largest effect for this purpose.

2.3.2 Defining the warning system

An especially useful structure for investigating warning variables that are interrelated was established by Rogers et al. (2000). The four principle components of any warning process are: Observe; Encode; Comprehend; Comply. Rogers et el. (2000) proposed that there are four steps in the warning process. These steps relate the warning variables and the individual to establish the probability of conformity. However the human variables that exist

as part of the warning system cannot be explicitly altered or controlled since these types of products will be used by a substantial and assorted population. Products although aimed at an exclusive consumer sector ought to have a warning planned to suit every possible end user, since the manufacturers cannot broadly disregard other end consumers. Consequently, human variables, for example the different ages of the consumer, should be adapted and warning variables adjusted, for example the text dimensions and sophistication.

The primary stage is to observe or become aware of the warning. It has been demonstrated that the Warning variables which influence this stage are broadly perceptual elements for example the colour, shape, and dimensions of the warning label. Perceptual variables are crucial in establishing the prominence of the warning and observing the warning. Symbols, pictures and signal words also perform an essential part in this stage. Appropriate pictograms, including symbols and other images, can assist in the warning being observed once situated in combination with warning text (Rogers et al., 2000).

Once the warning has been observed it is then essential that it is encoded. Encoding is the second, and subsequent, stage needed for the success of the warning system. Most of the observing variables are relevant to this stage also. Throughout the encoding phase, people continue to read and start to interpret the warning message. Even if an end user notes the presence of a warning, it has not been encoded if it has not been read. There are several fundamental perceptual variables for example colour, emphasis and size that perform a significant part in prompting the end user to observe the warning and to encode it. There are also supplementary perceptual variables which relate particularly to text. The employment of appropriate text and font style are crucial to evoke encoding in warnings.

Employment of signal words is once more significant, with the words 'Warning' and 'Danger' strengthening the probability that encoding of the warning will take place (Rogers et al., 2000; Wogalter et al., 1994). Lastly, and very importantly, the physical integrity of the communication device used to communicate the warning message should be sustained throughout the life of the product, for example the label should not become torn and the text should not fade (Rogers et al., 2000).

Once observed and encoded, it is then possible for a warning to be understood. Accordingly the third phase in the warning system is understanding, and this depends on a mix of variables. A person processes the warnings' meaning in the understanding phase, consequently successful understanding and warning comprehension are synonymous. Warning placement and text layout are variables that have an effect on encoding and which also affect understanding. If a warning is to be understood, variables such as the text complexity and exactness are crucial. To understand a warning, text sophistication such as syntax, voice and terminology should be appropriate. Syntax and terminology should not be complicated or needlessly at an elevated level (Rogers et al., 2000; Lepkowska-White and Parsons, 2001). Potential consequences of non-conformity however, should be unambiguously stated in the warning, as specifically as possible, which will assist in precisely comprehending the significance of the hazard (Rogers et al., 2000; Wogalter et al., 2002; van Duijne et al., 2008).

Conformity is the last stage in the warning system and depends on the warning being comprehended. The end user is still required to take the decision to conform even if a warning is understood. Warning elements are crucial, and the choice to conform can be determined by the variables significant to prior stages, for example the use of colour and

symbols. If conformity is to be the final outcome, then it is essential that the warning text communicates the characteristics of the danger, the appropriate behaviour to avoid the danger, and also the likely outcomes of not avoiding the danger. The literature includes a number of research investigations that assessed behaviour directly, for example obeying a prescribed action or reading a label, although these investigations have commonly been somewhat limited in approach. A study by Vernberg et al. (1984) demonstrated that warning stickers such as 'Mr Yuk' are not an effective deterrent for children. However, internal validity was limited in this study by the lack of a control group, while the power and external validity was limited by the small sample size. Nevertheless, it is clear that some warning stickers can act as an attraction without the accompaniment of an appropriate educational programme. The statement of the danger, according to Rogers et al. (2000) must be explicit and include as much information as feasible to enhance conformity. The warning must also deliver guidance as to conforming conduct.

Supplying response information in this manner steers the end-user towards choosing safer conduct. The warning system exposes a number of variables of varying intricacy that promote warning effectiveness and offer possible objectives for enhancement. Whilst it is principally perceptual variables that broadly influence detection and encoding, it is on the warning text content that the understanding and conformity phases are dependent.

Label effectiveness is frequently determined on the foundation of individual's accounts of the assumptions that they might make if they happened upon a warning label or just subjective judgment. However, the definitive safety consequences of labelling options and comparative validity are inadequately understood (Sattler et al., 1997).

2.3.3 Deduction and Warnings

A series of inferences regarding the meaning of the text are constructed each time individuals encounter original text, further than what is overtly stated (Cook et al., 2001). Individuals will engage in inferences when they read through certain kinds of text in order to anticipate the following text in a segment. This has the effect that the fundamental meaning of the passage can be confused (Gerrig, 2005). Both younger and older individuals have demonstrated the application of crystallized knowledge in order to construct inferences regarding warning meaning, and this seems to be true even for brief passages that are offered without any related product information (Hancock et al., 2005). Additionally, Hancock et al. (2005) established that individuals will frequently remember a deduction they made in relation to a warning instead of the specific content of the warning when they encounter circumstances where they are required to recall a warning. However, individuals are frequently confronted with more than simple inferences regarding the warning meaning. Furthermore, factors such as the time available for processing warnings and a restricted area for product warning text put limitations on warning text length. Consequently warnings frequently cannot include illustrations of safer conduct in all conceivable circumstances as a result of this restricted area. Individuals are obliged to form an assumption about safer conduct for each circumstance which the warning label does not overtly deal with. Therefore the content in the warning is translated into advice for product usage via these inferences (Argo and Main, 2004).

An inference that is inappropriate may produce a warning that falls short of providing an appropriate structure for safer interaction with a product. There would be a potential for failure if, after examining the warning with the intention of complying, an individual made inappropriate inferences (Edworthy et al., 2004). Even if the objective was safer conduct,

the consequence could be that the user had inadvertently failed to comply by incorrectly deducing the safer conduct. How a product functions is not specifically explained in warnings, and frequently this can result in the end user making inferences regarding the characteristics of concealed dangers. Frequently, warnings about concealed dangers are unsuccessful since the characteristics of the concealed dangers are not wholly clarified, the end user merely being given a direction regarding how to avoid the concealed danger (Edworthy et al., 2004).

Three predictors of a product's danger ranking, as ascertained by Wogalter et al. (2002), are its technical complexity, the person's perception of the risk and the self-confidence of individuals about their ability to comprehend the dangers. A study performed by Bowles (2004) investigated risk perception relative to age concluding that older people had a greater risk perception than younger people and that the younger the individual the more likely it was that they would not read the hazard label. However this study had a particularly complex design. It considered 7 types of hazard from chemical and electrical to medicinal and the use of tools such as axes and saws. Participants were given an 80 page pack with instructions, definitions and questions. The participants were expected to complete the survey in a 3 hour session. Half of the participants were young university students, and the other half were older people who lived in the locality. The student participants were not representative of the general population, and there is a question concerning the internal validity of using the older participants since they were chosen from a group of people who wanted to participate. However, this research generated some evidence to suggest that there was an age-related difference in the perception of hazards and their degree of severity.

Merely knowing that a product may be hazardous does not permit the conclusion of safe behaviour even though consumers may comprehend that concealed dangers exist for certain products. Consequently, there are two possible circumstances which might develop. A person can decide on non-compliance with a warning without completely comprehending the consequences of their behaviour, or a person can endeavour to interact in a safe manner with a product and be unsuccessful (Nichols et al., 2002). There will, of course, be situations where the end user is required to make inferences regarding conformity as a warning label cannot overtly embrace all potential circumstances. These inferences can indicate a position where the warning process might breakdown, and, consequently, a position where an appropriate intervention could improve conformity.

There have, however, been numerous instances of weak study design or inappropriate deductions from the data obtained. The use of convenience samples has characterised a great deal of the literature, and participants are frequently university students. Such samples are limited and, very often, unsuitable, as such individuals might be at variance from normal consumers of the product, for example in terms of hazard perception, product knowledge, safety motivation or perceptual abilities. In label-creation, the design variables in terms of warning effectiveness are not related in any known way to a reduction in injuries or a change in behaviour. In some research there is an anticipation that supplying safety information leads to an increase in safety behaviour, but this may be ill-founded. Recognition-recall studies investigate warning message recognition and also test the capability of people to retrieve the correct message some time later. They represent the majority of quantitative studies in the literature.

2.4 Educational Method

2.4.1 How children learn

Substantial progress has been made in the study of children's learning capacities due to theoretical and methodological developments. Four major areas have benefited from the impressive increases in knowledge due an enormous body of research.

2.4.2 A predisposition, early in childhood, to learn specific things

There is evidence to suggest that, early in life, positive biases to learn certain types of information are shown by young children. These forms of knowledge centre on broadly defined categories and are referred to as 'privileged domains' and they are biological and physical concepts, number, language and causality (Gelman and Lucariello, 2002).

2.4.3 Metacognition and stratagems

Children must rely on ingenuity, effort and willpower to enhance their learning, outside of privileged domains. Many studies over the last 3 decades have revealed previously unrecognized metacognitive and strategic competencies in children.

The knowledge and strategic competence (metacognition) to learn intentionally was previously thought to be lacking in young children (DeLoache et al., 1998).

2.4.4 Mind theories

As they mature, children, in situations that require a great deal of effort and purposeful learning, will cultivate concepts that describe what it means to understand and learn. These theories will strongly shape how they as an individual position themselves in these settings (Scardamalia and Bereiter, 2003). A variety of theories of intelligence and mind are entertained by children (Dupeyrat and Marine, 2005). Children go to school ready to

learn in many different ways. It is argued by some theorists that there is not just one way to be 'intelligent' and not just one way to learn. Working with children's weaknesses and supporting their strengths requires that multiple intelligences are understood (Gardner, 2003).

2.4.5 Community and children

Although children's learning is generally self-directed and self-motivated, principal roles are also played by other people as guides in developing and encouraging learning. Such guides include adults, for example parents and teachers, and other children. Powerful tools, such as cultural artefacts, can serve as guides too, notably television, videos, books and many other technological devices (Wright et al., 2001). Vygotsky's theory of zones of proximal development has supported many studies on assisted learning (Vygotsky, 1978). The concept of 'communities of learners' has also been influenced by Vygotsky's work and has supported the increasing popularity of this theory, be they face to face, via electronic media, or using other technologies.

Some critics of Vygotsky's work emphasize the potential drawbacks of guidance and collaboration. For example, if facilitators such as parents or teachers are too overbearing and controlling, some children may become lazy and expect help even when they are capable of achieving the goal on their own (Allal and Ducrey, 2000).

2.4.6 Advances in method

Due to the methodological progress in the field of developmental psychology the number of investigations that focus on early learning has considerably increased. The study of how children learn has contributed a great deal of knowledge to how the human mind develops.

Adults have a greater memory capacity than children, is one view of learning. There is an obvious increase, with age, in the abilities of children regarding memory and learning, however the mechanisms which affect these changes are still surrounded by controversy. Of course, there are critics of learning theories that strive to keep traditional educational practices. These critics refute the need for such theories; stating that the construction of theories, in an attempt to understand the process of learning, creates more problems and obstructs personal freedom (Holzman, 2012).

One view is that as children mature their short-term memory capacity increases (Pascual-Leone, 2000). Therefore they can perform more complex mental operations and retain more information with more mental space. However, a complimentary view is that the increase in memory and learning is achieved by children learning to use their limited capacity more effectively (Hitch et al., 2001). A relatively uniform improvement in achievement across learning domains would be the expectation if either of these positions were supported (Hitch et al., 2001).

Another point of view is that children cultivate activities which are used to help assimilate knowledge. These types of activities are usually called stratagems. Elaboration is the improvement of the retention of meaningful units, for example sentences. (Anderson et al., 2001); increasing comprehension and retention is summarization (Thiede and Anderson, 2003); and improving rote recall is Rehearsal (Souchay and Isingrini, 2004). There are many recognised stratagems to improve remembering, but these three are predominant.

A criticism of elaboration is that it is a design or model procedure rather than a learning theory (van Boxtel et al., 2000). It has also been suggested by van Boxtel et al. (2000) that

the theory of elaboration is basically a set of principles rather than a theory and needs to be reformulated to be more related to the learning process. The main criticism of Summarisation as an educational method is that it was felt that a definite summarisation technique needs to be learnt by children to make full use of this learning method (Wormeli, 2004). Also, Wormeli (2004) states that spoken, written, kinaesthetic and artistic summarization techniques, for both group activities and individual assignments, need to be learnt. Rehearsal tends to be viewed negatively as 'old fashioned' and 'boring'. A sign that learning is not taking place, as stated by Dixon (2004), is spending considerable periods of time on repetitive tasks. However, Heward (2003) states that rehearsal learning is a consistently effective method of teaching when properly applied.

In order to enhance memory performance, possibly the most pervasive stratagem that is used is termed 'Clustering'. Meaningful units are created by the organisation of dissimilar pieces of information. One of the main criticisms of clustering is that categorization stratagems need to be employed by the child (Bransford et al., 2000). Performance is poor in the absence of category-recognition stratagems. Categorization stratagems are employed less often by younger children than by older children (Bransford et al., 2000).

There are varying views on children's learning, and what is expected from children will have different implications in relation to these. It would be anticipated that progress in learning across most domains would be comparatively uniform if gradual increases in speed of processing or capacity were used to determine learning differences. Depending on the children's control over the stratagems that organize knowledge for learning and their conceptual knowledge, and if it is felt that stratagems and knowledge are important, it would be expected that there would be varying levels of learning.

Children's learning is also governed by another important aspect which is Metacognition (Veenman et al., 2006). Knowledge of the weaknesses and strengths in their own learning, the immediate demands of the learning task and knowledge about learning are all encompassed by prior knowledge. The fact that prior knowledge is crucial to children in determining performance should be emphasised. Self-regulation, which is necessary for effective intentional learning, encompasses the ability to orchestrate learning including planning, monitoring success and correcting errors when appropriate. It is included in metacognition (Scardamalia and Bereiter, 2003). The ability to reflect on performance is also referred to in metacognition. Reflection seems to be late in developing, however self-regulation seems to emerge relatively early. If the insight that children have into their own learning abilities is lacking they cannot self-regulate or plan efficiently.

The concept of metacognition is vague (Efklides, 2008). Most researchers agree that it involves knowledge and control of cognitive processes, however there is no agreed definition (Gumley, 2011). Distinguishing between what is metacognitive and what is cognitive is often difficult, and there is no means for assessing metacognition currently (Gumley, 2011).

Late childhood does not see a sudden emergence of metacognition. There is, the evidence suggests, a gradual development in metacognition, much like other forms of learning, which is equally dependent on experience and knowledge. There may be many reasons for this gradual development such as errors in encoding, errors in operations and errors in goal-seeking. For example, there can be errors in encoding caused by not separating irrelevant from relevant data or by missing important data. Failing to divide tasks into sub-parts or failing to select the right sub-skills to apply causes errors in

operations. Misrepresenting the task causes errors in goal-seeking.

Problems can also occur due to cognitive load. For example too many sub-skills required to complete a task or a procedure being too complex for some students who may not have learned how to carry out all the steps. There can also ability problems when students lack the needed mental abilities: for example, being able to think only concretely about specific situations when asked to think abstractly about issues and concepts (Peirce, 2003). Problem-based and project-based learning presuppose that students can access and apply knowledge and metacognitive stratagems which engage in self-regulated learning. Therefore, to learn effectively, the capacity to manage their own learning and a variety of learning stratagems and are essential (Boekaerts, 2000). The emphasis, according to recent metacognitive research, should be to balance social and cognitive competence with the need to create social, reflective and interactive environments so as to create a holistic support for metacognition (Lewis, 1998).

Engaging in reflection and self-regulation in areas that are not understood is difficult. Primitive forms of reflection and self-regulation appear early however, on subjects that children know (Veenman et al., 2006). The attempts, by pre-school children, at deliberate remembering are an indication of the initial development of the capacity to plan, coordinate, and use stratagems. A genesis of metacognition is shown by these attempts to aid remembering and an understanding that, without some effort, forgetting will occur. Older children start to use more mature forms of strategic intervention, for example rehearsal. In order to learn, between the ages of 5 and 10 years old, the use of strategic effort develops to become more sophisticated. Throughout the school years children's ability to reflect on and talk about learning continues to grow (Veenman et al., 2006).

Learning activities can be designed in the early school years, if this dawning understanding in children is recognised, so that what it means to learn and remember can be built on and strengthened.

2.4.7 Multiple stratagems and choices

With experience and age the stratagems which are used by children in order to reason, conceptualize, memorize and problem solve tend to be more broadly applied and grow increasingly flexible and effective. Age is not the sole factor for the use of different stratagems by children. Just because diverse stratagems are used by children should not be viewed as an idiosyncrasy of human cognition. To know and use multiple stratagems is based on sound reasoning. Stratagems differ in their processing demands, in their precision, in the extent of execution time required and the variety of problems to which they can be applied. Compromises, among these properties, are involved in the stratagem choices (Bransford, et al., 2005).

If children can appreciate where the range of stratagems they know are best applied, they can adapt their approaches to using these stratagems more precisely in specific circumstances. The strengths of different stratagems can be capitalized on, even by young children, who can then use each one for problems where the advantage is greatest (Bransford, et al., 2005).

As children gain experience with the domain the adaptiveness of these stratagem choices increases (Siegler, 2007). With the recognition that children know multiple stratagems and can decide which stratagem to use, the question arises of how such stratagems are constructed initially. Investigators can examine how individuals formulate their various

stratagems by giving children prolonged experiences in the subject matter. Those children who do not yet know a stratagem can, in this way, be observed as their stratagems evolve (Kuhn et al., 2000). Emerging from these studies are three major findings. The first of these is that discoveries are frequently made in the successful performance context not in response to failures or impasses. The second finding is that more enduring approaches are often preceded by short-lived transition stratagems and the final finding is that, when compelling rationales for their usefulness can be provided by children, generalization of novel approaches often occurs very slowly (Kuhn et al., 2000). New and useful stratagems are often generated by children without going through the intermediate step of having generated conceptually flawed ones.

2.4.8 Multiple intelligences

Just as the understanding of children's learning has been enhanced by the theory of multiple stratagems, there is a growing interest and influence, in the area of education, in multiple forms of intelligence. The existence of seven intelligences has been proposed by Gardner (1999) which are comparatively autonomous. These are, he proposes, linguistic and intrapersonal, spatial, bodily kinaesthetic, logical, musical, interpersonal. Gardner's proposal of the psychological theory of multiple intelligences has generated huge interest amongst educators globally since it has far reaching implications for learning and teaching. Based on this theory, educational programmes have generally focused in two ways Georghiades (2004). Firstly, that children should have each intelligence nurtured and secondly that curricula should be devised to address each intelligence directly. Because some educators believe that these intelligences receive little attention in education they favour the development of particular intelligences, for example, the personal ones. Strengths and weaknesses are possessed by each approach.

Gardner's theory has attracted three principal criticisms. First, Cohen and Swerdlik (1999) suggest that rather than being based on empirical study results it is based more on intuition. Hunt (2001) states that the theory cannot be legitimised as there are no tests to measure the intelligences, and Jussim and Harder (2002) suggest that the definition of intelligence is expanded beyond usefulness by this theory.

However, Gardner (2003) addressed the first two of these criticisms, stating that the theory was based wholly on empirical evidence and that hundreds of studies were reviewed in the development of this theory. He also states that the psychometric tests to measure intelligence are too limited, and complementary approaches covering several core components should be used. He argues that the cognitive aspects of intelligence are more appropriate and useful than psychometric test scores (Gardner, 2003).

Amongst teachers there is a new 'grass roots' movement to apply multiple intelligences to education. The attempt to modify traditional curricula is an interesting development. Whether teaching the arts, history or science there are a number of distinct approaches offered to teachers by the theory of multiple intelligences. Children can exhibit their understanding in an assortment of ways as key concepts can be presented in several modes (Gardner, 2003).

2.4.9 Motivation to understand and learn

Conceptions about how humans are 'intelligent' and learn are understood by children, who also possess their own perceptions about the minds of others as well as about their own minds (Wellman and Hickey, 1994). There are two principal belief classes, incremental and entity theories, children are said to favour one (Dweck, 1989).

Resnick and Nelson-LeGall (1998) have shown that children who favour entity theories consider intelligence to be a set property, whereas those who favour incremental theories consider intelligence to be flexible. The attributes of those who are entity theorists, in learning situations, are endeavouring to perform well, attainment of confirmed judgements on their competency, and the holding of attainment goals. They will avoid assessments which may result in a lower opinion of their work. They will easily become de-motivated and will, in the event of failure, show little perseverance (Bransford, et al., 2005). A good performance is their objective.

Children who believe that will and effort can improve intelligence will have learning goals and are incremental theorists. They demonstrate high persistence, they seek challenges, and their increasing competence is their goal. How children think about learning and how they learn affect children's theories about learning (Bransford, et al., 2005). Children may be entity theorists in art and incremental theorists in mathematics simultaneously, and therefore be positioned on the continuum between the two theories. However, motivational factors can affect their sense of failure, their persistence and their learning goals. If teachers understand that children bring beliefs to the classroom and also what those beliefs are, then children can be guided towards an improved conceptualization of their learning potential (Bransford, et al., 2005).

2.4.10 Directed learning

In intentional learning situations children often exhibit a strong desire to apply themselves relative to the privileged domains of language and physical causality when they are often self-directed learners. Children also learn in some situations, sometimes called competence or achievement learning situations, as there is no feedback or reward and no

external pressure to improve other than personal satisfaction (Dichter-Blancher et al., 1997). Novel challenges are created and pursued by children, they don't merely undertake to answer questions offered to them, and are therefore both problem generators and problem solvers. The challenge for schools is to harness and enhance, in the service of learning, children's aspiration to understand, to explore and to succeed (Piaget, 1978). There is a tendency by self-directed learners to select a course from a few narrow alternatives, which then structures their learning, rather than having pre-planned learning projects (Gribbons, 2003). However there has been criticism of self-directed learning for some years. It was suggested by Loyens et al. (2008) that self-directed learning research has been obstructed due to the continued confusion over the meaning of the term and the absence of a consistent theoretical base.

2.4.11 Guiding learning

To offer help in connecting different aspects of their knowledge is the role of effective teachers. By providing 'scaffolds' or supporting structures for the child's performance teachers attempt to extend their competencies by building on what children know (Frey and Fisher, 2010). This 'scaffolding' requires numerous tasks and activities. For example making the child interested in the task. By simplifying the task is one way of doing this, for example by cutting down on the number of steps necessary to find the answer to a problem and therefore decreasing the complexity. This serves to allow the child to administer all the elements within the process and identify if and when the project requirements have been accomplished. Another example is through motivating the child to maintain the pursuit of the goal. One way in which this can be achieved is by highlighting the divergence between the ideal solution and what a child has produced. This may cause exasperation which will need to be controlled (Bransford, et al., 2005).

In order to understand the changes in children's thinking the concept of 'development' is critical. For example, causal reasoning development, language development and the development of fundamental mathematical concepts. Children need to make sense of their world and are actively engaged in doing so. Physical and biological causality, language and number are just some of the particular domains in which children have strong predispositions to learn readily and rapidly.

Early learning is probably supported by these predispositions which facilitate competence in early learning. However a large amount of learning is still required even in these domains. By the use of absolute effort and determination children can learn virtually anything (Bransford, et al., 2005). Children need to develop stratagems of intentional learning when they need study non-privileged domains. Planning and designing, reflecting on their learning and revising all need to be understood by children. Strategic competence and understanding need to be developed by children relative to who they are as learners and what it means to learn. Children do not lack reasoning ability. They lack only experience and knowledge. Due to their inexperience children will, with the limited knowledge they possess, tend to reason in a facile manner (Bransford, et al., 2005).

In order to assist child learning adults tend to create associations linking familiar situations with new ones. Adults also support children's persistence and curiosity which then helps to structure their experiences, aids attempted learning, directs their attention and adjusts the complexity of information. Capacities that have been shaped by environmental experiences are exhibited by children. Structure is critical for learning to understand information. Learning and development should not be viewed as two processes run in parallel. Certain types of interactions are enabled by early biological underpinnings, and

through various supports, both social and cultural, children's learning experiences are expanded. Learning produces development and is regulated and promoted by both children's ecology and biology (Bransford, et al., 2005).

2.4.12 Learning styles

There is an enormous mass of learning and teaching research into learning styles. Investigators are attracted from many varied subject areas, primarily from the varied domains of the psychological sciences, but also encompassing the sociological sciences and fields such as business and education (Coffield et al., 2004). This is especially so in Western Europe (including the UK) and the United States, and there is now a mass of empirical and theoretical learning styles research. The field is expanding all the time. It commenced at the beginning of the twentieth century and is, even now, generating new concepts and a constantly flourishing number of instruments (Coffield et al., 2004).

As described by Light and Cox, learning is, "an active and meaningful construction of facts, ideas, concepts, theories, and experiences in order to work and manage successfully in a changing world of contexts" (Light and Cox, 2001). When students can choose information and arrange it into descriptions that make sense to them they produce the most from that information (Duffy et al., 2012). Learning styles are those sense making signals that establish individual variations in learning. Learning styles were generally described by Hawk and Shah (2007): "the characteristic behaviours of learners that serve as relatively stable indicators of how they perceive, interact with, and respond to the learning environment" (Hawk and Shah, 2007). In the learning styles area, researchers operating within or across these fields, have an inclination, in their own terms, to interpret theories and corroboration. Evidence regarding learning is appreciated in various different ways

from different standpoints and is directed by disputing and contrasting a whole range of theories from policy studies, education, psychological sciences and the sociological sciences.

The importance of determining preferred teaching and learning styles has been emphasised by numerous researchers. Nevertheless, ascertaining and characterizing the considerable number of learning styles can develop into a tremendous undertaking. Felder and Soloman (2000) stated that the multitude of categories and labels employed in ascertaining the distinct areas of style can be overpowering for teachers. Indeed, the learning styles domain is not united but is separated into three related fields of action: pedagogical, theoretical, and commercial (Coffield et al., 2004).

There are seven perceptual learning styles as stated by. The techniques that individuals use to acquire information from their surroundings are categorized as perceptual learning styles (The Institute for Learning Styles Research, 2010). The seven perceptual learning styles identified by the Institute for Learning Styles Research are haptic, visual, print, aural, kinaesthetic, olfactory and interactive. Individuals demonstrate predilections for learning that favours certain learning capabilities above others was the findings by Kolb from his research (Kolb, 2000). There are four fundamental learning modalities as defined by Kolb (2000), these are: abstract conceptualization, reflective observation, concrete experience and active experimentation and the learning preferences of everyone are explain by these learning modalities.

2.4.13 Preferred Sensory Modalities

Learning styles are classified by sensory modalities, which comprise kinaesthetic, visual,

tactile and auditory. Willingham (2010) were the original researchers to formulate a harmonized performance evaluation of learning styles centred on modality intensity. Modalities are defined as the conduits through which individuals acquire and store information. The educationally pertinent modalities, as defined by the Institute for Learning Styles Research (2010), are read/write, auditory, visual, tactile and kinaesthetic. The Dunn and Dunn learning styles model forms the basis for these. The Dunn and Dunn (1992) learning styles model displays properties that are available to comparatively simple environmental adaptation and blends virtues which the researchers deem to be constitutionally set. The Dunn and Dunn model was critiqued by Coffield et al. (2004), as summarised in table 3. Modality intensity and modality partiality are not the same. A modality intensity indicates enhanced performance in one or more perceptual conduits. A modality partiality is simply a preference and is typically evaluated by self-report tools. The review by Coffield et al. (2004) identified seventy one modes of learning styles.

Auditory learners employ their ears and their voices as the principal mode for learning. Many learners discover that their visual modality is more powerful in assisting them to comprehend and commit to memory novel concepts. Some individuals find their learning is enhanced when they handle materials and are physically involved in what they are learning. Some high achieving learners are able to operate in more than one modality. An individual's predominant modality is that conduit through which information is processed more competently. Some individuals also process a second modality (Hall, 2002).

2.4.14 Characteristics of learners relative to learning styles (Smialek, 2010)
Visual Learners
Visual learners memorize what is seen. They respond best to teaching that incorporates

graphs, reading, videos and posters.

Visual learners:

- are abundant note takers

- are proficient readers

- possess excellent imaginations

- are inclined to recall faces rather than names

- visualize and remember by closing their eyes

- wear carefully coordinated, neat and clean clothing

- respond well to visual presentations and illustrations

- find language, either spoken or written, which is abundant in pictorial imagery, stimulating

- favour passive, quiet environments.

Auditory learners

Auditory learners memorize what is heard. They achieve most from teaching founded on questioning, discussions and lectures. Auditory learners respond positively to singing songs or listening to dialogue that narrates to the subject matter being studied. Creating mnemonics and rhymes also contributes to helping auditory learners remember information.

Auditory learners:

- recall names, but are inclined to forget faces

- are particularly responsive to phonics instruction

- usually enjoy talking while writing

- may not match clothing but can rationalize what they are wearing with reasons

	Strengths	Weaknesses
General	Includes social interaction, environmental elements, motivational and psychological factors and is a user friendly model.	Simplistic connections tend to be made between psychological and physiological brain activity and preferences by this model.
Design of the model	• The adoption of specific techniques and changes to the environment such as sound and light form the basis of this method relative to the children's preferences.	• It is not a model of learning but a model of instructional preferences. • Adoption of ideas from other domains, modality preferences for example, is unsophisticated.
Reliability	Strong claims for reliability are made by supporters.	Critics have highlighted problems with the key instruments reliability and design.
Validity	Strong claims are made by supporters relative to its validity.	Critics state that there is a lack of evidence relative to validity.
Pedagogy implications	The following claims are made: • It is possible to discern individual differences in preference. • These preferences can be met by adapting pedagogy and environments. • An intervention will have a greater effect the stronger the preference.	• No other options are considered since the implications for pedagogy are so vehemently expressed. • Simplistic ideas regarding 'best practice' made lead to learners being labelled.
Evidence for pedagogy	• A broad international programme of research has been generated by this model.	• Many questions still need answering relative to effect sizes. • The learning styles inventory still lacks independent evaluation.
Overall assessment	The claims made relative to impact are still questioned due to a lack of independent research and limitations in some of the supporting studies, even though there is a large and evolving research programme.	

Table 3. Dunn and Dunn's model strengths and weaknesses (Adapted from Coffield, Moseley and Hall, 2004; Dunn and Griggs, 2003)

- like to talk or hum to themselves

- get pleasure from listening to themselves and others

- enjoy reading out loud

- memorize and recall by verbalizing

- find complex diagrams such as maps difficult to understand

- continue to concentrate even in a noisy environment.

Kinaesthetic learners

Kinaesthetic learners learn by action, participation and experimenting. Kinaesthetic

learners:

- need to be active, take numerous breaks and constantly move around

- tend to converse with hand gestures

- may struggle to remain focused

- enjoy role playing

- perform better with hands-on teaching

- will recall what was done, not what was heard or seen

- constantly seek excuses to move around

- will meddle if uninterested

- like to directly experience

- gain stimulus by manipulating materials.

Tactile learners

Tactile learners use their fingers and hands to learn. Tactile learners:

- need to handle and have touch sensation of objects in order to learn a new concept

- gain by doodling, writing and drawing, and are inclined to be creative

- gain most from teaching that includes such activities as drawing, sewing or painting

- get pleasure from designing

- enjoy illustrating textual work

- gain relaxation from craft work such as drawing, painting and sculpting

- like kudos to be physically expressed to them.

As the learning style theory proposes, learners have a principal learning modality followed by their second, third and fourth preference style. Learners whose styles are congruent with the teaching style are inclined to utilize the lesson content more successfully and remember information longer, and post-course attitudes toward the theme are more constructive. However, those who encounter learning style - teaching style mismatches tend to have the opposite experience.

This disparity puts a significant proportion of the student populace at a disadvantage. If there are excessive mismatches, the learner's interest is likely to be lost. If each learning style modality were focused on at least some of the time by teachers, the difficulties might be reduced and the quality of education considerably improved.

The learners could all be taught using an approach that frequently matches their learning styles, consequentially advancing successful learning and constructive attitudes. To attain the required balance does not require massive modifications in teaching style. To meet the needs of all the learners, regular use of a small quantity of supplementary teaching modes in a lesson should be adequate.

The conviction that learning styles are set has resulted in the strange suggestion that marriage partners ought to have compatible styles. Another example is that individuals from socially deprived groups are predisposed to possess a specific learning style. Notwithstanding the rejection of these radical instances, the concept of learning styles is inclined to suggest something set, permanent and stable with time. Various theorists, however, have formulated diverse assertions for the level of stability contained in their

learning styles model. A few theories characterize learning styles as 'flexibly stable', contending that different environmental aspects and prior learning experiences might produce approaches, stratagems or preferences not learning styles; or that learning styles might differ depending on the context or change depending on the task.

It is achievable to produce well-founded and relatively reliable assessments, and these can have prognostic as well as diagnostic application to improve learning is a view held strongly by supporters of this opinion. Smith et al. (2002) established, after re-examining the evidence, nine investigations demonstrating a greater success in learning where there was a mismatch in teaching and learning styles and nine that demonstrated a greater success in learning achieved where there was a match. They found that "for each research study supporting the principle of matching instructional style and learning style, there is a study rejecting the matching hypothesis" (Smith et al., 2002).

However three empirical investigations of mismatching and matching have been performed (Ford, 1995; Ford and Chen, 2001; Chen and Macredie, 2002). These studies, which were comparatively small but meticulously designed, found that matching was correlated with enhanced performance in all three studies. Another criticism of the learning styles theory is that it 'labels' learners (Pashler et al., 2008) which may lead to the negative consequence of learners viewing themselves as being capable of learning only through one modality. Evidence was produced by Lovelace (2005) which confirmed the Dunn and Dunn model's validity and stated that "matching students' learning-style preferences with complementary instruction improved academic achievement and student attitudes toward learning."

2.4.15 Active Learning

A significant level of accord exists in the work of investigators that active learning has a long-lasting and constructive effect on children's learning in primary school (Stephen, 2006).

When learners have sufficient opportunities to question, clarify, consolidate and apply new knowledge, an expanding mass of research has established, the general quality of learning and teaching is enhanced. This is in contrast to the traditional view that education was principally a process of broadcasting ('dispensing knowledge into hollow containers') (University of Minnesota, 2008).

Many teaching stratagems exists to actively engage children in the learning process and these may be used by incorporating case studies, group discussions, journal writing, problem solving and role plays. The advantages of utilizing these types of activities are numerous. They include enhanced critical thinking ability, increased motivation, improved transfer and retention of new information, and enhanced interpersonal skills (University of Minnesota, 2008). However, the use of active learning is not without its challenges. When adding active learning to their repertoire of teaching stratagems, teachers are frequently confronted by disinterested students, classroom management issues and time pressures.

Table 5 demonstrates the very positive effect active learning has on the retention of knowledge relative to the level of active learning used. Active learning is study that challenges and engages learners thinking via imaginary and real-life situations. It takes complete advantage of the opportunities for learning offered by (Stephen, 2006; Seed, 2001; Seed, 2006):

- focused teaching and learning

- exploring and investigating

- life experiences and events

- spontaneous play

- purposeful and planned play

assisted, when required, with perceptive intervention to extend or support learning.

Active learning can encourage learners to develop in the four capacities in many ways. For example (Stephen, 2006; Seed, 2001; Seed, 2006):

- successful learners

  o by utilizing their creativity and imagination, undertaking new experiences and learning from them and developing significant capabilities including numeracy and literacy by investigating and exploring and whilst pursuing their individual interests

- confident individuals

  o by being successful in their activities, having the fulfilment of a activity completed, learning about overcoming obstacles, and coping with safety risks

- responsible citizens

  o by finding various ways of viewing the world, learning to share, learning to value and appreciate themselves and others, and participation in decision making

- effective contributors

  o by playing collectively in supporting or leading roles, dealing with problems, expanding communication proficiency,

participation in prolonged thinking and talking, and valuing the

views of others.

Learner is passive	Learner is active
• It is presumed that the children's minds are 'empty vessels' that need to be filled with knowledge. • Lecture style – the children are passive note takers, the teacher verbalises the information. • Only 10% of the content of each lesson is remembered by learners. • In assessments the learners simply repeat remembered knowledge. • The expectation on learners is that they record and absorb knowledge.	• During lessons the learners engage in activities. • The emphasis on learners during lessons is to 'find out' for themselves. • Up to 50% of the content of each lesson can be remembered by learners. • The learners test and use concepts and facts. • The teacher guides learners to develop the skills to construct and use knowledge. • Active learning methods are employed.
The teacher	**The teacher**
• Teachers are only required to know their discipline they are not required to know how to teach.	• A learning environment is created to allow learners to restructure new information, together with their prior knowledge, into new knowledge. • Process and concept illustrations and examples are provided. • How to teach each topic has been given sufficient thought. • Acts as a coach and facilitator.
Teachers compile their course and then teach this course with little or no effort – considered a routine activity.	This teaching is viewed as complex and dynamic. With endless revisions needed to teaching and delivery methods.

Table 4. Contrasts between active and passive learning (Adapted from McManus, 2001 accessed in Las Positas Collge, Active Learning = Remembering = Learning)

Creating a more active method for learning necessitates a focus on (Scottish Executive

education department, 2007):

- growth in children's learning and development

- encouraging consistency in development and learning

- creating the right environment and atmosphere for learning

Percentage retained in memory	Active / Passive	Example	Comment
10% of what is heard	Very passive	Verbal lecture	Most 'standard lecture style' teaching
30% of what is seen	Passive	Verbal lecture with visual aids	
50% of what is seen and heard	Beginning to get active	Interactive presentation	The most that can be achieved with 'lecture style'
70% of what is evaluated and performed	Active	Problem solving	Experiential learning
90% of what is evaluated and verbalised	Very active	The child explains	Study groups and tutoring

Table 5. Retention in memory relative to active learning (Hanna, 2010)

In general children begin primary education as independent and enthusiastic learners who are well versed in taking decisions and initiating their individual problem solving and learning. They will bring a variety of skills which also includes very basic numeracy and literacy, and the capacity to utilize these skills in focusing and engaging during learning activities. They will be keen for new learning to expand their knowledge of nature, places and people. Most will react favourably to exciting learning and teaching that questions their thinking. Teachers should develop this by devising methods of learning which reflect these interests, needs and enthusiasms (Scottish Executive education department, 2007). The contrasts between active and passive learning can be seen in table 4 (McManus, 2001).

Some of the main criticisms of active learning come from teachers and relate to time and resources. The activities included in active learning can be challenging for a teacher. It is a frequently-cited concern by teachers that they cannot cover as much content in the time available when using active learning, and this together with increased preparation time causes problems in completion of the syllabus in the required time allotment. In some situations, planning and preparing for the activities may be financially costly and time

consuming. Teachers also state that the use of active learning is prohibitive with large class sizes. When teaching aids or transportation or specific materials are required for the activity, teachers might be wary about employing it. Furthermore, within group activities, fear of derision can lead to participants simply agreeing with a few dominant characters and not expressing their views or ideas. Care must also be taken to eliminate the problem that participation may not ensure contribution. Learners can remain unfocussed on the activity whilst appearing to be focussed.

The traditional hierarchical teaching exemplar, which differs from the programme of learner involvement, is that children are considered as 'empty vessels' that need to be filled with knowledge and that should be done by teachers who 'know' teaching children who 'don't know'. For some learners, active learning can be a novel experience, but it can be also a novel experience for some teachers. Some learners may have had a previous negative experience or may not have encountered this style of learning, therefore particular consideration may be required. Regarding learner participation, it is essential to realise that individuals that have had beneficial encounters with previous learning which permitted them to participate will usually have a more constructive approach than others who have had negative encounters.

Attaining an environment for learning can be achieved by the following (Stephen, 2006; Seed, 2001; Seed, 2006):

● Splitting the class into smaller groups

● Keeping the children moving to different groups

● Developing teams

● Encouraging learners to work collectively

● Quizzing and listening to learners.

Both the National Institute of Education and the U.S. Department of Education

emphasised, as an essential requirement to achieve excellence in education, learners'

participation, commenting,

> "It is not only the amount of time one can allocate for learning but the quality of
> effort within that time that makes the difference. . . quality of effort refers to the
> extent to which learning is active rather than passive and schools clearly can control
> the conditions of active learning by expecting students to be participants in, rather
> than spectators of, the learning process. Students learn best when they are actively
> involved in the process. Researchers report that, regardless of the subject matter,
> students working in small groups tend to learn more of what is taught and retain it
> longer than when the same content is presented in other instructional formats.
> Students who work in collaborative groups also appear more satisfied with their
> classes." (US Department of Education, 1984)

To assist in the achievement of an active learning scheme (Clarke, 2004), the following

should be pursued:

● Establish problem-solving actions in small groups and have all groups

　disseminate to the rest of the class

● Promote reflection

● Promote the challenging of ideas

● Offer learners real-life, concrete situations to examine

● Encourage learners to propose novel activities

● Make sure that time taken for each activity is valid learning

● Discern crucial concepts

● Make sure that learners contribute

● Endeavour to create interesting assignments to maximise involvement

● Combine two categories of knowledge: every day and theoretical.

2.4.16 Fundamental components of active learning

There are four fundamental learning activities by which all learners learn (University of Minnesota, 2010). Particular active learning stratagems use at least one and usually more of these components.

Reading

Learners do much of their learning by reading. Active learning tasks such as note checks and summarising can aid student's process what they have read which helps develop the capability to concentrate on significant information.

Writing

Like active listening and talking, writing presents a method for learners to review novel information using their own words. Independent learners also find this appealing.

Listening and Talking

By talking about a subject matter, whether explaining a point to another learner or answering a teacher's question, learners arrange and consolidate what they have learned. While listening they are relating their existing knowledge to the auditory stimulus. It is vital, in a learning environment, that they have regular breaks from passive listening to absorb what they have heard.

Reflecting

Learners require time to contemplate and consider, to link what they have recently learned with their existing knowledge, or to apply the knowledge they have acquired. Permitting learners to pause for refection is one of the most basic means to enhance retention. The retention in memory relative to active learn is demonstrated in table 5 (Hanna, 2010).

2.4.17 Stratagems for active learning

There are four general learning stratagems that can be used in an active learning

environment (University of Minnesota, 2010): collaborative tasks, paired activities, solitary activities, and informal small groups. The choice of these will be dependent on the physical space, the size of the class, the extent of available time to devote to the activity, and the objectives.

2.4.18 Active learning - planning an activity

When arranging an active learning lesson the following issues ought to be focused on (University of Minnesota, 2010). Objectives should be defined for each activity, and the timing of the activity in the context of the whole class should be planned. The nature of learners' participation should be considered (learning individually, in pairs, or in small groups), as should the locus of discussion (in groups, teams or whole class). The outcome and outputs from the session also require thought.

2.4.19 Summative and formative assessment

Classroom evaluation can incorporate a broad array of options – from documenting anecdotal observations on a pupil to administering standardised examinations. Summative assessments and formative assessments are the two separate categories that can be chosen.

To evaluate the efficacy of instructional courses at the conclusion of an academic year or at a fixed point in time summative assessments are characteristically employed. The objective of summative assessment is to form a considered opinion about pupil competence – following the conclusion of an instructional segment, i.e. the determination of each pupil's competence at fixed instants in time. Summative assessments are employed to establish if pupils have mastered explicit competencies.

The appraisal and summary of the learning and the progress of learners at a specific time points is referred to as summative evaluation or summative assessment. Subsequent to a phase of work, the pupil undertakes an examination which is then marked by the teacher who assigns a score. Learning is summarised up to that point by examination. Any weaknesses found, by using the examination analytically, can then be addressed by formative assessment. The categorisation of summative assessment is that it is the assessment of learning while the categorisation of formative assessment is that it is the assessment for learning. The general characteristics of summative assessment are that it uses well-defined evaluation designs; usually has fixed content and time; provides descriptive analysis; all activities are taken into account in order to assign a grade; and is non-oppressive and non-reactive as far as possible.

There are many criticisms of summative assessment, the main one being the de-motivational effect and the lowering of self-esteem that these types of assessments can have on some students. However, this assessment type can provide evidence for evaluating courses and teaching approaches which can then be modified.

Formative assessment is a procedure to advance pupil achievement and is considered as self-reflective (Crooks, 2001). Yorke (2003) characterises it as, "the bidirectional process between teacher and pupil to enhance, recognise and respond to the learning." An assessment is considered as 'formative' when adjustment is made to the instruction, to fulfil the learner's requirements, using the response to the learning activities (Black and Wiliam, 1998). Formative assessment and feedback studies were reinterpreted (Nicol and Macfarlane-Dick, 2006) and have exposed how these methods can assist pupils to take

charge of their 'self-regulated' or personal learning. Classroom assessment and educative assessment are other names for Formative assessment (Guskey, 2005).

Assessing the formation of the pupil is a description of Formative assessment. This is achieved, by teachers, by assessing pupils as they: Ask questions, Respond to questions, Work collectively with other pupils in the course of activities, etc. The teacher is then able to appraise the relevance of the subject matter and their own approach.

One criticism of formative assessment is that only a limited amount of empirical evidence exists that supports best practice, especially relating to which groups would benefit most from formative assessment. However, favourable effect sizes ranging between 0.4 and 0.7 were reported in a study performed by Black and Wiliam (2010) which support the use of formative assessment in classrooms.

2.4.20 History and objective

The expressions 'formative' and 'summative' assessments were coined by Michael Scriven (1967). He made the distinction between the two in terms of how this information was used and the objectives of the information sought. Formative assessment as a foundation was included in 'Learning for Mastery' by Benjamin Bloom (1968). Formative assessments can be related to teaching components in a range of content areas. This was the conclusion of Hasting and Madaus (1971) who included formative assessments in their 'Handbook of Formative and Summative Evaluation' also demonstrating the relationships.

Formative assessments have developed as a method to adjust the teaching to learners requirements (Crooks, 2001). Traditionally summative evaluations were employed for the

purpose of ranking and formative evaluations were of taught elements. Formative assessments are intended to impart vital feedback for pupils and teachers and are a very useful component of teaching. The knowledge of what has been taught adequately and where extra teaching is required is gained by assessment results which keep the teacher updated.

Conversely, they impart vital feedback to pupils as to what they have learned satisfactorily and what gaps are still apparent. In contrast with summative assessments intended to generate conclusions regarding grades and pupil accomplishment the enhancement of learning is the function of a formative assessment. Formative assessments are strongly associated with teaching quite the reverse of benchmark examinations which are used to estimate pupil achievement on other tests (Crooks, 2001).

An integral component of teaching and the instructional system is how formative assessments are considered today. They produce (Crooks, 2001):

Non-threatening results

The fact that assessments are scored but not ranked is a main characteristic of formative assessments. Encouragement is given to learners to pose questions regarding information covered by the assessment and the assessment itself.

Immediate and direct feedback

Assessment results are produced immediately with formative assessment teachers and learners obtain them instantly. Pupils acquire vision of their progress and teachers acquire vision of class performance and the individual performance.

Structured information

Using the formative results teachers can assess achievement and design enhancements. Learners experience achievement and can see improvement. The assessment results allow both learners and teachers to learn.

Ways to improve

The teacher can return to subject matter if required as long as the formative results are concise. Individual pupil responses present a basis for offering pupils supplementary experiences in topic areas where they performed below the required level.

Critical to the effectiveness of formative assessment are three fundamentals (Royce-Gibbs and Simpson, 2005). These are assisting pupils to identify the required goals; supplying evidence to learners so that they have an illustration relative to the goal and how well their work corresponds with it; and describing approaches to reduce the gap between their present performance and the goal. The significant lessons from studies about formative assessment can be summarised by five points.

Assessment that advances learning: requires that both teachers and learners comprehend and share the same learning goals; assists learners in the comprehension and identification of the required standards; requires that learners are included in self-assessment; that learners, helped by feedback, can identify what the next steps are and how go about taking them; that self-confidence is developed by learners that their work can be improved.

2.5 Health education

2.5.1 Harm management stratagems

Physical harm is the principal basis of mortality and impairment in children in nearly all developed countries (Baker et al., 2002). In substantially industrialised nations, for instance the USA, physical harm accounts for larger child mortality than alternative numerous principal reasons for mortality added together (Hoyert et al., 2003). Physical harm accounts for around fifty percent of child fatalities in the USA (Center for Disease Control and Prevention, 2012). The epidemiological data is clear, physical harm represents the most common risk to the wellbeing and health of children. Alternative outcomes consist of the societal effect on relatives of harmed children and the consequent load to the healthcare programme for difficulties that may be avoidable. The improvement and growth of harm management stratagems necessitates targeting physical harm, and requires assessment relevant to the kinds of interventions better used to decrease harm rates. The management of physical harm may be engaged with using a range of stratagems. Harm management stratagems may be passive or active; the stratagem may be directed at general populations, communities or individuals and the stratagem could entail policy modifications to encourage safe behaviour and minimise unsafe behaviour. With a variety of accomplishments and also a few confines, so as to focus consideration to several investigative issues, harm management has been sought from all of these standpoints.

2.5.2 Active and Passive Harm Management Stratagems

Williams (2002) states that interventions made with populations or individuals are repeatedly characterized as passive or active. These concepts, as stated by Sleet et al. (2010), should to be observed on a continuum, however the perception is that these are

divaricate and outwardly independent. Active prevention stratagems necessitate frequent engagement by people so as to realise harm protection, for example automobile users have got to personally and dynamically wear a seatbelt. Passive prevention necessitates partial or no personal engagement. Legislatively prescribed child-proof tops on medication and toxic substances, safer road planning, air bags in automobiles and flame-resistant night-wear are all illustrations of passive interventions. Environmental or structural interventions are other terms for passive intervention. Passive intervention is usually commune in scope or specifically populace oriented; it is not targeted towards individuals and their engagement as active prevention interventions are. The empirical facts are mounting to affirm the efficacy of passive and active interventions for harm management. Consequently, the limits of each category are becoming apparent and necessitate enhanced consideration to conquer them.

2.5.3 Passive stratagems

The principle on which the passive view of harm management is established is that an effective method is evidently successful and dependably and reliably used (Sleet et al., 2010). Passive methodologies minimize the requirement for personal engagement so that safety is attained by a onetime adjustment of the environment or by design. The aims of this method were profiled, by Sleet et al. (2010) as comprising:

- New hazards should not be generated,

- Eradication or adaptation of existing hazards,

- Instigating passive stratagems to diminish risk from un-modifiable hazards.

A passive policy for averting falls from windows illustrates the empirical proof for the efficacy of passive prevention. McClure et al. (2005) described a health code restriction in

the USA for window screens to be fitted in elevated apartment buildings housing children. They ascertained that these shields decreased child falls by fifty percent. Also in the United States governmental regulations have targeted child poisoning. For instance, the Poison Prevention Packaging Act (1970) mandated child-resistant lids for medicines and domestic (consumer) toxic substances. Child poisonings reduced considerably after the new laws were enforced (Rodgers, 2002). Alternative statutory methods have reduced passivity and necessitate additional engagement by people, for example laws demanding the use of seatbelts - changing relative to seating arrangement or age. As a common rule, passive interventions have been successful when applied and made obligatory (Zaza, 2001; Ekman et al., 2001). The effectiveness of passive stratagems is partial, and there are also questions concerning whether passive stratagems may actually be implemented.

Occasionally, injury prevention interventions have delivered novel hazards or problems. For instance, difficult to open, 'child-proof' lids on medicines make unfastening challenging for adults with disabilities, for instance, arthritis; therefore the consequence could be that numerous lids are not locked back onto the container at all. Moreover, a critical constraint is the problem of having passive interventions acknowledged and applied (Ayers, 2007). A study by Sharrard et al. (2005) stated that passive stratagems were not reducing child injury in Australia because older users were not re-applying the child-proof lids after use. Sharrards' study (2005) used an intervention to educate older people in the use of these passive stratagems. Since the child injury rate was much greater in rural areas the interventions were centred in these areas. However, the study showed no positive effects from the intervention. The study used participants that had a higher level of education than the general population. There was also a lack of an adequate age range. As this study was performed on a rural population there is a concern that, since more chemicals and

medicines tend to be stored as access to shops was very limited, the children in the study were more familiar with safety practices. There also tends to be an imperfect fit between what those involved in policymaking view as important passive prevention stratagems and what others may view as important and worthwhile changes. This view can also be skewed by relevant industry input into government departments if a change in legislation could cost the industry more money or make them less competitive with other producers. This can inevitably lead to the watering down of any proposal or the abandonment of the proposal altogether. In general, conversely, passive interventions continue to be a notably successful approach, although not relevant to all circumstances.

2.5.4 Active stratagems

Active prevention depends on people undertaking actions on their own behalf. There are constraints to the effectiveness of active prevention. Conversely, an expanding investigative literature suggests means to evade these restrictions to deliver feasible, effectual intervention stratagems for harm management. Where passive prevention has been demanding or unattainable so the focus of social science investigations has centred on the active prevention of those harm creating circumstances. Roberts et al. (2003) and Ayers (2007) determined that optimum harm management, when passive stratagems are unsuccessful in some respect, necessitates active stratagems.

Gielen et al. (2003) evaluated, for problems such as domestic hazards, the psychological and behavioural contributions to harm prevention. Passive interventions have not completely ameliorated these hazard-harm creating circumstances which are amongst the most critical for children. An intricate series of safe behaviours have been imparted via application of behavioural psychology. An example of this is Mayhorn et al.'s (2006) study

to educate children in the age range 3 to 6 years old about household hazards and warning symbols. This study successfully demonstrated that such children could acquire safety information by the use of symbols and pairing the information to the symbol which would then be paired to the particular household item. However, Mayhorn et al.'s (2006) study results should be viewed with caution as the number of participants was low. Also, since this study was performed on children in the age range 3 to 6 years old there are some concerns regarding the intervention procedures and educational content relative to the ages of the participant children and their cognitive abilities within this age range. This study was performed in a day-care centre and so this setting and the length of time for which children in this age range can remain focussed on the tasks may detract from experimental control. The 'Safe at Home game' has been used as a behavioural education method to educate those children who, with no adult supervision, reside at home in domestic safety (Hardy, 2002). The curriculum encompassed food selection and preparation, emergency responding and encountering strangers. Children exhibited substantial growth in their knowledge of how to react in an emergency situation after teaching using rigorous teaching methods. This successful active intervention programme for child domestic safety used a range of teaching designs.

Most active interventions employing behavioural techniques frequently display some deterioration in the operation of safety behaviour eventually. Nevertheless these safety behaviours may rapidly be restored back to elevated levels with supplementary teaching or re-teaching. An exemplar of this was given by Hotz et al. (2004) who established that children who were initially instructed in the correct street-crossing behaviour exhibited only 50% of the correct behaviours one year later. Conversely, with remediation teaching of just one supplementary class, they re-established their elevated level of accurate response. It

has been shown that analogous booster sessions are necessary after teaching for alternative safety behaviours (Hardy, 2002).

Health education, as such, has not been outstandingly effective. Even though instructive curricula is now frequently viewed as essential and fundamental for numerous active interventions it is not considered adequate to transform behaviour in substantial numbers of people over the long-term (Klassen et al., 2000). In health education interventions great consideration is given to the relative scientific merits of different designs, and major significance is placed on the nature of the principal effect evaluated. Even though educational programmes share a common objective, comparatively few formal assessments use actual decline in harm rates as their end point. In place of this, some investigations evaluate modifications in behaviours thought to be proximally linked to injury prevention. Others evaluate the acquirement of knowledge. Yet others depend purely on process measures, for example the quantity of posters erected or leaflets circulated.

Evidently, investigations that incorporate figures outlining transformations in the real rate of injuries are of paramount significance. They are, though, exceptionally challenging to perform due to the substantial numbers of subjects necessary. Consequently, it is not unexpected that numerous investigations rely on proxy measurements of efficacy. Disappointingly, the correlation between these measurements and the true decline of injuries is frequently open to question.

An array of other investigations employing survey data and quasi-experimental models have been completed that offer additional insights into our comprehension of a programme's impacts (Gibson and Leitenberg, 2000; Finkelhor, 2007). As a set, both the

non-randomized and randomized investigations have evaluated an array of populations and programmes, used a range of study designs, and employed various outcome measures (MacMillan et al., 2009).

The majority of the investigations study the effect of classroom centred teaching on pre-school and primary school age children and comprise the evaluation of the knowledge gained and, to a lesser degree, the behaviours and skills, and the measures used are usually pre-test and post-test comparisons. An example of this is the study by Black (2004), which measured the effect of the Home Instruction for Parents of Pre-school Youngsters (HIPPY) educational intervention programme which includes child safety education. The study produced valuable insights into teaching children such as the utilization of characteristics and abilities which engage children in positive social interactions and the use of specific language for specific purposes. The efficacy was measured by the use of the pre-test post-test research design. However, there are several problems in the study design. Firstly, there was no longevity check to determine whether the knowledge was retained for a reasonable length of time, the results were simply based on the immediate post-test result. There was also an ethical issue as the comparison group did not receive any safety teaching, so its members were more at risk than the experimental group. The fact that children do learn from the event is usually deduced from the majority of investigations however the usual finding is that such learning is neither universal nor comprehensive (MacMillan et al., 2009).

Gradually, though, psychological concepts calculated to increase learning and produce modifications in behaviour have been incorporated into health education interventions. Enriched education for injury prevention has been acknowledged by the World Health

Organisation (2008).There is also mounting evidence that health education endeavours have been successful in harm reduction in various sectors including general domestic safety (King et al., 2001).

2.5.5 Multi-faceted techniques

Public health application comprises a broad spectrum of methodological and theoretical approaches, which requires the affirmation of numerous professionals and disciplines encompassing psychology, social sciences and medicine (Triletti et al., 2005). This multi-disciplinary method recognises that specialists from various disciplines and from diverse backgrounds with different experience present distinct elements of data to close the gaps in the enigma of comprehension relative to intervening with un-intentional physical harm. A Multi-faceted and multi-disciplinary approach is essential to target additional facets of a complicated situation (Barss, 2000; Triletti et al., 2005).

However, the methodological limitations that are frequently encountered in applied research also apply to the appraisals of child injury prevention interventions. Problems of inadequate design and measurement stratagems and low sample size are frequently quoted. To establish, with respect to the skill and knowledge levels detected, if the changes in these investigations are as a consequence of the intervention effects or natural maturing, or other educational activities or other factors, is problematical. The appraisal of changes in children's behaviours, attitudes and knowledge is possibly the most important constraint found amongst this mass of research.

2.5.6 Health promotion investigations

Health promotion has particular grounds to re-evaluate the approach taken towards

investigations. It necessitates stratagems and methodologies which makes activities and their effects evident with metrics that assess pertinence and confidence of investigative conclusions. The question 'do the programmes work?' is not the issue the critics focus on; the issue usually focussed on is 'should the programmes be offered?' (Tutty, 2000). The only partial capability of this type of teaching, to protect school children, has been the focus of the most incisive critiques.

Towner and Dowswell (2002) reaffirm the doubtful capability of such interventions to change behaviour, especially amongst young children. Quoting seventeen research papers, they observe that the extension of prevention intervention efforts tends to be founded upon "the strength of their positive goals rather than on a systematic evaluation of their effectiveness." Towner and Dowswell (2002) contend it is not confirmable that the interventions are attaining their objectives on the foundation of the empiric evidence.

Koelen et al. (2001) summarised the main points as:

- Research in health promotion needs to use methods, other than traditionally used biomedical research methods, as it entails investigation of different issues. In less countable areas the indication of health promotion success using conventional investigative techniques and methodologies is inadequate.
- Research needs to produce knowledge regarding the reasons why and how health promotion programmes are successful not just about the efficacy of interventions. The intention to continue collaboration can be considered a success factor along with others such as inter-sectoral action taking place.
- Combinations of qualitative research techniques give a full view of conditions for improvement, achievements and processes, contrasted with solitary qualitative

investigative methods that might offer only a partial insight. In order to measure change and innovation health education research functions as a tool. This tool can also help to facilitate these outcomes.

The capability of children to react to a series of questions may or may not represent a significant or meaningful change as a consequence. Contrasting mean achievement between control and test groups is the usual method employed by investigators. The investigation of individual achievement differences may, however, allow further information to be acquired. Only a few investigations have evaluated concurrently two or more techniques of presenting the information to children.

Whether a particular curriculum has any significant influence on behaviour, knowledge or attitudes can be determined by comparing means which is of value in this category of investigation. However, determining if particular sets of children produce a greater response than others or whether one particular curriculum is more productive than another is of more value.

There is mounting acknowledgment of the distinct ability of qualitative approaches to supply enlightening perspectives and the extensive epistemological foundation of health promotion studies (Green, 2000). The fifty first World Health Congress appealed to all countries, ".... to adopt an evidence-based approach to health promotion policy and practice, using the full range of quantitative and qualitative methodologies ..." (W.H.O., 1998a).

Additionally the World Health Organisation proposal to policy makers on health promotion

assessment (W.H.O.,1998b) also asserts robustly that "*... the use of randomized control trials to evaluate health promotion is, in most cases, inappropriate, misleading and unnecessarily expensive ...*"

It also encourages utilization of numerous methodologies (Towner et al., 2001). The majority of appraisals performed on these interventions state that they achieved significant, but not always large, increases in children's knowledge, and this was the conclusion of at least six key critiques (Towner and Dowswell, 2002; Topping and Barron, 2009). Generally, the interventions that were evaluated showed a statistically significant, albeit small, increase in knowledge gained through the effects exhibited. This was the finding of a meta-analysis which re-appraised the results from thirty such studies (Herbert, 2001). The efficacy of these interventions was greatest in the primary school age population even though these findings pertain to interventions which targeted the broad spectrum of age groups.

However, caution is justified concerning the positive results because of the conceptual and methodological limitations of some of these investigations. A considerable proportion of children who took part in these courses were already knowledgeable about the concepts at the commencement of the courses. However, over time the stringency of appraisals in this field has increased. This has helped to shape both the focus and the content in health education intervention programmes. Whether all the essential components of a course are in position should be considered.

Type III error can be detected by using this mode of examination, in the perspective of assessment, which is defined as the repudiation of the efficacy of a course when the

course itself was unsatisfactory and this may be by virtue of its delivery, design or content (Green, 2000). Particularly susceptible to type III fault are courses created on an extemporized footing - which may be designated as the 'suck it and see' method (Green, 2000). Scarce consideration of type III errors are usually paid by schematic reviews. The worth of the intervention per se is usually not the focus as the exclusion and inclusion criteria normally concentrate on the design of the appraisal element of investigations (Green, 2000). The anxiety is usually with developing criteria to guarantee the evasion of unfounded declarations of success, characteristically for the reason that there are unsatisfactory controls – this is generally denoted as type I error (Green, 2000). The investigations merit is consequently ascertained relative to the assessment methods, often neglecting the quality of the course itself (Green, 2000). The lack of success using a straightforward input-output type assessment that attends to the health promotion intervention intricacies has been criticised by numerous authors. The fact that assessment ought to be concerned equally with both process and outcome signals have been very well established (NSVRC, 2011). How these signals are identified and selected has been the fundamental problem. Using a comprehensive theoretical analysis can ascertain a World Health Organisation array of possible results which can act as a foundation for choosing those designated as the most pertinent (NSVRC, 2011).

2.6 Knowledge and Memory

Knowledge acquirement is the procedure of assimilating and accumulating novel knowledge in memory. How successfully this is accomplished is frequently determined by how effectively the knowledge can be retrieved at a later time (recalled from memory). The procedure for retrieving and storing knowledge is heavily dependent on the organization and representation of the knowledge (McNamara and O'Reilly, 2002). Additionally, the

usefulness of knowledge may additionally be shaped by how the knowledge is ordered. Knowledge acquirement can be enhanced by taking into consideration the function and purpose of the desired knowledge (McNamara and O'Reilly, 2002).

2.6.1 Knowledge organization and representation

How knowledge is organized and represented in the brain is described by many different models including distributed networks, propositional models and rule-based production models. All these models, however, are essentially founded on the semantic networks theory. This theory was developed by Light and Carter-Sobell (1970). In this theory, knowledge is represented as an array of links connecting concepts in memory.

2.6.2 Semantic networks

Semantically associated concepts are interconnected and knowledge is ordered relative to meaning (Novak and Canas, 2008). Characteristically, knowledge networks, are symbolized as node diagram links, that is, relations between concepts. Usually numerical powers are assigned to denote intensity in memory. Figure 7 shows the node signifying CHEMIST is powerfully connected to SPATULA, however CHEMICALS is weakly connected to SPATULA. The connection intensities are symbolized here by width of line.

Mental activation disseminates unconsciously from one concept to another connected concept (Novak and Canas, 2008). For instance, thinking of CAKE disseminates excitement to connected concepts, for instance CREAM and ICING. These concepts are called 'primed', and so are more simply identified and recalled from memory. Network models symbolize much more than straightforward connections.
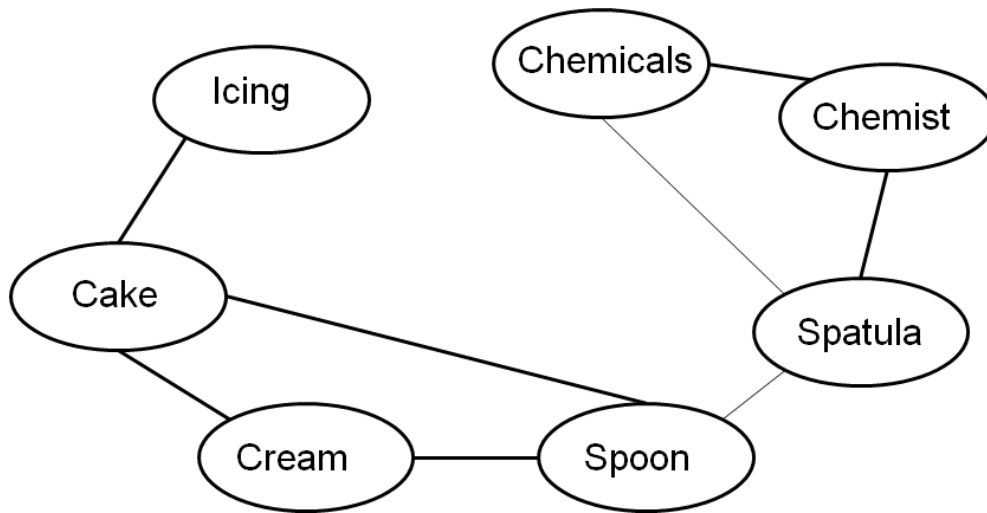
Figure 7. Example of a Node diagram showing connections and intensities

They correspond to the complex relationships and ideas that encompass comprehension and knowledge (Guastello et al., 2002). For instance, the concept "The chemist uses a spatula" can correspond to the suggestion USE (CHEMIST, SPATULA), which is comprised of the nodes CHEMIST and SPATULA and linkage USE (see Figure 8). Educationalist have effectively used comparable schema, termed 'concept maps', to convey significant attributes and relations amongst the key concepts of a lesson (Pintrich, 2002).
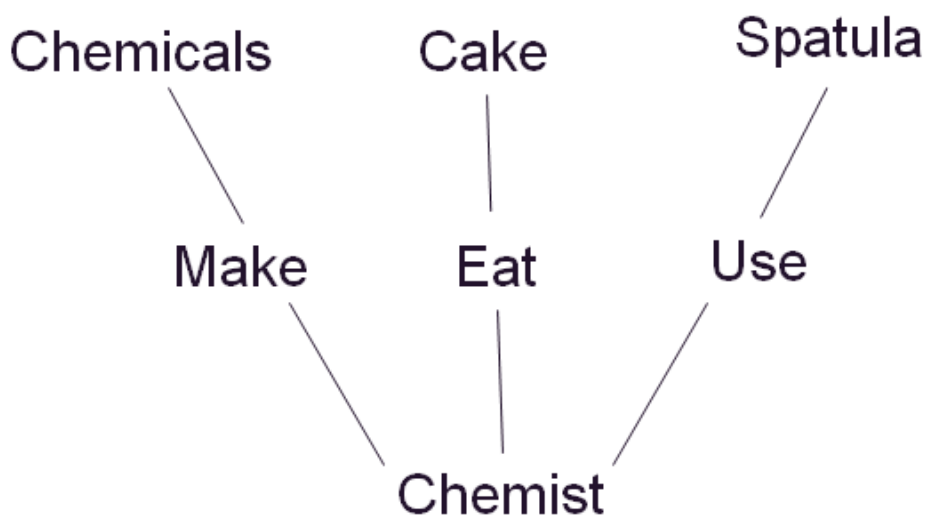
Figure 8. An example of a concept map

The main criticism of the semantic network theory is the concept of spreading activation. The main question is how the semantic network knows when to stop spreading activation. A simple word could cause the activation of many of thousands of other words in semantic memory. Clearly, this does not occur, but this question is yet to be answered by further research.

2.6.3 Knowledge types

There are many categories of knowledge, however the most significant division is between 'procedural' and 'declarative' knowledge (Lohse and Healy, 2012). Declarative knowledge pertains to an individual's memory for episodes, facts and concepts whilst procedural knowledge relates to the capacity to execute a variety of tasks. How to solve a multiplication problem or how to drive a car are all types of procedural knowledge, referred to as 'productions' or 'procedures' (Lohse and Healy, 2012). Declarative knowledge can transform into procedural knowledge with rehearsal. For instance, you may be told to 'change gear' when first learning to drive a car, which is a declarative statement. This function develops to become habitual and is performed with barely any thought, however, after subsequently changing gear many times. In reality, procedural knowledge has a tendency to be accessed reflexively and entails very little thought. In addition it has a propensity to be much more robust and is less vulnerable to non- retrieval than declarative knowledge (Lohse and Healy, 2012).

2.6.4 Acquisition of knowledge

Emerging from how knowledge is organized and represented are five principals for the acquisition of knowledge.

2.6.5 Semantic processing

An optimum for the acquirement of knowledge occurs when the student concentrates on the meaning of the novel information, since knowledge is ordered semantically. Substantiation for semantic processing significance was presented by Craik and Tulving (1975), who were amongst the first to suggest this. In their research, subjects responded to questions relating to target words which differed relative to the depth of processing required. They found that words semantically processed had more enhanced learning than words processed structurally or phonemically. However, Craik and Tulving's (1975) work has been criticised for not explaining how deeper processing results in greater long-term memory retention. Additional research has substantiated the advantages of learning using more semantic processing of the information, and has stated that the advantage is due to greater elaboration which enriches the memory representation by linking into pre-existing sematic association networks (Watkins, 2002).

2.6.6 The frequent processing and retrieval of information

Another learning precept is to retrieve and test the material many times. Retrieving, also termed 'self-producing', material this can be differentiated with merely copying or reading it (Rugg and Wilding, 2000). Passively examining information by reading or copying it has a diminutive effect for memory in contrast to 'generating' (self-producing) an article. This has taken many years of investigation and the phenomenon is termed the 'generation effect' and was demonstrated in research by Bauml (2002). In the bounds of an educational setting, this principle indicates the requirement for regular practice exercises, worksheets, quizzes and tests. It is, in addition, essential to separate, or 'distribute', retrieval efforts under the conditions of study, (Bauml, 2002). Studying or assessing material randomly, on separate days or with intermittent rests, may comprise distributed retrieval. However,

reiterating material many times in sequence requires just a solitary retrieval from long term memory. Raaijmakers (2003) demonstrated that very little enhancement of memory for the material occurs from this process.

2.6.7 Conditions for learning and retrieval

The setting or context (external and internal) in which knowledge is learned is how it is symbolized, which then establishes how it is recalled. Knowledge is better recalled when the conditions of learning and recall are similar. Rugg and Wilding (2000) established this tenet termed 'encoding specificity'. Conversely, Nairne (2002) states that rather than being causal the encoding-retrieval match is correlational and cue distinctiveness is what determines successful memory. Nairne (2002) also states that there is an increased probability that memory performance will be improved by encoding-retrieval matching as distinctive features will come into play.

2.6.8 Prior knowledge and new knowledge

Knowledge is interrelated and so, consequently, new knowledge that is connected to prior knowledge has a better retention (Kendeou and van den Broek, 2007). Prior knowledge assists in filling contextual gaps and aids in developing a greater comprehension (Kendeou and van den Broek, 2007). Additionally, reflecting on a subject can impart linkages to the novel knowledge – the probability that knowledge will be retrievable increases relative to the number of additional linkages that are created (Kendeou and van den Broek, 2007).

2.6.9 Cognitive procedures

Procedural knowledge exhibits greater retention and has greater accessibility (Hedberg

and Higgins, 2011). Consequently, cognitive procedures should be developed and used when learning. Procedures can simply comprise of using shortcuts for task completion and memory stratagems which serve to increase the distinct meaning of the knowledge (Hedberg and Higgins, 2011).

2.6.10 Conclusion

How the mind represents and organizes knowledge is fundamentally connected to knowledge acquisition. By taking into account the elemental properties of knowledge, in addition to the fundamental purpose of this knowledge, learning can be improved. The fact that knowledge is semantically ordered is one of the most fundamental properties; consequently, learning techniques ought to augment meaningful study of novel knowledge. Students ought to generate as many connections to the knowledge as feasible. Furthermore, learning techniques should be matched to the desired result.

There was insufficient evidence to establish that the retention of learned knowledge is due to Learning Styles alone was the opinion of Kratzig and Arbuthnott (2003). Connecting memory and learning styles together relies upon various components. These components are interest level, motivation, delivery of information method, background knowledge and the physical and emotional state of the students. Figure 9 (Posit Science, 2010) shows the generally accepted outline structure of the human memory. It is generally accepted that knowledge is only held in sensory memory for a few seconds (Baddeley et al., 2004). Knowledge will only be held in Short term, or Working, memory for between 30 seconds and up to a few minutes (Myers, 2006) and intermediate long term memory will last for a few minutes up to several weeks (Rafael, 2006). If the knowledge has not then passed into Long term memory it will be lost (Atherton, 2010). The Perceptual Learning Style Theory

illustrates how important individual learning styles are but also how vital it is to know how memory functions within the learning system.
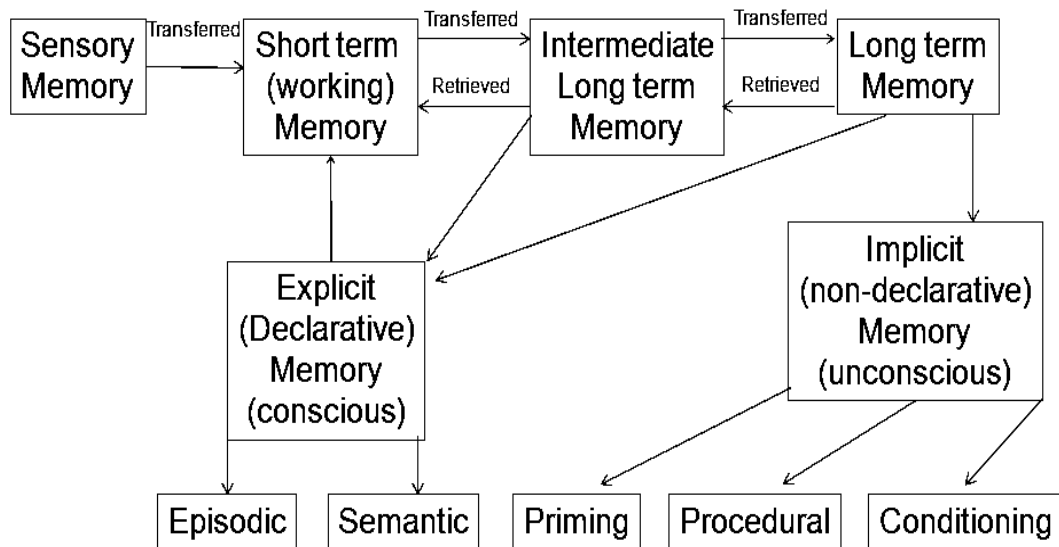
Figure 9. A General Model of the Human Memory System (Adapted from Posit Science, 2010)

2.7 Current education stratagems

The disparity between the best performing countries and the worst performing countries for child injury can clearly be seen in figure 10 (Unicef, 2010). Sweden is the best performing country whilst the United States of America and Canada are some of the worst performers even though Canada and the United States of America have active educational interventions. Therefore the obvious question is then why this should be the case.

2.7.1 Approaches that work

The fact that injuries are a significant threat to child health was recognised by Sweden in the 1950's. Child injury death rates were higher than those in the United States at that time. They were the first country to tackle the problem in a coordinated manner (De Leon et al., 2007). Since the 1950s Sweden has been the most successful country in the world in bringing child injury death rates down and since the 1980's has had the world's lowest

child injury death rate. The main factors that seem to have contributed to this success include a commitment to research, partnerships with different agencies to produce safety education campaigns, dedicated management of safety issues, the assimilation of good surveillance data and legislation and regulations for safer environments and also by allowing educational institutions to contribute to public health policy making and organizing a national multi-sectoral safety promotion programmes (De Leon et al., 2007). Sweden, in setting up policies for safety, was one of the very few countries that followed W.H.O.'s recommendations (Ramsay, 2001). In Sweden a major goal of society has become the protection of children. This has been fuelled by a sense of 'communal responsibility' which has assisted in the escalation of the prevention of child injury to the top of many agenda's. Since relatively few systematic studies have been performed examining the factors that may affect child injury rates, it is very difficult to explain the differences between countries. One of the few systematic studies that has been performed is the O.E.C.D. investigation of road safety practice and policy. This study employed socioeconomic/demographic indicators, mortality data, exposure surveys and the principle informants in transportation departments in O.E.C.D. countries were surveyed using a questionnaire. The fact that good data was found to have a pivotal role was one crucial finding of the study. Countries with the lowest injury rates, the best-performing countries in the study, all had a co-ordinated stratagems on road traffic injuries which was comprehensive and they had applied a holistic method (Christie et al., 2004). Also, the importance of an international network of researchers was identified which would encourage the prompt dissemination of ideas between countries (Denman, 2000).

Education, enforcement and engineering, or the 'three E's' as they are commonly termed, has been the way unintentional injury interventions have conventionally been considered.

The paragon for the assessment of the efficacy of injury prevention programmes is the randomized control trial, however in relation to child injuries such trials are still relatively rare. The problem is that if the benefits of such trials are obvious it would be impractical or unethical to implement them.

2.7.2 Education, skills and behaviour change

In the field of child injury prevention the value of educational programmes, as a form of injury prevention, has been the subject of much debate. Some stratagems, for instance safety device promotion, home visiting and legislation clearly underpin education. An improvement in children's knowledge can be the result of an educational safety intervention and this may also result in a change in behaviour. Whether the risk of injury is reduced is unknown (Duperrex et al., 2002). More research experiences should be shared worldwide and more interventions need to be fully evaluated. Interventions still need to be customized to the physical and social environments of those localities even though many of the principles of injury prevention can be transferred. Interventions should build on existing networks, involve communities and reach across different sectors (WHO, 2008).

2.7.3 Approaches that are not working

An example of an educational intervention that doesn't seem to have worked is the 'ToxMystery' intervention. This educational intervention, which was produced by the United States National Library of Medicine to aid children between the ages of 7 and 11 recognise, understand and stay away from household chemical hazards. In this educational approach 'Toxie the cat' helps children find the hidden hazards in various rooms of a house and offers hints when required. 'Toxie' dances and celebrates when all the high risk areas for chemical injuries in the house have been discovered. A

personalized certificate of completion can then be printed out for the successful players. The claim is made that 'ToxMystery' has been usability tested by educators and children and has received high grades by all (National Library of Medicine, 2010).

ToxMystery also provides parents and teachers with resources on environmental health as well as trying to provide injury prevention education children. This educational resource is an active stratagem. It requires children to access the resource via the internet or the school to request the compact disks and load them onto the school computer. As this is not a compulsory part of the school curriculum, uncertainty exists over the extent to which it is actually used. There is also uncertainty over the evaluation of this intervention, the issue that children work only individually on the activities, and that there is no final evaluation.

Another example of an approach seeming to fail is Canada's 'Safe Kids' campaign. 'Safe Kids Canada' is the injury prevention programme of The Hospital for Sick Children which in turn is affiliated to the University of Toronto (SafeKidsCanada, 2010). It provides advice and resources for education, funds research into child injury prevention, and is funded by charitable donations. In order to deliver its programmes it has built a network of strategic partners. These partners deliver the programmes using 'Safe Kids' resources. In order to maximize the social impact through reducing preventable injuries, it actively pursues these partnerships. A strategic partnership was formed in 2012 with the Canadian Injury Alliance. This is a group consisting of four national injury organizations: SMARTRISK, Safe Kids Canada, ThinkFirst Canada and Safe Communities. This new collaboration seeks to increase stakeholder engagement and fundraising capacity as well as increase knowledge and research brokering. For safety awareness programme promotion and delivery they

have also engaged multi-level national partners such as The Boys and Girls Clubs of Canada. Since 'Safe Kids Canada' is a charitable organisation and therefore its work is restricted by the level of monetary donations received. This could potentially affect its reach within Canada and also its ability to influence change. The organisation is disparate to say the least and seems to lack leadership. The 'Safe Kids' curriculum is not compulsory, and therefore the extent of its use is questionable.

2.7.4 Approaches conclusion

In order to have the greatest positive impact on the educational programme it is important to know which injury prevention stratagems have the greatest proven efficacy and those that have the least proven efficacy. The programme and the message can be too general, to 'watered down', or the message can be too specific – only mentioning very specific chemicals.

There is also lack of clarity about interventions being enshrined into the curriculum and therefore becoming mandatory. Widespread, multi-sectoral efforts to provide safer social and physical environments together with positive leadership can produce sustained reductions in injury mortality and morbidity. This has been shown by countries with the best safety records. Countries have made significant advances when they have recognised that in order to address child injury effectively the responsibility should be assigned to a designated government focal point.

2.8 Conclusion

In this chapter, a literature review was carried out, relative to the search strategy, on the theoretical perspectives relevant to the hazard warning system and use of this system,

educational theories that are relevant to this study and the application of these theories, such as active learning and teaching to learning styles. Theories of memory, which are

Rank	Countries	Amount ▼	
# 1	Korea, South:	25.6	
# 2	Mexico:	19.8	
# 3	Portugal:	17.8	
# 4	United States:	14.1	
# 5	New Zealand:	13.7	
# 6	Poland:	13.4	
# 7	Czech Republic:	12	
# 8	Hungary:	10.8	
# 9	Canada:	9.7	
# 10	Switzerland:	9.6	
# 11	Australia:	9.5	
# 12	Austria:	9.3	
# 13	Belgium:	9.2	
# 14	France:	9.1	
# 15	Japan:	8.4	
= 16	Germany:	8.3	
= 16	Ireland:	8.3	
# 18	Finland:	8.2	
= 19	Denmark:	8.1	
= 19	Spain:	8.1	
= 21	Greece:	7.6	
= 21	Norway:	7.6	
# 23	Netherlands:	6.6	
= 24	Italy:	6.1	
= 24	United Kingdom:	6.1	
# 26	Sweden:	5.2	
	Weighted average:	10.5	

Figure 10. Child injury death index (most recent) by country (Unicef Innocenti research centre, Report card 9, 2010)

relevant to the retention of gained knowledge, were also explored. All these areas have been reviewed relative to young children. It also aimed at establishing that there was a gap in the transfer of learning relative to child safety interventions and thus whether this gap could be bridged by changing the teaching methods used.

Chapter 3: Study Design

3.1 Introduction

This chapter provides a detailed discussion of the study design, including population and samples, methods of data collection and instruments, settings and procedures, ethical issues, and the means of data analysis. The overall design was based on a pre-test, post-test, follow-up test structure. A Delphi survey was employed to elicit consensus of expert opinion on the design of an educational intervention intended to improve chemical safety knowledge, and the retention of the gained knowledge, of primary school children aged 7 to 11 years.

3.2 Aims and Hypotheses

3.2.1 Study Aims

The overall study aim was to identify more productive methods of teaching home chemical safety interventions to primary school children, aged 7 to 11 years old, in order to increase their knowledge uptake and increase the retention of this knowledge using the new GHS chemical hazard warning system. It was, therefore, necessary to test both the efficacy of the method in increasing knowledge and the longevity of that learning.

3.2.2 Hypotheses

With regard to establishing the efficacy of interventions on knowledge acquisition, the following hypothesis was set:

- H_1 : **the method identified will significantly increase the knowledge uptake of the GHS system.**

- H_0 : **the method identified will not significantly increase the knowledge uptake of the GHS system.**

Longevity of learning was assessed through a second hypothesis:

- **H_1 : The method will stimulate retention of the increased knowledge for at least 1 month**

- **H_0 : The increase in knowledge will not be retained for the expect period of 1 month**

3.3 Study Design

3.3.1 Choice of design

Research designs may be characterised into three types as shown in figure 11(Trochim, 2006). The type depends on the inclusion or exclusion of random assignment into groups and the use of a control group. A study is a randomized or true experimental design when there is random assignment of the participants to control groups and experimental groups. If a control group is included but random allocation to groups cannot be undertaken, then the study is based on quasi-experimental design. The third type is labelled a non-experimental design and is characterised by lack of both randomisation and control group.

Examining the design classification in this way is particularly useful with regard to internal validity. The randomized experimental design is the strongest of these designs when seeking to determine a cause and effect relationship. Relative to internal validity or causal assessment the non-experimental design is the weakest design (Trochim, 2006).

3.3.2 Quasi-experimental and true experimental designs

The evaluation of the efficacy of educational interventions is usually addressed using experimental designs. Confidence that the outcomes are the result of the intervention and not just a function of extraneous variables is increased by these designs. True

experimental designs use specifically created, randomly assigned groups, and have a common measured outcome.
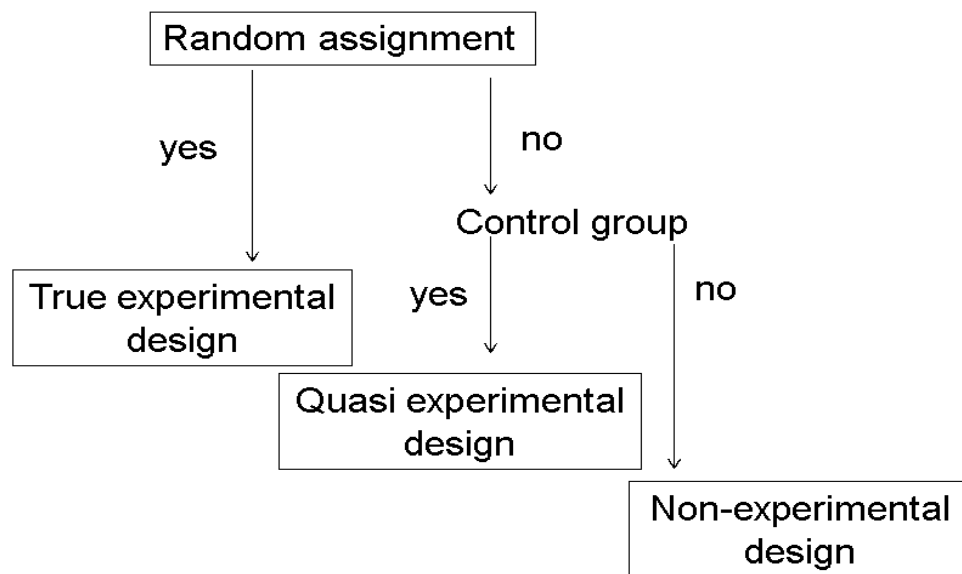
Figure 11. Design classification (Adapted from Trochim, 2006)

Quasi-experimental designs tend to be used by researchers when random assignment cannot be used (Black, 2004). This often relates to the ethical unacceptability of a control group which would deny access to an essential service or intervention.

3.3.3 Quasi-experimental designs in evaluation

When random assignment is not practical or possible, researchers will typically use quasi-experimental designs for educational programme evaluation (Trochim, 2006). These designs can be subject to many problems of interpretation. There are several quasi-experimental designs which are commonly used, these will now be explored.

3.3.4 Non-equivalent group, post-test only

Two groups are used in the non-equivalent group, post-test only design, a programme /test group and a comparison group. Both groups have an outcome measure administered. One group, for example, may receive an educational programme using a particular

pedagogical method whilst the comparison group receive the instruction using a different pedagogical method. A test can be administered, after the programme has been completed, to see which programme had the greater efficacy (William et al., 2008).

The major problem with this design is that before the instruction takes place the two groups might not be necessarily equivalent. The outcomes may be influenced by these differences rather than the effect of the programme. If the test group perform better than the control group then this could be due to the intervention or may be due to other extraneous factors such as the test group being better prepared or possessing greater subject knowledge to begin with (Gribbons and Herman, 1997). For these reasons and the fact that the gain in knowledge could not be measured using this approach it was decided that this method was not suitable for this study.

3.3.5 Time series design

Many measurements, which may be observations, are taken from the programme and control groups before and after the programme in the time series design. This can provide valuable information about the success, or otherwise, of the programme. The time series design provides a more reliable picture of achievement as it is sensitive to trends in performance because it uses measures at several time points before and after the programme. The time series design provides, especially if the comparison and test groups are equivalent, a strong picture of the outcomes of interest.

However the time series method requires many measurements, and so many school visits, which did not have the approval of the participant schools since it would cause more disruption to the normal school routine. This design also has the problems and limitations

of the non-equivalent group, pre-test / post-test design (Black, 2004). For these reasons it was decided that this design was not used.

3.3.6 Non-equivalent group pre-test / post-test

The non-equivalent group, pre-test/post-test design partially eliminates a key limitation of the non-equivalent group post-test only design. The pre-test was used to gauge the differences empirically between the two groups. Therefore if one group performs better, as evaluated by the post-test, initial differences can be ruled out as explanations for the results. This however depends on the two groups being equivalent initially (Dimiter et al., 2003).

However, this design has several weaknesses. Motivational issues or exposure of the control group to the intervention, for example. Also if the groups differ on the pre-test assessment then the interpretation of the results can be more difficult (Dimiter et al., 2003).

However, since the control group and experimental group were at different schools it was unlikely that the control group would be exposed to the intervention. Also since this design only required two visits to each school, as the pre-test and immediate post-test were undertaken in one visit, the disruption to the normal school routine was minimised. Therefore it was decided that this design was used.

3.4 Recommendations for design evaluation

The evaluations purpose is the main factor that directs the design choice. The experimental design should be carefully considered if the intervention's effect on

participant outcomes is the main objective, as in this study. It is also critical to consider the evaluations utility relative to practical and ethical considerations (Patton, 2008, Johnson and Onwuegbuzie, 2004).

The programme's objectives or goals should be aligned to the evaluations. Observed differences in outcome measures should be considered relative to alternative explanations. For example, if the treatment group out-performs the control group then not only should the explanation that the programmes' efficacy is greater be considered but also the full range of possible alternative explanations (Gribbons and Herman, 1997).

3.5 The Non-equivalent groups design

3.51. The basic design

Possibly the most frequently used design in social research is the non-equivalent groups design (Black, 2004). Random assignment is a key feature of randomised designs but it is lacking in this design type, although it has a similar structure to the randomized pre-test / post-test experimental design. The control and treatment groups are chosen to be as similar as possible. For example in an educational setting two comparable schools may be chosen. Since the groups are not randomised and therefore non-equivalent there will never be any certainty that they are comparable.

The term non-equivalent means that there was no random assignment to groups and therefore the groups may not be equivalent prior to the study. This makes the internal validity of the non-equivalent groups design particularly vulnerable. Therefore a conclusion can be reached by the researcher that the programme made a difference when actually it did not or did not make a difference when actually it did (Trochim, 2006).

3.5.2 Possible outcomes

If the non-equivalent groups design is used then there are potentially several different outcomes which are discussed here in relation to interpretation (Trochim, 2006). Each potential outcome is plotted against an arbitrary scale. Some of the potential outcomes are more susceptible to internal validity threats than others. The means as line plots are shown in scenario's A to E in figure 12 (Trochim, 2006). The control group pre-test and post-test means are connected with a green line and a blue line connects the pre-test and post-test means of the programme group. The first possible outcome is shown in scenario A. This line graph demonstrates an original pre-test difference and an even larger post-test difference, thus demonstrating no change in the control group pre-test to post-test. Therefore this outcome is very unlikely to be due to a selection-maturation threat. This type of threat indicates that the maturation rate is different between groups. The illusion is created of a programme effect when there is none. However, since the control group shows no maturation at all then differential maturation is very unlikely. It would seem more likely that a selection-history threat could cause this outcome. For example a non-programme event could have occurred to which the programme group alone responded. It is much more likely that a history threat caused the outcome rather than a maturation threat.

There is another possibility for the outcome – that of a selection-regression threat. This type of threat is similar to the selection-maturation threat. Regression to the population mean might explain the rise in the programme group. However, the control group would need to be below the population pre-test average for this to be the case. If this were the case, the programme group would regress upwards on the post-test to the population mean. The problem with this explanation is that since the control groups' pre-test average

was lower than the test groups' average, the control group should also regress towards the mean. As the control group does not seem to show any regression whatsoever it is very unlikely that this outcome is the consequence of a regression to the mean.

The second possible outcome is shown in scenario B. This graph shows that the programme group achieved a greater gain even though the control and programme groups both achieved a gain from pre-test to post-test. The difference between groups at the pre-test is likely to be due to a selection-maturation threat since they must be maturing at different rates. The post-test results seem to confirm this. The outcome may also be due to a selection-history threat. The outcome pattern shown may be obtained if the groups react differently to a historical event due to their initial differences.

Depending on the nature of the measures used selection-instrumentation and selection-testing are both possible reasons for the outcome. Moreover, if more low-scoring programme cases drop out between testing, a selection-mortality problem could be indicated. It is unlikely that selection-regression would give this outcome since it would be expected that regression would be greater for the control group since it had the lower pre-test score.

The third possible outcome is shown in scenario C. The outcome is probably due to selection-regression. It is likely that the programme group was selected because it scored higher in the pre-test compared to the population mean,. The post-test result is attributable to its regressing towards the population mean.
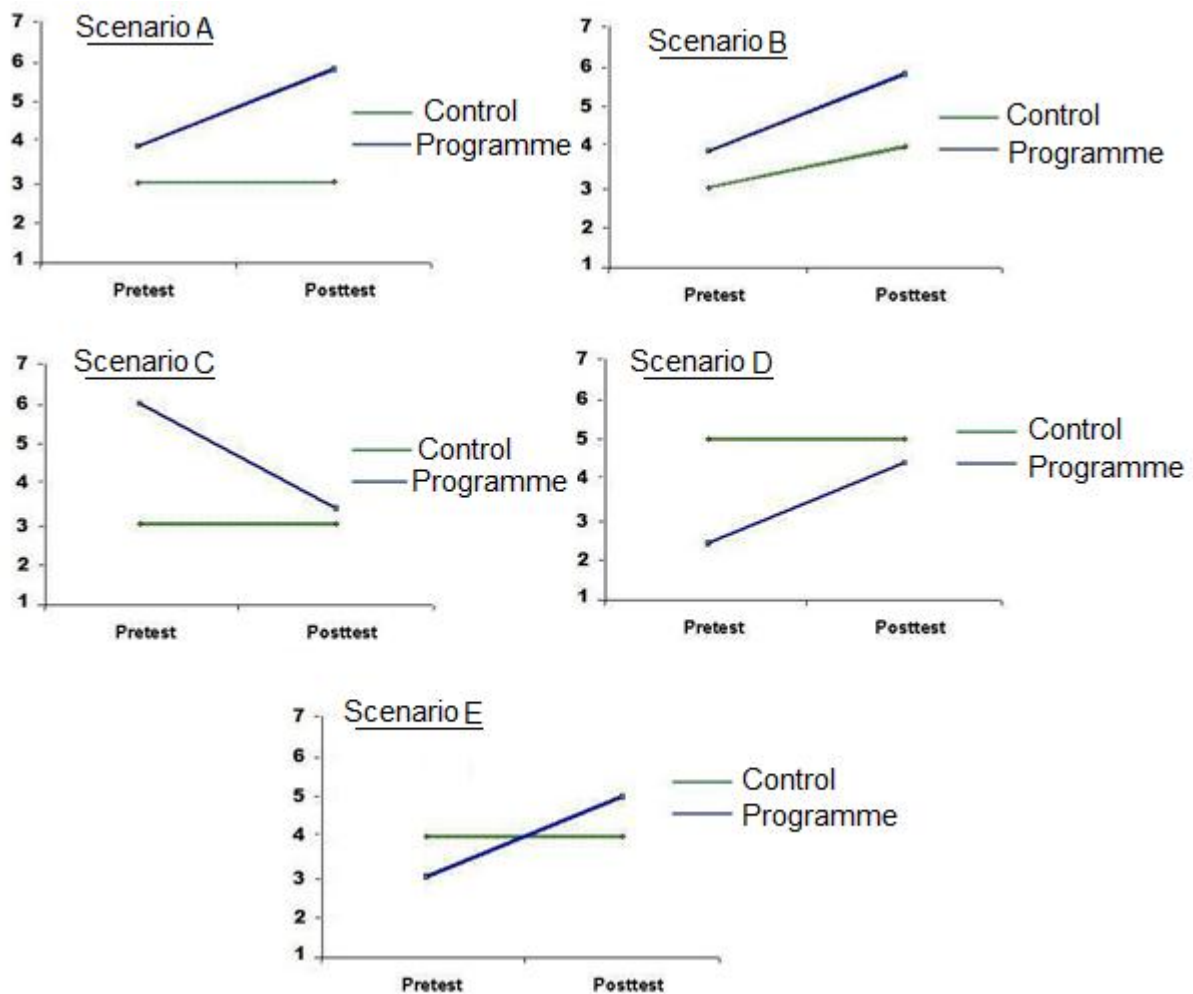
Figure 12. Possible outcome line graphs using the non-equivalent groups design
(Adapted from Trochim 2006)

The fourth possible outcome is shown in scenario D. This outcome also suggests a selection-regression threat. The pre-test result shows that the programme group started at a disadvantage. Its apparent closing of the gap with the control group on post-testing is probably as a result of regression.

The last possible outcome is shown in scenario E. This is often called the cross-over arrangement. On pre-testing, the performance of the programme group is lower than the control group. However, the performance of the programme group is higher than the control group on post-testing. The performance of the control group does not vary from

pre-test to post-test. This outcome gives the clearest evidence for the efficacy of a programme. There are no obvious threats to internal validity with this outcome. It is most unlikely that selection-maturation is responsible as that the likelihood that the programme group happened to start maturing as the control group stopped maturing is too remote. It is also unlikely that selection-regression was responsible, as this might explain why the programme group approached the control group but not why it should have crossed over.

3.6 Threats to internal validity

The internal validity of a study can be threatened in many different ways. Therefore to have confidence that the measured outcomes are a function of the observed outcomes, and haven't been affected by other factors, table 6 (Robson et al., 2001; Bieger, 1998) below provides a summary of the mitigating action taken relative to the possible internal validity threats.

3.7 Threats to external validity

The extent to which a research sample is representative of the population from which it was selected can be affected by threats to external validity. These threats, and the mitigation of these threats in this study, are summarised in table 7 (Robson et al., 2001; Bieger, 1998).

3.8 Assumptions, Limitations, Scope and Delimitations

3.8.1 Assumptions

Studies involved with determining the correlation(s) between academic attainment and distinct learning styles have confirmed that children learn in different ways and that children's success in distinct topic areas is correlated to how they learn. If children are

taught using methods and aids that are complementary to their individual learning styles, their attainment is considerably improved (Klein et al., 2001; Cassidy, 2004). Each learning style displays identifiable characteristics. Various hypotheses have been postulated concerning children's learning styles. One of the models most accepted by educationalists deals with five types of learning style: tactile, auditory, visual, read/write and kinaesthetic. The function of the four senses implicated in the learning system form the foundation of these five types of learning. The child's preferred sense establishes the learning style.

Underlying this study are the assumptions that children have a prevailing learning style, and that a multi-sensory method of tuition will encourage and augment children's learning processes and so will boost their knowledge uptake and retention considerably.

3.8.2 Scope of the study

The scope of the study was limited by several factors, for example the number and size of primary schools that agreed to participate. Also the time allowed for the teaching and assessment was limited by the schools that did participate. Twenty eight questions were asked in the Delphi study.

Further detail and insight may have been achieved by asking additional questions. However the panelists time was limited. The number of panelists in the Delphi survey also limited the scope of the study. Only eight participants completed the first round and only five completed the second round. The scope was also limited by the method of interfacing with the participants. All of the questionnaires for both rounds were manually collected and retrieved. The scope of the investigation was also constrained since the researcher did all the teaching rather than a professional teacher.

Threats to internal validity	Description of threat	Mitigating action
History	The outcome could possibly be affected by a major influential event occurring during the intervention.	As the pre and immediate post-tests occur in the same session this is very unlikely. The final post-test happens 1 month later but this is still only a short period of time and so it remains unlikely that the internal validity would be affected.
Instrumentation / Reporting	Over the course of the intervention the validity of measurement method changes.	This is not a threat since the measure remains constant.
Regression to the mean	This could explain the outcome measure which has given a onetime extreme value which then naturally changes to a normal value.	There is no specific basis for choosing the intervention group – except for age and access. Thus regression to the mean is very unlikely.
Testing	The outcome may be affected by taking measurements such as a test.	The act of taking the before measurement (pre-test) should not affect the outcome. Care was taken in the development of the test not to include questions in one part of the test which provide answers to other parts of the test. Even if the pre-test did affect the outcome it would not affect the validity as long as the pre-test is always given.
Placebo	A non-specific effect could be caused by the intervention on the outcome independently of the main intervention component.	Very unlikely that the pupils belief in the efficacy of the intervention would cause an effect.
Hawthorne	The outcome could be affected by the involvement of outsiders independently of the main intervention component.	This could occur when teachers present at the intervention prompt pupils towards the correct answer during testing. This was mitigated by asking the teachers to desist from this during the tests and approaching them if this starts to occur.
Maturation	The outcome could be affected by the intervention group developing in ways independent of the intervention. One example would be group members increase in experience.	Since the intervention is only over 1 month this is unlikely to occur.
Dropout	The characteristics of the group change which may affect the outcome. For example some participants dropping out.	This is unlikely since I am using a school setting and therefore the population should remain reasonably static within the school year. Results were only used for pupils that had the intervention and all three tests.

Table 6. Threats to internal validity (Adapted from Robson et al., 2001; Bieger, 1998)

3.8.3 Intervention age range

As young children are the focus of this study the question arises as to whether children in infant school, age 5 and 6 years old, should take part in the intervention together with primary school children, age 7 to 11 years old.

Threats to external validity	Description of threat	Mitigating action
Effect of testing	The performance or responses of participants in the study may be affected by the administration of a test.	This is unlikely – see Threats to internal validity- also since the GHS system has not yet been implemented in the EU.
Multiple-treatment interference	Where more than one intervention session is received by participants in a study.	In this study only one intervention session is given.
Selection-treatment interference	Some characteristics of the participants, for example personality factors, prior learning and experiences, can interact with aspects of the intervention.	The participants are selected simply based on a schools' participation. Prior learning is very unlikely as the GHS system has not been implemented in the EU yet. There could be prior experiences – for example poisoning incidents – but this should not affect the outcome validity.
Effects of experimental arrangements	As a result of participants being aware that they are in a study their performance or response is modified.	Whilst the children knew that a study was being performed they did not know whether they were in the test or control group. There could be an effect caused by wanting to perform better to a visiting teacher however this would apply to both schools and therefore any effect would not skew the results.
Experimenter effects	The situation where the performance of participants in a study is influenced, unintentionally, be the researcher.	Considerable care was taken not to influence the performance of participants in the tests
Specificity of variables	How operationally defined and adequately described the study variable are.
.	The measurement instruments have been thoroughly researched – see statistics section. The variables are simply the test scores, and mean test scores, to the questions relative to the use of traditional teaching in the control group and the use of teaching to learning styles / active learning in the experimental group.

Table 7. Threats to external validity (Adapted from Robson et al., 2001; Bieger, 1998)

The main theory for child cognitive development was produced by Jean Piaget (1928). It has been expanded more recently by Vygotsky, Bruner and others relative to language and facilitated learning but remains the principal theory of child cognitive development. In Piaget's cognitive development theory he identified four distinct phases which were dependent on age. These are, occurring from birth to 2 years old, the sensory motor stage; occurring from 2 years old to 7 years old - the pre-operational stage; occurring from 7

years old to 11 years old - the concrete operational stage; occurring from 11 years old to 16 years old - the formal operations stage.

Children in the pre-operational stage are considered to be logically inadequate relative to mental operations. Children in this age range are not able to perform operations, which are mental tasks rather than physical tasks. They are very egocentric and they have difficulty taking the viewpoint of others. They also fail to understand cause and effect relationships (Jardine, 2006).

However as the concrete operational stage begins the child will start to apply new thinking to events they encounter by using cognitive operations. They can re-arrange and change symbols and mental images into logical thought and understand cause and effect relationships. They also start to take the views of others into account when decision making and will actively seek others views and modify their own views accordingly (Jardine, 2006).

Consequently, as children aged 5 and 6 years old do not possess the cause and effect cognitive abilities required to understand the relationships between hazard labels, hazardous chemicals and the potential harm these chemicals can inflict, it was decided not to include these ages in this study. Also since the active learning method will be employed, which requires significant interaction and discussion between the school children, seeking others views and opinions and working together, and these cognitive abilities are lacking in 5 and 6 year old children, this added to the decision that these ages not be included.

3.8.4 Delimitations

Particular delimitations on the study were imposed by the investigator. Most importantly, the investigation did not focus on any other type of intervention but instead focused specifically on teaching the GHS. The study was also limited to certain learning styles as suggested by experts who participated in a survey: visual, auditory, read/write, kinaesthetic and tactile. The study was also limited to primary school children – effectively from age 7 to 11 years of age.

3.8.5 Conclusion

Extraneous variables other than participation in the chemical safety programme had to be minimised or controlled in order to verify with confidence any cause and effect relationship (Black, 2004). The interval between the pre-test and post-test needed to be as short as possible so as to minimise the likelihood of maturation affecting the gains between the two tests. A testing effect is possible if the same test is used for pre-testing and post-testing, however using the same test safeguards against instrumentation effects (Black, 2004). Administering the pre-test and post-test immediately before and immediately after the programme was designed to eliminate any maturation effects.

3.9 Instruments

3.9.1 Pre-tests and post-tests

Knowledge gained from participating in an educational course is measured using pre-tests and post-tests. Before the training begins a pre-test, which is a set of questions to determine the participants course content knowledge level, is administered. Participants are given a post-test after the completion of the course. The post-test can be the same set of questions used in the pre-test or may be a set of comparable questions. Whether the

programme was successful in increasing the participant's knowledge can then be determined by comparing pre-test to post-test scores.

3.9.2 Using pre-test and post-tests

Whether or not participants have learned from the educational intervention can be determined from the test scores. However a well-designed pre-test / post-test allows teachers to understand which competencies and concepts were understood, which may need additional time and which pedagogical methods work well (Dimiter et al., 2003).

Pre-tests and post-tests may not be suitable for every educational intervention. If a course contains sufficient opportunity for the assessment of participants' knowledge, for example highly interactive courses where formative assessment could be used, then tests may not be warranted. It may not warrant the time requirement for creating, administering and analysing tests for very short courses (Black, 2004).

 It is very important to consider the type of assessment to be used as the evaluation tool. In this research the pre-test / post-test method was used as it was fundamental to the research that there was an understanding of exactly what knowledge could be credited to the teaching. Also if only a post-test was administered the knowledge gains could not be assessed to any extent. In addition a limitation of the pre-test / post-test design of knowledge gained is the recall of this knowledge in the future. Therefore a one month post-test was also used to assess entry into long term memory.

3.9.3 Developing a pre-test and post-test

Tests are devices used to assess change. Changes in knowledge cannot be assessed

accurately if the device itself is faulty. The tests, pre and post, must be reliable and valid and composed of clear and well written questions. The following were taken into account when developing the tests.

Questions should be created that focus on the course objectives.
At least one question was developed to cover each course objective to ensure participants could demonstrate their knowledge of the most important course concepts. The questions were created so that extraneous details need not be memorised. The emphasis was placed on simple core concepts and facts.

Only questions to which clear answers were provided during the course were included. Participants were not tested on knowledge or concepts that were not sufficiently covered in the course.
A test was developed that should take the participants approximately 15 – 20 minutes to complete.
The course will take approximately two hours to complete. Therefore it was considered that a test lasting 15 – 20 minutes was appropriate.

3.9.4 Question creation
There are a variety of questions types that could be used in the tests (iTech, 2008). For example true / false; open-ended and multiple choice. True / false questions only ask the participant to choose between two possible options and are therefore very limiting. Open-ended questions may make the test more interesting for the participant; however they tend to require large amounts of time to complete and analyse. Multiple choice questions require less time but since they give the answer as an option they do not resemble 'real life

situations'. Therefore relative to the time constraints and the other factors discussed above the test was comprised of short answer questions. Questions were very simply worded, unambiguous and focussed. Multi-phrase sentences were not used as these were considered as too complex for the age group. Simple sentences were used with as few words as possible. Vocabulary that could be interpreted in different ways was also avoided. The use of conjunctions such as 'and', 'but', 'except' and 'or' were also avoided as these words imply a second concept which would be confusing to the participants. It was also considered important that the children should not be overwhelmed with words when attempting to answer the question. The test was reviewed by an expert in the GHS system for wording simplicity, usability and accuracy and the expected correct answers.

Rating and coding of test responses

Expert judgement was required as to the level of correctness and in order to rate the responses to the intervention test. The categories for coding were:

> **Correct:** Is fully consistent with the intention or the meaning is identical with the GHS system. Answers not totally the same as the GHS meaning are included in this category but the information given would be sufficient as the basis for a safety action and / or precaution.
>
> **Incorrect:** There is very poor relation to the intended GHS meaning or is completely wrong.
>
> **Crucial Misconceptions:** Indicates a comprehension contrary to the intention of the GHS system. Such a crucial misconception may result in a dangerous behaviour or action.
>
> **Does not know / Cannot answer**

3.10 Sample

3.10.1 Sampling

Two primary schools agreed to participate in this study and all of the participants for this part of the study were pupils aged between 7 and 11 years old within these schools. All of these pupils, and teachers, were not known or related to the researcher. The schools were small Church of England schools where the head teacher gave the consent to take part in the study. Therefore these are samples of convenience. Due to the small size of the schools, this is both an advantage, as the intervention can be done within one session, and a disadvantage as the number of pupils in each age band are small. The schools were semi-rural village schools and consequently may not be representative.

3.10.2 School setting

All the data gathered from the school intervention teaching and testing was coded. The name code took the format Sx/y where S denotes school, x denotes school number and y denotes participant number. For example code S1/23 denotes school 1 and participant 23.

3.11 Procedure

The same test (shown in appendix D) was administered to the pupils before the intervention (pre-test) and immediately after the intervention (immediate post-Test). The same test was then given again 1 month after the intervention. The test was composed of 13 questions. The first 7 questions asked the pupils to define the pictures (GHS Symbols). The next 3 questions asked the pupils to define certain words generally used in safety language. The final 3 questions asked the pupils to state the usual places in the home where hazardous chemicals can be found.

School 1 – control (Ofsted Report, November 2008)

Type of school: Primary

School category: Voluntary controlled

Age range of pupils: 4–11

Gender of pupils: Mixed

Number on roll: School (total) 47

Description of the school

"This is a small school. Most of the pupils who attend are White British, a very small number of whom are known to be eligible for free school meals. The proportion of pupils with learning difficulties and/or disabilities is very low. The school recently achieved the Activemark in recognition of its work to promote physical activity and encourage pupils to develop healthy lifestyles. Children in the Early Years Foundation Stage (EYFS) join the school in the Reception class."

Overall effectiveness of the school
Grade: 2

"This is a good school. Pupils' personal development is good and this, along with good teaching, contributes well to their good achievement.
Pupils' spiritual, moral, social and cultural development is good. They behave well, show respectful attitudes and are supportive of each other."

School 2 – test (Ofsted report, May 2008)

Type of school: Primary

School category: Voluntary controlled

Age range of pupils: 5–11

Gender of pupils: Mixed

Number on roll: School (total) 92

Description of the school

"This is a smaller than average sized school. Almost all of the pupils who attend are White British. The proportion known to be eligible for free school meals is broadly average. A smaller than average proportion has learning difficulties and/or disabilities. The school holds the Healthy Schools award and has achieved the Activemark and Artsmark awards, and is a leading SEAL (Social and Emotional Aspects of Learning) school."

Overall effectiveness of the school
Grade: 2

"This is an outstanding school. Exemplary leadership and management have brought about significant progress since the previous inspection. This has resulted in excellent teaching quality throughout the school, continually rising standards and achievement, and outstanding care, guidance and support for pupils."

In addition to the questions as text on the test paper the researcher also read out loud each question to the group and only moved to the next question when all the pupils had been given sufficient time to produce an answer. Great care was taken to make sure that there was no external prompting from those present.

3.11.1 Course school 1- control

The approach used will be teacher-centred so that the teacher will be the only source of information and all pupils will be taught at the same time. The classroom will remain quiet and questions will be answered only by the teacher. Pupils will work alone. The teaching schema for school 1 is shown in table 8.

3.11.2 Course school 2 – test

The approach taken will be pupil-centred where pupils will interact with each other as well as the teacher. There will also be a multi-sensory approach and pupils will have some choice regarding the activities they can undertake. There will also be some pacing that is pupil controlled relative to the time available. The session will be a mixture of noisy and quite periods. The teaching schema for school 2 is shown in table 9 and table 10.

3.12 Data Analysis

3.12.1 Statistical analysis

A statistical test can be performed comparing two or more groups in order to answer a scientific question. A null hypothesis is formulated which can then be accepted or rejected dependent on the result of the statistical test. A statistical calculation is performed which determines the probability of obtaining the observed data if the null hypothesis is correct. The probability is slight if a small p-value is obtained. Relative to the level of significance, which is determined in advance, the null hypothesis is rejected if the p-value is less than

this level. The basis of the statistical test is a test variable, test statistic, which is calculated from the observed data (McGraw-Hill, 2001).

Calculated from the observations the value of the test variable, if the null hypothesis were correct, is compared with the distribution that would be expected. The null hypothesis is rejected if this value is less or greater than a specific limit. The result is then 'statistically significant at a certain level'. A decision on whether the observed value is statistically significant - can be explained by chance, or whether it is greater than chance – is given by the statistical test. There are two basic goals in analysing data. The first is to produce summary statistics which give a concise description of a substantial number of data points. The second goal is to analyse the characteristics of a sample to produce inferences about a population (McGraw-Hill, 2001).

3.12.2 Representation of data

Frequency distributions are often used to represent data and indicate the frequencies, for example each test score in a set of test scores. Some examples of such representations are frequency histograms, pie graphs and line graphs. To represent the relationship between dependent and independent variables, for example the results of an experiment, line graphs are usually used.

3.12.3 Descriptive, correlational and inferential statistics

It is usual to use both descriptive and inferential statistics when analysing data. Classically, in most research conducted on groups of people, both descriptive and inferential statistics will be used to analyse the results and draw conclusions.

This is a purely instructional course. It will be teacher centred with minimal pupil interaction.		
Activity	**Objective**	**Outcome**
Talk to the children about chemicals, Define types of chemicals, Bad chemicals – Good chemicals.	- To introduce the concept of 'Good' and 'Bad' chemicals - To understand that they are being communicated too - To understand the types of hazardous chemicals they might see - To understand where these chemicals may be located in their homes	- To know that some chemicals are 'good' – won't cause harm - and some chemical are 'Bad' and can cause harm - To know that there are labels on hazardous chemicals - To know that there are many hazardous chemicals in the home - To know where these chemicals may be located in the home
Hold up A4 size Symbol images	To test subjects understanding of symbols relative to hazard type and dispel any misconceptions	Ability to identify the correct symbol for each hazard type
Describe verbally the hazard symbols		
Describe verbally each hazard symbol meaning.		
Hold up A4 size hazard words e.g. 'Hazard', 'Harm', 'Precaution'	To test understanding of Hazard related words and overall precaution message	To know the meaning of hazard related words and overall precaution message
Describe verbally the meaning of each hazard word		
Perform 'Ice Walk' * to help explain the meanings		
Hold up A4 size red diamond	To test understanding of red diamond	To know that the red diamond means hazardous chemical
Describe verbally Red Diamond meaning		
Keep Repeating all above	Reinforce learning	To reinforce knowledge gain for all elements

*The 'ice walk' is pretending to walk along a pavement and come across a patch of ice. It is designed to teach children about the terms 'Hazard', 'Harm' and 'Precaution'.

Table 8. Teaching schema for school 1 – control

Initial Teaching			
Activity	**Learning Style**	**Objective**	**Outcome**
Query children about chemicals, Types of chemicals, Bad chemicals – question and answer	Active teaching	• To introduce the concept of 'Good' and 'Bad' chemicals • To understand that they are being communicated too • To understand the types of hazardous chemicals they might see • To understand where these chemicals may be located in their homes	• To know that some chemicals are 'good' – won't cause harm - and some chemical are 'Bad' and can cause harm • To know that there are labels on hazardous chemicals • To know that there are many hazardous chemicals in the home • To know where these chemicals may be located in the home
Display very large Symbol images projected onto a screen	Visual	To test subjects understanding of symbols relative to hazard type	Ability to identify the correct symbol for a hazard type
Describe verbally the hazard symbols	Auditory		
Project hazard type words onto the large screen	Read/Write		
Describe verbally the hazard words	Auditory		
Make sounds for each hazard type e.g. Choking sound for Toxic	Auditory		
Circulate empty bottles with symbol labels / hazard names on around the class	Tactile Read/write Visual		
Project hazard associated words onto screen e.g. Hazard, Harm, Precaution	Read/Write	To Test understanding of Hazard related words and overall precaution message	To know the meaning of hazard related words and overall precaution message
Describe verbally each word	Auditory		
Perform 'Ice Walk' and get 'volunteers' to perform as well	Visual Kinaesthetic		
Project red diamond onto large screen	Visual	To test understanding of red diamond	To know that the red diamond means hazardous chemical
Describe verbally Red Diamond meaning	Auditory		

Table 9. Initial teaching schema for school 2 – test

Active Learning activities			
Activity	**Learning Style**	**Objective**	**Outcome**
Hazard Definition match	Read/Write	To test understanding of key words	To know what the key words mean
Hazard Dominos game	Visual Read/Write Kinaesthetic Tactile Auditory	To match the correct word meaning to the correct symbol	Ability to identify the correct symbol for a hazard type
Hazard maze	Visual	To understand the concept that hazardous chemicals should be locked away	To know that hazardous chemicals should be stored in a safe place
Chemical Safety Poster	Visual Read/Write Kinaesthetic Tactile Auditory	To produce a poster warning children of the dangers associated with hazardous chemicals	To reinforce the knowledge of : • The overall message to 'stay away from chemicals' • The meaning of symbols • Where hazardous chemicals may be found in the home •
Identify the hazard pictures	Visual Read/Write	To write the correct word meaning to the correct symbol	To know the meaning of each hazard symbol
Hazard Word Search	Read/Write	To find the key hazard words	Become familiar with the key hazard words
Hazardous chemical Location match	Visual Read/write	To match hazardous chemical type with location in the home	To reinforce the knowledge of where hazardous chemicals may be found and what types of chemical are hazardous

Table 10. Active learning activity schema for school 2 - test

3.12.4 Descriptive statistics

Research data is organised and summarised by descriptive statistics. The measure of central tendency is described as the typical score in a set of scores. The mean score of a set of scores is the arithmetical average. The most frequently occurring score is known as the mode and the middle score in a set of scores is known as the median score. The degree of dispersion of the scores is represented by the measures of variability. The distance between the lowest and highest scores is termed the range. The square root of the variance is the standard deviation. The average of the deviations from the mean

squared of a set of scores is called the variance. A Gaussian, or bell-shaped, curve is indicative of many kinds of measurements. Within this curve a specific proportion of the scores fall below every point on the abscissa. Scores that fall below a particular score are identified by percentiles.

3.12.5 Correlational statistics

The relationship between two or more groups of scores can be assessed using correlational statistics. Correlations can be negative or positive and they can vary from minus or plus one to zero. Changes in one variable may cause changes in another variable however it does not necessarily follow that a correlation exists. Scatter plots are usually used to graph correlations. Probably the most common correlational technique is Pearson's product-moment correlation. In order to produce an indication of the amount of variance in one variable which is accounted for by another variable the Pearson's product-moment correlation is squared so producing the coefficient of determination (Jargowsky and Yang, 2003).

3.12.6 Inferential statistics

Inferential statistics facilitate the indication of whether a researcher can generalise from their research findings, relative to their samples, to the populations they represent. For example a study with a test group that is exposed to an educational programme and a control group which is not. A low probability must exist - usually less than 5 percent – that the difference between the two groups mean test scores has not occurred by normal random variation.

3.12.7 Descriptive statistics

Descriptive statistics allow the elucidation of patterns which might emerge from the

analysis of data. They help summarize, describe or show data in a meaningful way.

Conclusions drawn outside of the data analysed or drawing conclusions around any hypotheses made is not the role of descriptive statistics. They are used to describe data in a very fundamental way and are a very useful tool. Trying to present raw data and discover any patterns which may be present would be virtually impossible with them. Using these types of statistics, data can be presented in a meaningful way allowing simple interpretation.

Data is classically described by using two general types of statistic. The central position of a frequency distribution, for a group of data, are described by the measures of central tendency. This is, for example for a group of test scores from the lowest to the highest, the pattern and distribution of marks scored. This central position can be described using different statistics, for example the mean, median and mode. The second general type of descriptive statistics are the measures of spread. These describe the spread of the data in a summary. These include quartiles, the range, the variance, the standard deviation and the absolute deviation statistics (Field, 2006).

Descriptive statistics can be used to provide a useful summary for a group of data. This is usually achieved by use of a graphical description, tabulated description and statistical commentary. There are however, some terms used in statistics that have a specialised meaning. A distinction needs to be made between 'samples' and 'populations'. Populations possess parameters which are usually unknown but are fixed. Statistics are produced from experimental data; these are then used to estimate the population parameters. The data

analysis depends on the characteristics of the data which then will limit any meaningful measures employed (Field, 2006).

3.12.8 Forms of data

The characteristics of one or more objects being studied are represented by variables. Data are comprised of variables and all statistics are based on data. A variable consists of a defined measurement (Trochim, 2006). The unit of analysis is the object type on which measurements are taken (Jargowsky and Yang, 2003). For example in this research the unit of analysis is children.

3.12.9 Levels of measurement

Something that, potentially, can vary between observations is called a variable. Variables don't all vary in the same way however. A variables attributes are the specific values which can adopt. Information regarding any differences between the observations are conveyed by the attributes relative to the variable dimensions (Jargowsky and Yang, 2003).

3.12.10 Time structure

Time is often a variable in studies however, whether it is or not, data will always have a time structure. Fundamentally there is a distinction to be made between longitudinal data and cross-sectional data. When gathering longitudinal data, a variety of time points are used to take measurements. The same point in time is used to take a single set of observation measurements on appropriate variables in cross-sectional data collection (Jargowsky and Yang, 2003).

3.12.11 Inferential statistics and hypothesis testing

Whether the difference found between control groups and experimental groups is due to the groups variation in performance happening by chance or whether the manipulation of the independent variable causes the difference is determined using inferential statistics. There can be confidence in the inferences made, if there is a low probability that the difference is caused by chance variation, from the samples to the populations they represent. To test the null hypothesis inferential statistics are used on the experimental data. The statement of the null hypothesis is that the independent variable has no effect on the dependent variable (Coolidge, 2006).

A significant difference between the control and experimental groups would not be seen if there was no effect caused by the experimental manipulation. Therefore the null hypothesis would not be rejected. However, if the two groups differ significantly, that is the experimental manipulation has an effect; the null hypothesis would be rejected. In this case the research hypothesis would be indirectly supported. However, the statistical significance of the difference between the groups must be determined to minimize chance variation as an alternative explanation of the results (Coolidge, 2006).

In hypothesis testing there are four possible outcomes (Coolidge, 2006) - two types of error and two correct decisions.

Retain the null hypothesis when the null hypothesis is true

When looking for a relationship between two variables the null hypothesis is that no relationship exists between these variables. A correlation statistical test is performed on the sample data which shows that any observed relationship is due to chance. Therefore the null hypothesis is retained and the inference is that no relationship exists between the

two variables in the population sampled. Actually it is not known whether the null hypothesis is true. However, if we retain the null hypothesis for the sample and it is true for the population a correct decision is made.

The null hypothesis is actually true but rejected - Type I Error

Of the two types of error, Type I is considered the more serious. When committing a Type I error researchers are, in effect, claiming that their research hypothesis is true when it is not. This is considered to be a very serious type of error since it misleads people. The type I error probability should be 5% or less or $p<0.05$.

The null hypothesis is actually false and rejected - Correct decision

The conclusion in this scenario is that there is a relationship between the two variables. Also there is only a very small probability that this relationship can be attributed to chance. Consequently the null hypothesis is rejected and the assumption is made that there is a relationship in the population between these two variables. Therefore if there is a relationship between these variables in the population then rejecting the null hypothesis is the correct decision.

The null hypothesis is actually false but accepted - Type II Error

When the alternative hypothesis is rejected and the null hypothesis is accepted this states that there is no relationship between the variables. However, a Type II error has been committed if there is a relationship between the variables. As these types of errors do not mislead people they are not considered as serious as Type I errors. However potentially useful discoveries can be missed.

3.12.12 Statistical significance

Usually, samples drawn from the population they represent have characteristics that to some degree vary from the true population. This is termed sampling error. If random samples were repeatedly taken it would usually be found that they differed from the population. As the difference between the two sample means becomes greater then the lower the likelihood becomes that this could be attributed to chance. If the probability that the difference between the means could occur by chance is less than five percent it is normally considered by researchers as statistically significant (McGraw-Hill, 2001). This statistical significance level is known as the .05 level or the 5 percent level. If there is a 5 percent, or less, probability of the difference between the control group and the experimental group occurring by chance this would cause the rejection of the null hypothesis. A stricter standard can be employed, if required, which is the .01 level of statistical significance. Therefore if the probability that the difference between sample means is one percent or less of being obtained by chance alone it would be statistically significant (Field, 2006).

When the sample sizes are large, the variability between the groups is small, therefore it is much more likely that the difference between the means of the groups will be statistically significant. It can never be definitely ascertained that effects shown by samples will be shown by the population they represent. Statistical significance is only a statement of probability. Therefore all scientific findings are considered tentative. Also practical significance is not indicated by statistical significance. Even though a statistically significant effect may be attained the financial cost may be too great or the usefulness may be too small to pursue any practical applications (McGraw-Hill, 2001).

3.12.13 Parametric and non-parametric statistics

When analysing research data a decision must be made regarding what kind of statistical analysis to perform. Care must be taken to select tests that are most appropriate for the data generated. Selection of an inappropriate test may cause the interpretation to be incorrect. One of the main decisions to be made is whether parametric or nonparametric statistical tests should be used (Winks, 2007).

The mean is typically one of the first statistics calculated after experimental data is gathered. The average value of a sample is indicated by this statistic. The spread and the central tendency of the group of numbers is given when this is combined with the standard deviation. A large spread in the data is reflected by a large standard deviation and a small standard deviation reflects a small spread in the data. In order that these statistics can be considered dependable and accurate the assumption must be made that the data follows a normal distribution – a Gaussian distribution (Field, 2006). A normal distribution is achieved if the following conditions are met: 65% of data within the mean plus/minus one standard deviation and 95% of data within the mean plus/minus two standard deviations. When the assumption is made that the data generated follow a normal distribution the statistical test used to perform the calculations are called parametric statistical tests (Winks, 2007). Many well-known parametric statistical tests can be used to analyse the data when this is normally distributed. Tests such as t-tests, for example. If the data is not normally distributed then there are several ways it can be approached. The usual method is to use non-parametric statistical tests. The assumption is not made in these tests, also called distribution-free tests, that a normal distribution is followed by the data. If the data was normally distributed, for example, an independent group t-test may have been

performed on the data, however a Mann-Whitney U test may be performed if there is not a normal distribution as this is the corresponding nonparametric test (Winks, 2007).

The answer to the research question of whether there is a significant difference between the values of the observations between groups can be found using this test to calculate a significance level. This however does not compare the means. Most standard parametric tests have a corresponding non-parametric equivalent. For example the paired t-test's non-parametric counterpart is the Wilcoxon Signed Rank test. The problem with non-parametric tests is that they are less powerful than parametric tests since they make no assumption regarding the distribution and therefore have less information upon which to determine significance. However a non-parametric test is a reasonable substitute if a parametric test is not appropriate (Winks, 2007).

A reasonably useful guide to approximating the normality or non-normality of a distribution is by examining a histogram which has the normal distribution curve superimposed. The question then arises regarding what the degree of deviation from the normal is before the distribution should be considered non-normal. This question cannot be answered definitively by only viewing the histograms. However, there is another method which can be used to decide whether a distribution is normal or not which are more objective.

This method of determining if the distribution is significantly skewed requires the determination of the range within which the distribution can be considered normal. This range is given by twice the standard error of the skewness, both positive and negative. The skewness is not considered significantly outside the normal distribution if the value for skewness is within this range (Price, 2000).

A distribution can also be described by its kurtosis. This describes the relative concentration of scores in the tails, the shoulders and the centre of a distribution. The kurtosis, relative to a normal distribution, can be checked using the same process to determine if it fits within the normal range. This is established by doubling the standard error of kurtosis, both positive and negative, to produce a normal range. If the kurtosis fits into this range it can be considered normal. (Price, 2000)

3.12.14 Analyses – intra-school

All data are ordinal. Basic calculations of means and proportions relative to different strata are the analyses used for this part of the study. The dependent t-test, or its non-parametric equivalent, will be used depending on whether the results are normally distributed. The dependent t-test, or the non-parametric equivalent, will be used for the following reasons:

- There are two (paired) samples

- No population information

- Matched subjects (matched with themselves by comparing before and after scores)

The within group variation can easily be identified and excluded, and therefore this test used, if the same observation unit sample (for example, participants) are tested twice (for example, prior to and subsequent to teaching).

In both groups of scores the within group variation can be ascribed to the initial individual differences between the observations which means that this can be deducted from the error which improves the sensitivity of the model.

3.12.15 Analyses – interschool

All data are ordinal. Basic calculations of means and proportions relative to different strata are the analyses used for this part of the study. The independent t-test (unpaired samples

t-test), or its non-parametric equivalent, will be used depending on whether the results are normally distributed. The independent t-test, or the non-parametric equivalent, will be used for the following reasons:

- There are two unpaired samples each with a different number of participants
- No population information

The 'independent samples' or more commonly the unpaired t-test, or its non-parametric equivalent, is used when two discrete groups of identically distributed independent samples are acquired, one from each of the two comparison populations.

3.12.16 Feedback and follow up

Subjects participating in these evaluations were re-tested after 1 month to assess retention. All head teachers will be given the option of viewing the final results of the knowledge uptake evaluations.

3.12.17 Variables, software and testing

The independent variable is the timing of the teaching and the dependent variable is the knowledge uptake which relates to the stated hypotheses of this study, namely:

- Can a more productive learning method be developed which will significantly increase the knowledge uptake by primary school children in a chemical safety intervention?
- If there has been an increase in knowledge uptake has this been retained over a 1 month period?

The statistical software PASW (SPSS) version 17.0 student edition was used to perform all the statistical analysis.

3.13 Ethical Issues - intervention

3.13.1 Consent

Before conducting this research the head teachers and parents were asked to give informed consent. The objective, together with the procedures that would be used, were described to the head teachers, parents and participants. The parents and head teachers were informed that they had the absolute right to withdraw their involvement and their child's involvement at any time. Participants were not put under any pressure to participate. The consent process, and the information supplied, was suitably minimal so as not to disclose the specific hypotheses being investigated.

3.13.2 Reward / Compensation to participants

Schools were given Book Tokens as a reward for participating in the study.

3.13.3 Access to participants

Access to participants within the schools was authorized by the head teacher of each school. In school 1 (control) the children were gathered together in one teaching area for the intervention. The teaching was presented as outlined in table 8. In school 2 (test) two classes were taught in separate classrooms. The teaching was presented as outlined in table 9 and 10. At least one full time qualified primary school teacher was present throughout the interventions including the testing and at least one school teaching assistant was also present. The process is not invasive or stressful for the children. The process is not a substantial deviation from the children's usual experiences within the school environment. Confidential information regarding the children or families was not being obtained.

3.13.4 Concern for ethical research

Research with any human subjects gives rise to ethical issues and concern for the wellbeing of the participants. Such concerns are more acute in the case of research with children. Indeed, there has been a general reluctance on the part of authorities and individuals to accept the inclusion of children in health care decisions (Carnevale et al, 2008) and especially in research (Alderson, 2007, Livesley and Long, 2012). While previous stances of children being unable to understand sufficiently to make an informed choice on such matters have largely been surpassed by more enlightened thinking, this brings additional rather than fewer problems for the researcher. The power differential between adults and children increases the level of concern (Punch, 2002) and perhaps more so in the primary school environment.

Many organisations have offered ethical guidance on research with children, for example, the Economic and Social Research Council (2005); the British Psychological Society (2009); or the Royal College of Nursing (2009). Six principles were proposed by the UK Royal College of Paediatrics and Child Health (2007) for research involving children:

- A research ethics committee should review all research on children.
- Where it is possible, using adults, to answer research questions then research should not be done on children;
- Whilst research on children is for the benefit of all children it must be conducted ethically;
- The agreement of the child, if of school age (less than 16 years old), together with parental consent should be gained;
- It is not necessarily illegal or unethical for a research procedure not to directly benefit the child;

- Children are not small adults;

In this study, it is clear that the research could not be undertaken with adults instead of children. While often the benefits of research are felt by others in the same group but not by the participant personally, in this case the child participants themselves benefited. Consent was gained from parents and children, and formal research ethics committee approval was secured.

3.13.5 The Approach to Research Ethics

Although there are many espoused approaches to research ethics, two major theoretical stances encompass these. Many researcher and professional governing bodies propose a principles-based approach, urging researchers to consider what is the right course of action according to varying sets of rules or basic principles. Such a principles-based approach can be fraught with conflict and contradiction as demands from different rules or principles clash with opposing demands from others (Johnson, 2007). For this reason, such an approach was rejected in this study.

A risk-analysis approach was adopted instead (Long, 2007). This involves identifying the risks to participants and then taking actions to eliminate, minimise or compensate for them.

3.13.6 The risk of perceived coercion

The most common ethical threat in research is the potential for participants to feel compelled to take part even when there is no such requirement. Clearly, the strength of this perception of a duty or expectation to agree to the researcher's request may vary according to the setting. Parents, for example, might feel more pressure to acquiesce to medical research as part of their child's treatment, while schoolchildren may feel more

pressure to agree to research in school – an environment in which they are used to being compliant. Alderson (2007) notes that children should have as much right as adults to accept or decline the invited participation in a study.

3.13.7 Information

To correct or minimise this misconception, three main strategies may be employed. The first of these is to ensure that potential participants have sufficient information about the study and their possible contribution to make a personal choice about whether or not to take part. As is usually the case in UK schools, the head teachers had standing agreements with parents for their children's participation in activities within school and linked to wider curriculum delivery, including visiting teachers and professionals. Parents were informed of their child's participation in a class to learn about chemical hazards in the home. The provision of information may be in varied forms. In this study, a formal, printed study information sheet was provided for parents and distributed by the schools. This held details of the study's purpose, why the children had been selected, what would happen to them if they agreed to take part, how to contact the researcher for more information or to ask questions, and how to complain about the study if necessary.

However, while full details of the study were provided in print for the parents and head teacher of each school, in studies with children this is not always the best way to ensure that participants themselves are appropriately informed. Alternative means of explaining the study might be more helpful for research with young children (Livesley and Long, 2012a). Indeed, the Department of Health (2005) in introducing the Research Governance Framework for Health and Social Care noted specifically that additional care is needed in gaining consent from children, and that this is dependent upon ensuring that "relevant

information is provided in appropriate written or pictorial form…" Various strategies have been employed by researchers to introduce child-friendly processes for informing children and eliciting their consent to proceed (Bray, 2007; Gibson and Twycross, 2007; Coad, 2009).

The informed consent process for the child participants started with an explanation from their form teacher several weeks before the intervention commenced. This was after parental permission had been given. The teachers outlined that the study was about dangerous chemicals in the home and that a person was going to come to the school to show them how to recognise these chemicals so that contact with them could be avoided. The teacher informed the children that the person who was going to teach them was looking at the best ways for them to learn about this subject. They emphasised that no chemicals would be used. The teachers also stated that the children would be given some tests but that their teachers would not see their individual test scores and that if they didn't want to attend this session they did not have to do so. Finally they were informed that their parents knew about this teaching and that if they had any questions, concerns or they did not want to participate they could talk to their form teacher, the head teacher and /or their parents.

3.13.8 The ability to withdraw from the study

The second strategy, which links closely to the first, is to ensure that participants feel able to withdraw from participation at any time and without negative consequences. In part, this is addressed in the provision of information about the study, stating explicitly that participation is not compulsory, and that an individual may stop participating at any time. Continued agreement to take part is checked at intervals throughout the data collection

process. In this case, it was a simple matter of asking a child if they wished to take part in the next activity or to do something else. Close observation of children's behaviour is also essential if indications of failing willingness to continue are to be appreciated (Livesley and Long 2012b).

3.13.9 Consent forms

The third strategy is to gain evidence of consent by means of a signed form. In some ways, this is more of a protection for the researcher, since it forms a guarantee that the individual agreed to take part. Although it is possible that signing a consent form may emphasise the importance of the decision being made, general experience of signing forms bearing a great deal of small print without reading or understanding it may suggest otherwise. In some cases, insistence on a signed consent form can prevent participation, particularly in circumstances in which potential participants may feel that statutory authorities may be involved. In such cases, verbal consent is usually acceptable. In this study, signed consent forms were not used. Parents had opportunities to express concern opposition to the intervention but none did so. Children were allowed to choose whether or not to take part, and their starting to do the activity was taken as evidence of a desire to participate.

3.13. 10 The risk of breach of confidentiality

Disclosure of personal information by the researcher without consent is another potential threat to participants. Personal contact details, clinical details, or financial details may be required for a study but should then be kept confidential. While the risk in this study was small, the following actions were undertaken. First, no personal information that was not essential to the study was collected or recorded. Additionally, access to all data was

restricted to the researcher, and supervisors when required, and the data was stored securely. Electronic data was stored on a password-protected computer which was used only by the researcher. A single backup CD was maintained, stored separately but securely. Hard copy data was stored in a locked filing cabinet in a secure room. As soon as possible data was made anonymous. With the children's permission, some artwork done by them was retained, but this bore no personally identifying marks.

3.13.11 Practical Safeguarding Issues

In school 1 (control) the children were gathered together in one teaching area for the intervention. The teaching was presented as outlined in table 8. In school 2 (test) two classes were taught in separate classrooms. The teaching was presented as outlined in tables 9 and 10. At least one full time qualified primary school teacher was present throughout the interventions including the testing and at least one school teaching assistant was also present.

3.13.12 Ethical Review of the Study

The University of Salford Research Governance and Ethics Committee gave formal ethical approval.

Chapter 4: Delphi survey

4.1 Introduction

In this chapter I start by describing the Delphi method as a tool to elicit a consensus of expert opinion regarding the pedagogies which the experts consider would provide a greater knowledge gain, and retention, in the teaching of home chemical safety for children in the age range 7-11 years old. The results of the Delphi study together with the appropriate analyses of the data gained are then described. Finally I summarise the Delphi study findings which leads on to the intervention in chapter 5.

4.2 History and background

Glenn and Gordon (2009) maintain that the term 'Delphi' pertains to the sacred location of the highly venerated oracle in ancient Greece. Mediators at this oracle offered predictions and advice from the deities to people who sought them. The Delphi method has been used by government, industry and academia. Several investigations have used the Delphi method to look at public health problems, for example strategies for prevention of HIV/AIDS infection and drug abuse reduction and many other health education fields (Adler and Ziglio, 1996).

The assembly of appropriate information for use in making decisions or the consistent and imaginative investigation of concepts are the two usual aims of the majority of Delphi studies. The foundation method of the Delphi is an ordered and controlled programme for assembling and condensing opinion based on expertise from a set of knowledgeable specialists by use of consecutive questionnaires intermingled with partial viewpoint feedback (Adler and Ziglio, 1996). Linstone and Turoffs' (2002) work suggests that the Delphi method is a valuable communication tool amongst a collection of specialists and so

assists in the construction of a group conclusion. Rowe and Wright (2001) assert that the Delphi method has been produced and refined to make debate among specialists achievable without accepting particular social interactive behaviours as occurs in the course of a conventional group debate and impedes opinion development. The Delphi method has been extensively used in education, technology and alternative fields (Rowe and Wright, 1999). The Delphi method was initiated in nineteen forty four and was created and developed initially for technology forecasting research. There was a requirement to deliver a prediction of prospective technological capacities which may be of importance to the armed forces and General Arnold had invited Theodor von Karman to produce this report (Bell, 2009).

This project was initiated in 1946 and was called project RAND. In 1959 Helmer, and associate RAND investigator Rescher, wrote an article entitled 'The Epistemology of the Inexact Sciences' (Helmer and Rescher, 1959) which offered a philosophic foundation for forecasting (Adler and Ziglio, 1996). In disciplines that have not yet developed empirical laws, the evidence of specialists is acceptable the article contended. The dilemma is how to use these statements and, in particular, how to merge the evidence of several specialists into a single valuable testament. The Delphi method acknowledges individuals judgement as valid and constructive contributions to build forecasts. Solitary specialists occasionally experience individual biases; meetings experience 'follow-the-leader' inclination and an unwillingness to discard formally expressed opinions (Milevska-Kostova and Dunn, 2009). These deficiencies are fundamentally overcome by the Delphi method.

4.3 The Delphi method basics

A group consultation activity between physically spread specialists is what the Delphi

method facilitates (Adler and Ziglio, 1996). It permits intricate tasks or problems to be dealt with by specialists in a methodical manner and yet the method, though fundamental in nature, is reasonably simple. It consists of a succession of questionnaires dispatched as hard copy, computerised programmes or some alternative way, to a preselected panel of specialists. The surveys are devised to facilitate the specialists to enhance their own opinion and extract and cultivate personal answers to the problems presented. The key objective underpinning the Delphi method is to conquer the weaknesses of traditional group engagement. Relative to Rowe and Wright (1999), moderated response, anonymity and statistical feedback differentiate the Delphi method. The panel communication in a Delphi is anonymous, so that remarks are not recognized as to their creator. The mechanism for gathering comments that are offered to the panel is organised so as to conceal any identification of the commenter. The key elements of the Delphi process are (Glen and Gordon (2009):

1. Feedback to the participants,

2. Structuring of information flow, and

3. Inter participant Anonymity as a minimum.

This technique provides properties that offer obvious and distinctive benefits, as a communication device, over the traditional face-to-face meeting. Therefore typical difficulties associated with group interactions are therefore totally avoided. The following ten steps for the Delphi method were illustrated by Glen and Gordon (2009):

1. A supervisor needs to be established to start and monitor the Delphi

2. Panelists, who will participate in the various rounds of the exercise, must be selected. Panelists are usually specialists in the subject area that is to be investigated.

3. Primary round Delphi questionnaire improvement

4. Analysing the wording of the questionnaire for its aptness (e.g. removing vagueness, ambiguities)

5. Primary questionnaire Communication to the panel members

6. First round response examination

7. Second round questionnaire preparation

8. Second round questionnaire communication to the panel members

9. Second round response Examination

10. Analysis and Preparation of a report to deliver the results

The critical question, as argued by Rescher (1998) is that the purpose of the Delphi study should be appreciated by all members. Alternatively panel members might respond unsuitably or become discouraged and lose concentration. The panel members must be knowledgeable in the appropriate subject field (Armstrong, 2001). Conversely Amos and Pearse (2008) proposes that a very elevated level of knowledge is not considered vital. The least number of panelists to assure a high-quality set achievement is relatively reliant upon the appropriate investigational design. Linstone and Turoff (2002) demonstrated in their trials that, when conditions are ideal, panels as few as four may function competently. Prior to making a decision on whether the Delphi method ought to be employed, it is vital that the context inside which the method is to be employed should be meticulously examined (Amos and Pearse, 2008).

Several challenges should be made prior to deciding to select or not the Delphi method (Adler and Ziglio, 1996):

- Which type of panel communication programme is required to enable the exploration of the Issue/problem?

- Who are the individuals with the necessary knowledge in relation to the Issue/problem and what is their location?

- What alternate methods are accessible and what answers may realistically be anticipated from their employment?

The decision whether or not the Delphi method is relevant to the context in which it will be employed can only be made when these issues have been resolved. Furthermore Adler and Ziglio (1996) also assert that not dealing with these issues could result in unsuitable appliance of the Delphi technique. The Delphi study only provides opinion as the final result. The views of the panel members are the only form of legitimacy for the outcome of the series (Graefe and Armstrong, 2011). The group opinion is summarised statistically. The Delphi method, whilst being generally well affirmed, has been the subject of criticism. Rowe and Wright (1999) performed a comprehensive critique of the Delphi method in which they criticise the technique as being un-empirical and emphasise that the Delphi is a technique of final choice in addressing intricate questions which have no satisfactory models. They also maintain that, on occasion, dependence on intuitive conclusions is not just a transient means to an end but actually an obligatory requirement. The fact that there have been numerous inadequately performed Delphi studies is accepted by Mullen (2003). However, it is a basic error, he cautions, to compare the Delphi method itself with the application of the Delphi method, as numerous commentators do. There is a significant conceptual difference between appraising a method and appraising an application of a method. He goes on to add that generally, the Delphi method is valuable in resolving a one dimensional set of questions.

4.4 The Delphi method - how others have used it

Numerous researchers, for example Adler and Ziglio (1996) and Rowe and Wright (1999), have scrutinized an assortment of research that has used the Delphi method. Table 11 shows the extents of the Delphi possibilities. A broad assortment of research areas have used the Delphi method as a research tool to forecast, identify, develop, and validate. Single and Double round Delphi investigations, whilst not being as characteristic as the three round Delphi study, have also been carried out. Sample sizes can vary enormously from four to one hundred and seventy one 'experts'. Therefore the conclusion is that a standard Delphi study does not exist but instead the method is customized to correspond with the situation and research question (Skulmoski et al., 2007).

4.5 The Delphi method critique

4.5.1 Possibility of low rate of response

Because of the numerous response processes integral and fundamental to the method and practice of the Delphi technique (Hsu and Sandford, 2007) the possibility of poor response rates exists and trying to sustain dynamic comment is very demanding. Hung et al. (2008) describe this as, "In the Delphi technique poor response rate is magnified fourfold because a maximum of four surveys may be sent to the same panelists." Therefore if a particular participant fraction cease responding at some stage in the Delphi study, the quality of information acquired might be dismissed or in any case critically examined. Participant motivation is vital to the successful execution of a Delphi investigation according to Okesola et al. (2009) and the facilitation of as large a response rate as practicable is the researcher's responsibility and they ought to actively engage with the participants.

Study	Delphi focus	Number of rounds	Sample size
Gustafson et al., Shukla, Delbecq & Walster, (1973)	Estimate almanac events to investigate Delphi accuracy.	2	4
Hartman & Baldwin, (1995)	Validation of research outcomes.	1	62
Czinkota & Ronkaimen, (1997)	Impact analysis of changes to the international business environment.	3	34
Kuo & Yu, (1999)	Identify national part selection criteria.	1	28
Nambisan, (1999)	Develop a taxonomy of organisational mechanisms.	3	6
Lam, Petri & Smith, (2000)	Develop rules for ceramic casting process.	3	3
Roberson, Collins & Oreg, (2005)	Examine and explain how recruitment message specificity influences job seekers attraction to organisations.	2	171

Table 11. Delphi method as used in published research demonstrating its great diversity (Skulmoski et al., 2007)

4.5.2 Use of substantial periods of time

The Delphi method has been described as laborious and protracted. Contrasting with, for instance, the telephone survey, which can be concluded in a brief time period if the sample size is reasonably low and can be performed concurrently by a set of individuals, the Delphi method, however, is sequential and iterative.

Therefore, consequently, the requirement of taking substantial time periods to conclude the sequential Delphi procedure makes it unavoidable. Okesola et al. (2009) also suggests, "a drawback to Delphi was that the questionnaire method may slow the process greatly as several days or weeks may pass between rounds." The iteration aspects used in the Delphi process allow a greater accuracy in the results achieved by researchers and participants. The substantial increase in the researcher's workload, due to the large time

period required to effectively conclude gathering the data, is also caused by the same property (Cunliffe, 2002).

4.5.3 Potential for influencing opinions

Opinions can be moulded by the researchers due to the iteration properties of the Delphi method (Altschuld, 2003). Distorted feedback was found in an investigation by de Meyrick (2003) to affect how participants would assess their answers. It was observed by Osborne et al., (2003) that, "some 'leading' by the experimenters inevitably resulted from the selection of the information supplied." A statement, originally rated below average, was then rated above average in Hsu and Sandfords' (2007) investigation after false feedback. Therefore the Delphi method might, "be used to mould opinion as well as to collect data" (Hsu and Sandford, 2007). Hung et al. (2008) stated that, "subtle pressure to conform to group ratings" formed the chief disadvantages of the Delphi method. Caution should be employed by Delphi researchers who should be aware that appropriate preventative measures should be put in place to deal with this subject.

4.5.4 Potential for Identifying specific topic related information vs. general statements

There is a presumption regarding Delphi subjects that there experience and knowledge are comparable (Young and Jamieson, 2001). This presumption, however, may be unwarranted. The Delphi participant's expertise might be unequally spread (Young and Jamieson, 2001). As Young and Jamieson state, "Some panellists may have much more in-depth knowledge of certain topics, whereas other panellists are more knowledgeable about different topics" (Young and Jamieson, 2001). Participants that have in-depth knowledge relating to the objective subject can specify the most significant statements, however, participants who possess a less comprehensive knowledge of specific subjects

are incapable of specifying the most significant statements. Instead of an in-depth elucidation of the subject the Delphi investigation result might be the identification of a sequence of general statements (Young and Jamieson, 2001).

4.6 General issues for testing – Delphi study

In this part of the research all of the participants were selected by virtue of their qualifications and experience in education. Therefore they were not randomly selected they were specifically selected. The researcher actively selected these participants to gain insights into their opinions. The number of participants recruited for the Delphi study was 8. Samples sizes for these types of studies can vary from 4 upwards – see table 11 (Skulmoski et al., 2007). There is a trade-off between quality of the results and manageability of the study. However the drop-out rate is quite large. In this study 15 people indicated that they would take part but only eight returned round 1 and only five returned round 2.

4.6.1 Access to participants

All the participants in the Delphi study were based at the same further education college. They were asked to participate in the study by face-to-face communication by a contact who works at the college and who is known to the researcher.

The first round of the Delphi was given in printed form by hand and collected by hand. If a participant decided not to return or complete their questionnaire no pressure was put on them to comply. Both rounds of the Delphi study were completed in this manner.

4.6.2 Coding procedure and software

All the participants in the study were assigned a number – participant 1, participant 2, etc. Details of their qualifications were not coded. The round 2 Delphi questionnaire used a Likert scale with the following coding:

Likert Scale :

Strongly agree	Agree	Moderately agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly Disagree
7	6	5	4	3	2	1

The statistical software PASW (SPSS) version 17.0 student edition was used to perform all the statistical analysis.

A two-round Delphi investigation was performed with educational experts. A Delphi investigation is a method which is especially suited for producing ideas concerning issues on which educational knowledge is sparse. The method permits assurances to be agreed regarding the anonymity of the answers given that could make the experts answer unreservedly, and is directed towards achieving consensus on the principal topics.

The first round of the Delphi study was aimed at identifying potential educational teaching and learning methodologies with respect to teaching primary school children chemical safety in the home using the new GHS system. The significance of the elements described in the first round was the objective of the second round by establishing and achieving agreement on which elements were significant.

The Delphi investigation was performed by means of hard copy questionnaires given to the participants by hand. The Delphi participants were requested to specify which factors, in their opinion, would be significant for children in the age range 7 to 11 years old in the

first round of the investigation. The full Delphi investigation was performed within three months (April to June 2010).

4.6.3 Participants and procedure

A total of 15 educational experts were asked to complete the first round of the Delphi investigation with eight returning responses.

4.6.4 Delphi participants

Participant	Minimum qualification	Other qualifications	Experience
1	BA(Hons)	Ofsted inspector; PGCE	Former primary school head teacher
2	BA(Hons)	MSc, PGCE	Lecturer/Advanced practitioner
3	BEd(Hons)		Primary school teacher
4	BEd(Hons)		Primary school teacher
5	BA(Hons)	PGCE	Head of teacher training/Advanced practitioner
6	Registered Nurse	Cert Ed	
7	BSc(Hons)	PGCE	Lecturer
8	BSc(Hons)	PGCE	Lecturer

Table 12. Delphi participants' qualifications and employment roles

Criteria for choosing key experts in the first round were the following, as summarised in table 12:

1) each expert had a graduate degree or equivalent and a PGCE if their degree was not in education, and

2) they were experienced primary school teachers or teacher trainers.

People were also included if they might bring a different and novel perspective. The experts were asked to take part in the investigation by means of a face-to-face request. Face-to-face contact was employed, but in a one-to-one discrete way, to give a description and explanation of the procedure and purpose of the Delphi study.

The first questionnaire was also given in this way. The front sheet of the round one questionnaire also had a brief summary of the aims of this study. The round 1 questionnaire also contained a summary of the GHS system and background information. Invitees returned the questionnaire by hand once completed.

4.7 Measurements

4.7.1 First round

A structured questionnaire with an open-ended answer format was used for the first-round. There were 16 questions, some questions contained sub category questions. An A4 sheet was allotted for writing each comment. Participants were asked to give: 1) their views on the most appropriate teaching and learning methods for this intervention, 2) their views on assessment, 3) their views on other factors which could affect the knowledge uptake and retention. The participants were also requested to make suggestions regarding factors that may relate to the teaching - learning environment and course material.

4.7.2 Second round

A closed-ended response design was used for the second-round survey which incorporated the elements stated in the first round by the experts.

The survey comprised of 28 statement items (see Appendix D). A Likert scale was created and the experts were requested to signify their degree of agreement with each statement. The Likert scale created was a seven point scale which ranged from 1 = Strongly Disagree to 7 = Strongly Agree.

4.7.3 Data analysis

The first-round survey replies were listed and, so as to condense the number of elements, comparable responses were clustered together. In the survey for the second round the residual list of potentially significant elements was incorporated. The median scores were evaluated to ascertain agreement on the significance of the statements for the second round so as to comply with the principles for examining figures from a Delphi investigation. The significance of the statements was determined using the inter-quartile deviations (IQDs) which were calculated so as to ascertain the level of agreement between the participants and therefore the significance. An IQD a 1.5 is regarded as good consensus as, using a 7-point Likert scale, this shows that greater than 50% of all opinion falls within one point on the Likert scale (Hasson et al., 2000; Linstone and Turoff, 2002).

Items having a median ≥ 6 (Agree or strongly agree) and an IQD ≤ 1.5 are regarded as significant factors (Hasson et al., 2000; Linstone and Turoff, 2002). Items with a median ≤ 2 with an IQD ≤ 1.5 indicates a consensus disagreement. PASW (SPSS) 17.0 (Pearson Education Inc, USA) was used for all the statistical analyses.

4.8 Result of Delphi study

4.8.1 Participants and response rates

In total, eight of the fifteen experts contacted completed the first round survey (53% response rate (table 13). Five of the eight first round respondents completed the second-round survey (62% response rate). Explanations for the nonparticipation and withdrawal of the other experts are not known, however a number of stated lack of time as the reason.

First round			Second round		
No. Invited	No. Responded	Percentage	No. Invited	No. Responded	Percentage
15	8	53	8	5	62

Table 13. The response rate for the first and second rounds of the Delphi study

4.8.2 Measurements - First round

After receiving the first round responses – open questions – all comments were collated

and analysed. This analysis looked at the number of times key words were used by the

participants as a basis of how important the comment was. The analysis of the first round

responses are shown in tables 14 to 30.

4.8.3 Analysed responses to Delphi round 1

Question 1: At what age do you think it is reasonable for children to use hazardous chemicals in the home and why e.g. bathroom cleaner; some types of glue; hair spray; etc

Analysed response	Rank order
Aged 10	1
Aged 11	1
Aged 12	1
Aged 3	2
Aged 9	2
Aged 14	2

Table 14. Delphi first round: analysed response to question 1

It was clear that participant 2 misunderstood the question and thought that the question

was 'when should teaching commence' and they gave the answer 3 years old. The

majority of participants thought that it was reasonable for children to start using hazardous

chemicals around the age of 11 years old (as an average of the top ranked). When a

participant gave an age range each age within that range was counted.

Question 2: How would you initially assess existing knowledge?

Analysed response	Rank order
Group questions and answers	1
Group discussion	2
Mini tests	3
Roll play	3
Making posters	3

Table 15. Delphi first round: analysed response to question 2

Most participants favoured group questions and answers as the primary technique used to

initially assess existing knowledge.

Question 3: What teaching and learning methods would you employ when teaching

the meanings of symbols and pictograms?

Analysed response	Rank order
Games	1
Active learning	2
Video clips	2
Quizzes	3
Drawing	3
Presentations	3

Table 16. Delphi first round: analysed response to question 3

Most participants favoured the use of games to teach the meaning of symbols and

pictograms. However all responses seem to point towards the use of active learning, which

is ranked second, incorporating all suggested responses.

Question 4: What teaching and learning methods would you employ when teaching about hazard definitions?

Analysed response	Rank order
Posters	1
Q&A/ Discussion	2
Active learning	3
Use of colours	3
Research for themselves	3
Games	3

Table 17. Delphi first round: analysed response to question 4

Most participants favoured the creation of posters by the children. Again the emphasis was

indirectly associated with the types of activities that would be used in active learning.

Question 5: What teaching and learning methods would you employ when teaching about precautions?

Analysed response	Rank order
Active Learning	1
Q&A / Discussions	1
Games	2
Role Play	2
Demonstrations	2

Table 18. Delphi first round: analysed response to question 5

Active learning together with question and answer sessions and group discussions was

the most popular response.

Question 6: How would you relate the following hazards to children? Corrosive; Acutely toxic; Long term toxic; Flammable; Dangerous for the environment

Analysed response	Rank order
Use of large pictures	1
Use of videos	2
Rote Learning	2
Use of sounds	2

Table 19. Delphi first round: analysed response to question 6

The size of the symbol pictures used was thought to be of major importance by most participants. Interestingly the use of sounds to define hazards was also mentioned.

Question 7: What would you define firstly and how would you build the whole picture?

Analysed response	Rank order
Role Play	1
Story Telling	1
Games	2
Use of mock real life situations	2
Hands on learning	2
Q&A/ Discussions	2
Showing actual containers	2

Table 20. Delphi first round: analysed response to question 7

Role play and story-telling were considered to be the most effective way of introducing the subject to the children. Also the use of product containers that had held hazardous materials was mentioned.

Question 8: What activities could be used to enhance the learning experience?

Analysed response	Rank order
Teaching to learning styles	1
Games	1
Demonstrations	2
Using sounds	2
Q&A	2
Labelling containers	2
Creating posters	2

Table 21. Delphi first round: analysed response to question 8

Most participants felt that the use of teaching to learning styles and the use of games would enhance the learning experience to the greatest extent.

Question 9: How would you assess the learning at each age?

Analysed response	Rank order
Formative	1
Summative	2

Table 22. Delphi first round: analysed response to question 9

Most participants felt that the main assessment should be formative.

Question 10: What do you think are the main teaching and learning methods when teaching about chemical hazards to different ages of children?

Analysed response	Rank order
Make it fun	1
Continuous reinforcement	2
Active learning	2
Teaching to learning styles	2
Assessment	2

Table 23. Delphi second round: analysed response to question 10

The view of the participants was that the learning should be fun as the children could

view the subject as boring.

Question 11: For children between the ages of 5 and 11 years old should these ages be split into groups to be taught and if so how?

Analysed response	Rank order
Yes (By age groups)	1
No	2
Yes (Infants and juniors)	3

Table 24. Delphi first round: analysed response to question 11

The participants favoured the children being taught separately be age group.

Question 12: Should the overall message differ relative to age?

Analysed response	Rank order
No	1
Yes	2

Table 25. Delphi first round: analysed response to question 12

The vast majority of participants felt that the overall message should not differ relative to

age.

Question 13: Do you think that there is a difference between the specific teaching of chemical hazards as opposed to other types of hazard?

Analysed response	Rank order
There is a difference	1
There is no difference	1

Table 26. Delphi first round: analysed response to question 13

The participants were equally divided on this question with 50% stating that there was a

difference between how chemical hazards are taught and 50% stating that there was not.

Question 14: How do you think ethnicity might affect this teaching and learning?

Analysed response	Rank order
Lack of English could cause a problem	1
Will not be affected	2

Table 27. Delphi first round: analysed response to question 14

The participants did not think that ethnicity would affect the teaching and learning but felt

that if English was not a first language a check would need to be made to make sure that

the child's comprehension of the English language was sufficient.

Question 15: Do you think that gender would be a factor in teaching about chemical hazards?

Analysed response	Rank order
No	1
Yes	2

Table 28. Delphi first round: analysed response to question 15

Most participants did not think that gender would be a factor in the teaching and learning of

chemical safety.

Question 16: What do you think the maximum lesson duration for each age should be?

Analysed response	Rank order
30 – 45 minutes	1
1 hours	2
<30 minutes	3
2 hours	3

Table 29. Delphi first round: analysed response to question 16

Most participants felt that the maximum lesson duration should be between 30 and 45 minutes.

Question 17: Do you think that this should be taught in schools as a subject, as part of a subject e.g. Science, or some other way? Should it be taught as a 'one-off' or should it continue throughout school?

Analysed response	Rank order
Science	1
PSHE	2
Subject in own right	2
Continued throughout school	1
One off session	2

Table 30. Delphi first round: analysed response to question 17

There was quite a spread of opinion relative to this question. Chemical hazard safety should be taught within the science curriculum was ranked top. The majority however, felt that this teaching should be continued throughout school.

4.8.4 Delphi - Second round

The round 2 questionnaire (appendix C) was then compiled specifically addressing all the points raised in the first round. This was then delivered to the first round participants who were asked to review these items and rate them relative to the given scale – strongly agree to strongly disagree.

The responses to round two of the Delphi questionnaire are shown in table 31. Consensus was reached for all but one of the items – namely Q18 – 'The main teaching method is that only the basics should be taught.' The cause of this non-consensus seemed to be the definition, or lack of one, regarding what the term 'Basics' means. I define the basics as symbol recognition, symbol meaning and key word definition. However I accept that this was not clear. I decided not to perform a round 3 of the Delphi study just to answer this question as I did not feel that this would be cost effective and the resultant effect on this study would be negligible.

All items reached consensus – defined as a Median ≥6.0 or ≤ 2.0 and an IQD of ≤ 1.5. The consensus results are shown in table 32. There were 2 outliers namely Q8 participant 4 and Q23 participant 1. A numerically remote observation from the remainder of the data, in statistics, is termed an outlier. The term outlier was defined by Grubbs (1969) as, "An outlying observation, or outlier, is one that appears to deviate markedly from other members of the sample in which it occurs."

The reason given by Participant 4 for their rating of Q8 was that they felt that the youngest children would be unable to match the text definition to the symbol and the extra effort involved to explain this would make this section of the teaching boring for older children. All other participants felt strongly that this was not the case.

The reason Participant 1 gave for their rating of Q23 was they felt strongly that it should be taught as part of the current PSHE teaching in primary schools and that chemical hazards should not be treated differently than other hazards such as 'Stranger Danger' and 'Road

Safety'. All the other participants felt strongly that chemical safety was a very different subject and should be addressed separately.

The outliers in Q23 and Q8 caused the interquartile deviations to rise above the ≤ 1.5 threshold to 2.5 and 3.0 respectively. This was not a single participant who was out of step with all the other participants but two participants who were in general agreement with the other participants but differed on this single item. However, since the medians were 6 and 7 respectively and the percentage agreement was 80% for both questions, this was deemed to have reached consensus.

4.9 Summary of Delphi study findings

The Delphi study produced very definite answers and the experimental intervention was developed around these results. It was the explicit opinion of the Delphi participants that the two principal methods which should be used in the experimental intervention were 'teaching to learning styles' and 'active learning'. The course should utilise instruments such as large pictures, sounds, bottles and large text to ensure that the VART learning styles were accommodated. The use of photographs, games, role play and demonstrations would cater for the kinaesthetic learning style and also the active learning method. The teaching of precautions was not included in the intervention since the result of the Delphi survey was that children should not handle chemicals until at least 11 years of age, and therefore this would be best taught in secondary schools.

Question Number	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Percentage
Question 1	6	5	6	6	6	80
Question 2	7	7	7	6	7	100
Question 3	7	6	7	7	7	100
Question 4	7	6	6	7	6	100
Question 5	7	6	7	7	6	100
Question 6	7	6	7	7	5	80
Question 7	2	2	2	1	2	100
Question 8	7	7	7	1	7	80
Question 9	7	6	7	5	6	80
Question 10	6	6	7	7	6	100
Question 11	7	6	7	7	6	100
Question 12	4	6	6	7	6	80
Question 13	7	7	7	7	5	80
Question 14	6	6	6	7	5	80
Question 15	7	7	7	7	4	80
Question 16	7	6	7	6	6	100
Question 17	7	7	7	7	5	80
Question 18	3	5	5	1	4	
Question 19	7	6	7	7	5	80
Question 20	6	6	6	5	6	80
Question 21	7	6	7	7	6	100
Question 22	6	6	6	7	6	80
Question 23	2	6	6	7	6	80
Question 24	7	6	7	7	7	100
Question 25	7	7	6	7	7	100
Question 26	7	7	7	7	6	100
Question 27	7	6	6	4	6	80
Question 28	6	6	7	7	5	80

Table 31. Responses to round 2 of the Delphi study

The Delphi participants considered that ethnicity and gender would not affect the content nor teaching of the intervention and so the intervention was not adapted in this respect. They did state, however, that children should be taught relative to their age but unfortunately the time allotted by the participant schools and the small number of pupils in each age group would not facilitate this. The Delphi experts considered that the maximum lesson duration should be 1 hour followed by activities and this was attained.

Question Number	Question	Median (Inter Quartile Deviation)	Percentage agreement
Q1	It is reasonable for children aged 11 years old and above to use hazardous chemicals in the home.	6.0(0.5)	80
Q2	Existing knowledge should be assessed using open discussion question and answer sessions.	7.0(0.5)	100
Q3	The Q&A session should be conducted in a 'fun' style.	7.0(0.5)	100
Q4	When teaching the meanings of symbols and pictograms the best methodology to employ is trying to teach relative to the learning styles of the children.	6.0(1.0)	100
Q5	When teaching about hazard definitions and hazard phrases the best methodology to use is trying to teach relative to the learning styles of the children.	7.0(1.0)	100
Q6	When teaching about precautions and precautionary phrases the best methodology to employ is trying to teach relative to the learning styles of the children.	7.0(1.5)	80
Q7	Precautions and precautionary phrases should only be taught to older children (11 years old upwards).	2.0(0.5)	100
Q8	The best way to relate chemical hazards to children is by relating the pictures to the text definition.	7.0(3.0)	80
Q9	The best way to relate chemical hazards to older children is by using photographs of the hazard and relate to text definition.	6.0(1.5)	80
Q10	Showing actual products used in the home should be defined firstly.	6.0(1.0)	100
Q11	This should be followed by basic definitions – such as 'Danger' , 'Hazard', 'Risk', 'Harm'	7.0(1.0)	100
Q12	The course should build slowly over time.	6.0(1.5)	80
Q13	Games should be used to enhance the learning experience and to take into account the learning styles of the children.	7.0(1.0)	80
Q14	Role play should be used to enhance the learning experience and to take into account the learning styles of the children.	6.0(1.0)	80
Q15	Demonstrations should be used to enhance the learning experience and to take into account the learning styles of the children.	7.0(1.5)	80
Q16	Formative evaluation should be used to assess the learning at each stage as the course progresses with a final summative evaluation.	6.0(1.0)	100
Q17	The main learning methodology is that the learning should be fun and address the learning styles of the children.	7.0(1.0)	80
Q18	The main teaching methodology is that only the basics should be taught.	4.0(3.0)	40
Q19	The main teaching and learning methodologies are that there should be lots of activities which address the various learning styles.	7.0(1.5)	80
Q20	In order to teach chemical safety in the home pupils should be grouped, and taught, by age	6.0(0.5)	80
Q21	The overall safety message should be the same whatever the age	7.0(1.0)	100
Q22	The overall message should be 'Keep away from chemicals as they can harm you'	6.0(0.5)	80
Q23	Chemical hazards should be taught differently than other types of hazard	6.0(2.5)	80
Q24	Ethnicity will not be a factor in the chemical safety teaching and learning	7.0(0.5)	100
Q25	Gender will not be a factor in the chemical safety teaching and learning	7.0(0.5)	100
Q26	The maximum lesson teaching duration should be 1 hour followed by activities	7.0(0.5)	100
Q27	Chemical Safety in the home should be linked to the teaching of science	6.0(1.5)	80
Q28	Chemical Safety in the home should be continually taught by refresher sessions	6.0(1.5)	80

Table 32. Median, inter-quartile deviation and percentage consensus for round 2 of the Delphi study

They also thought that home chemical safety should be taught as a topic in its own right which fitted the objectives of this research. However, they considered that continual refresher sessions should be conducted which was not possible due to the school time constraints. In their view formative evaluation should be used throughout the intervention using question and answer sessions and open discussion but that a summative evaluation should be used at the end of the intervention. Finally they considered that the overall message should be 'stay away from chemicals'.

Chapter 5: Chemical safety intervention results

5.1 Introduction

The outcome of the Delphi study, described in chapter 4, was that the teaching methods employed in the test intervention should be to teach to the learning styles of the children and use active learning. In this chapter I describe the results from the chemical injury prevention program together with the appropriate analyses. I also describe the crucial misconceptions that the children held.

5.2 Results – Chemical safety intervention

Twenty three children in school 1 acted as the control group and forty nine children in school 2 acted as the experimental group. There were no drop outs in the control school however there were two drop outs for the one month post-test in the experimental school due to the children being absent on the day of testing.

5.2.1 Age and gender results for school 1 – control

The group consisted of 12 females and 11 males. The total number of participants was 23. The age ranged from 7 to 11 years old – the mean age being 9 years old.

5.2.2 Age and gender results for school 2 – test

The group consisted of 30 Females and 19 Males. The age ranged from 7 to 11 years old – the mean age being 8.5 years old. The total number of participants was 49.

5.3 Distribution

The skewness and kurtosis were determined together with the standard error of skewness and kurtosis. As the data needs to be statistically analysed the question then arose

regarding how close to a normal distribution the data is. The data is not normally distributed if it is significantly skewed either positively or negatively or there is a significant kurtosis – either leptokurtic or platykurtic. A method of determining if the distribution is significantly skewed is to determine the range within which the distribution can be considered normal. This range is given by twice the standard error of the skewness, both positive and negative. The skewness is not considered significantly outside the normal distribution if the value for skewness is within this range (Price, 2000).

A distribution can also be described by its kurtosis. This describes the relative concentration of scores in the tails, the shoulders and the centre of a distribution. The kurtosis, relative to a normal distribution, can be checked using the same process to determine if it fits within the normal range. This is established by doubling the standard error of kurtosis, both positive and negative, to produce a normal range. If the kurtosis fits into this range it can be considered normal (Price, 2000).

As shown in tables 33, 34, 35 and 36 the skewness and kurtosis for all the distributions fall within normal distribution parameters.

Test	skewness	S.E. of skewness	Normal distribution skewness range	Within normal distribution parameters
Pre-test	0.508	0.481	+0.962 to -0.962	√
Immediate post-test	-0.556	0.481	+0.962 to -0.962	√
1 month post-test	-0.126	0.481	+0.962 to -0.962	√

Table 33. School 1 Skewness

Test	Kurtosis	S.E. of Kurtosis	Normal distribution kurtosis range	Within normal distribution parameters
Pre-test	-0.961	0.935	+1.87 to -1.87	√
Immediate post-test	0.757	0.935	+1.87 to -1.87	√
1 month post-test	-1.208	0.935	+1.87 to -1.87	√

Table 34. School 1 Kurtosis

Test	Skewness	S.E. of Skewness	Normal distribution skewness range	Within normal distribution parameters
Pre-test	0.648	0.340	+0.68 to -0.68	√
Immediate post-test	-0.499	0.340	+0.68 to -0.68	√
1 month post-test	-0.236	0.383	+0.766 to -0.766	√

Table 35. School 2 Skewness

Test	Kurtosis	S.E. of Kurtosis	Normal distribution kurtosis range	Within normal distribution parameters
Pre-test	0.831	0.668	+1.336 to -1.336	√
Immediate post-test	-0.621	0.668	+1.336 to -1.336	√
1 month post-test	-0.149	0.750	+1.5 to -1.5	√

Table 36. School 2 Kurtosis

From these results the data does not appear to be significantly skewed from the normal distribution.

The data from all tests were then plotted to give a visual analysis of the distributions. The graph plots are show in figure 13.
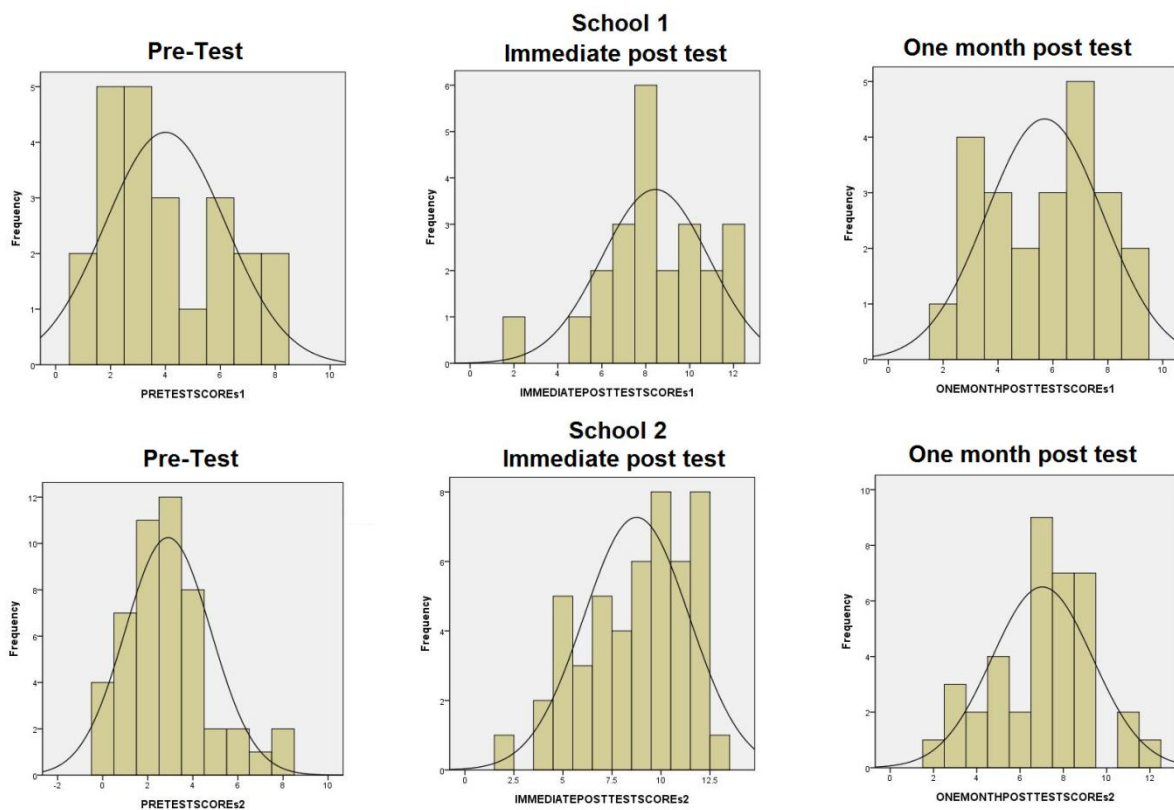
Figure 13. The distributions for each test for both schools

As can be seen from the graphs in figure 13, some of the distributions are potentially bimodal. Because of this it was decided to use parametric t-tests for the statistical analyses but also non-parametric tests to ensure that a high degree of confidence in any effects found independent of the distribution. The non-parametric tests chosen were the Mann-Whitney U test for the independent analysis and the Wilcoxon signed-ranks test for the dependent analysis.

5.4 Statistical results for both schools

Power calculation

Given the small scale of the study and the absence of previous, comparable studies, a power calculation was not computed at the study design stage. On reflection, this was a

misjudgement, but retrospective power calculations were made during final data analysis and are reported below.

Confidence intervals

Figure 14 shows the confidence intervals for all tests. Since none of these intervals overlap zero they all could be statistically significant. The pre-test results showed a small overlap and the immediate post-test results showed a large overlap indicating that there may or may not be a statistical significance. However, there was no overlap for the 1 month post-test results which demonstrated a highly significant result.
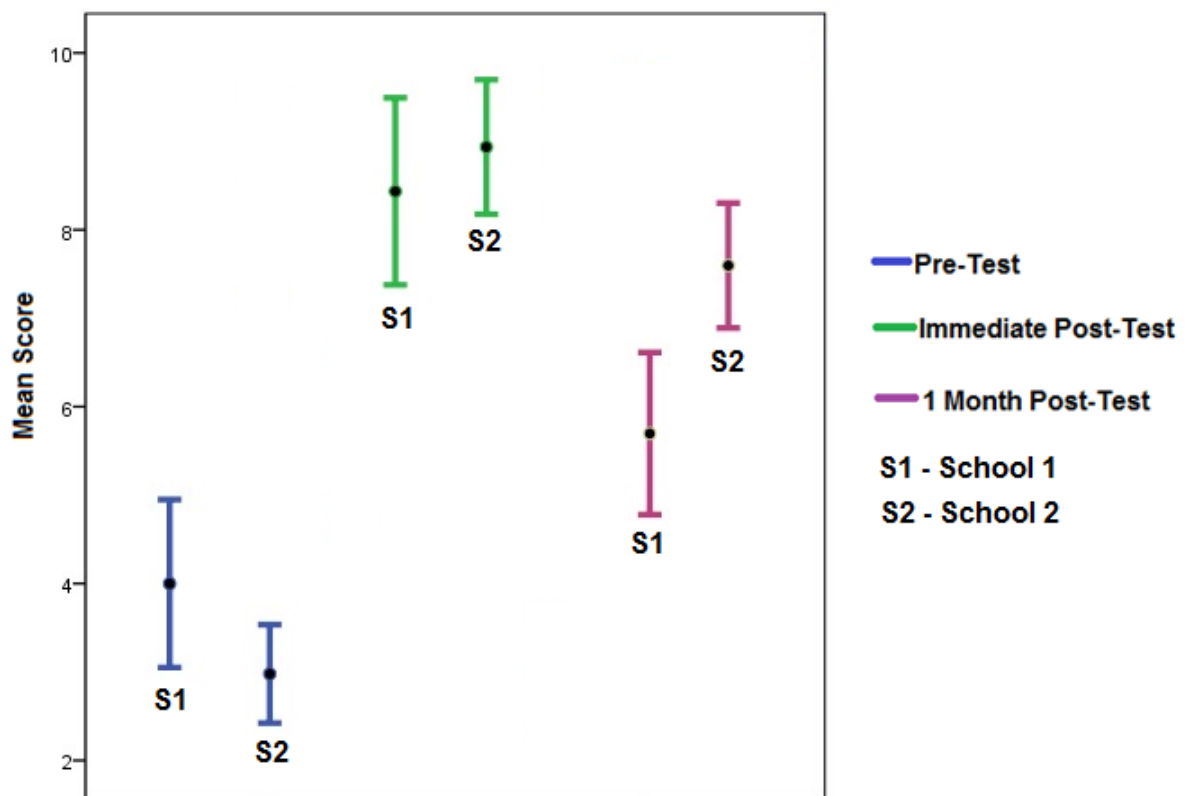
Figure 14. Mean score for all tests with 95% confidence interval

The test results from both school 1 – control and school 2 were analysed separately using paired comparison t-tests to assess the significance in mean scores between pre-test,

immediate post-test and 1 month post-test. The non-parametric Wilcoxon signed-ranks test was also performed as a double check.

School 1 - control

Paired T-Test

A significant improvement was achieved from the baseline (Test 1) pre-course to test 2 immediately post-course. The mean improvement T1 (M=4.0, SE=0.45) to T2 (M=8.43, SE=0.51, t(22)=-8.82, p<0.05(p=0.00), r=0.69) was 34.8%. This signified a statistically significant increase in the knowledge uptake by the participants resulting from the taught course, and the effect was large.

Wilcoxon Signed-Ranks Test

Median T1=3; Median T2=8; Z=4.167; p<0.05 (p=0.00); r=0.62 The Wilcoxon signed-ranks test supported the paired t-test showing statistically significant increase in the knowledge uptake by the participants resulting from the taught course. The effect was large.

Power

The observed power was 88.9%

Paired T-Test

The T1 (M=4.0, SE=0.45) to T3 (M=5.69, SE=0.44,) improvement was 13.7%. This was still significant, however the effect was markedly diminished, (t(22)=-3.38, p<0.05 (p=0.003), r=0.37). The effect size was medium. Therefore, the fall-back after a 1 month period was 21.1%.

The Wilcoxon signed-ranks test supported the paired t-test, showing a medium effect size but still a statistically significant though diminished effect. (Median T1 = 3; Median T3 = 6; Z=2.813; p<0.05 (p=0.005); r=0.31)

Power

The observed power was 76.1%
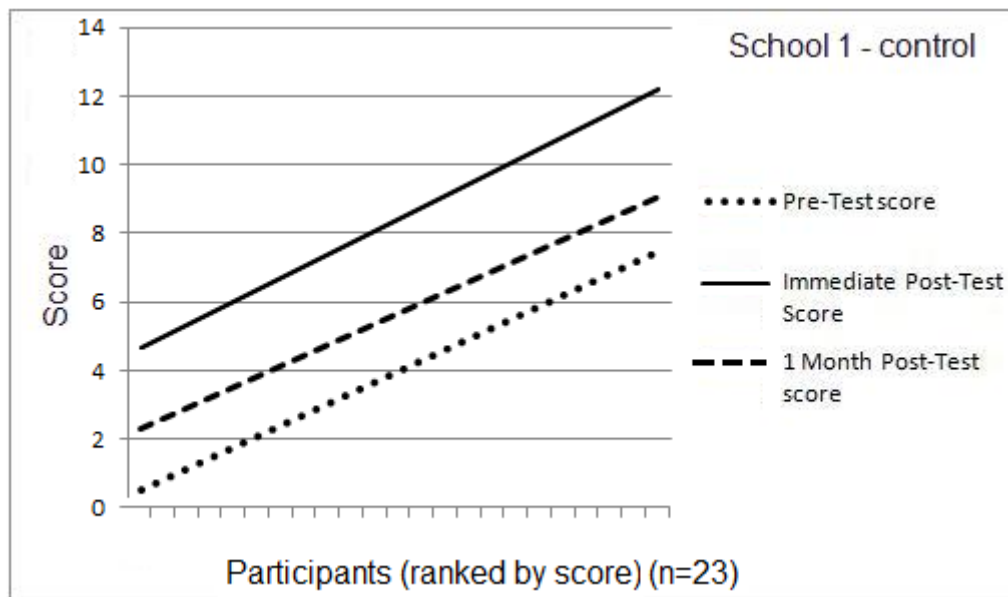
Figure 15. A linear trend graph of pre-test, immediate post-test and 1 month post-test scores from school 1(control)

The significant rise between pre-test and immediate post-test can be seen clearly in the trend graph figure 15. This graph also shows clearly the large fall back after 1 month.

School 2 – Test

Paired T-Test

A highly significant improvement was achieved from the baseline (Test 1) pre course to test 2 immediately post course. The mean improvement was 43.3%. (T1 (M=2.9, SE=0.27) to T2 (M=8.5, SE=0.38, t(48)=-17.09, p<0.05(p=0.00), r=0.78). This signified a highly

significant increase in the knowledge uptake by the participants resulting from the experimental course, and the effect was large.

Wilcoxon Signed-Ranks Test

The Wilcoxon signed-ranks test supported the t-test, signifying a highly significant increase in the knowledge uptake by the participants resulting from the experimental course. The effect was large. (Median T1 = 3; Median T2 = 9; Z=6.107; $p<0.05$ (p=0.00); r=0.62)

Power

The observed power was 97%

Paired T-Test

The T1 (M=2.9, SE=0.27) to T3 (M=7.6, SE=0.35,) improvement was 36%. This was a highly significant result (t(46)=-14.3, $p<0.05$ (p=0.000), r=0.73). Therefore, the fall back after a 1 month period was only 7.3%.

Wilcoxon Signed-Ranks Test

The Wilcoxon signed-ranks test supported the t-test, signifying a highly significant result with a large effect. (Median T1 = 3; Median T3 = 8; Z=5.919; $p<0.05$ (p=0.00); r=0.61)

Power

The observed power was 96.7%

The significant rise between pre-test and immediate post-test is obvious in the trend graph in figure 16. This graph also shows clearly the very small fall back after 1 month.
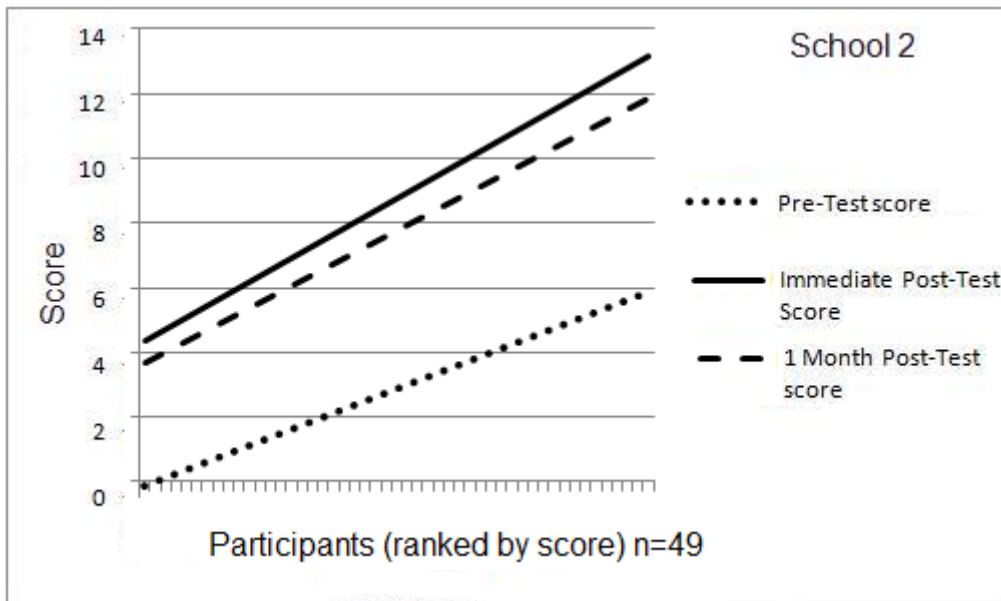
Figure 16. A linear trend graph of pre-test, immediate post-test and 1 month post-test scores from school 2 - test

5.4.1 Comparison of all test results for both schools

The means were then plotted (figure 17) for all results pre-test, immediate post-test and 1 month post-test. Both school 1-control and school 2 made statistically significant pre-test to post-test gains. The gain for school 2 pre-test to immediate post-test was larger than school 1 as school 2 gave a lower pre-test result but achieved about the same post-test result. School 1 gained 34.8% and school 2 gained 43.3%.

T1 comparison

Un-Paired T-Test

Unpaired statistical t-tests were then used to compare the test scores between the schools and the non-parametric Mann-Whitney U tests were performed as a double check.

A statistically significant difference was found between school 1- control and school 2 pre-test scores. The T1(school 1) (M=4.0, SE=0.46) to T1(school 2) (M=2.9, SE=0.27) was

considered to be statistically significant, (t(71)=2.17, p<0.05 (p=0.03), r=0.25), although the effect size was very small.

Mann-Whitney U test

The Mann-Whitney U test supported the un-paired t-test, showing a small effect size (Median S1 = 3; Median S2 = 3; U=408.5; P=0.057; r=0.22). However, the probability was on the 95% significance level.

Power

The observed power was 56.8%

Comment

The mean scores of the two schools pre-test would suggest that there was a small difference between the schools. This was reflected in the non-parametric independent statistical test. However, since the effect size was small and the 95% probability value in the Mann-Whitney U test was greater than 0.05, this suggests that there may not be a difference. Since the power was low (56.8%) a definitive answer could not be given. Therefore, there may or may not have been a small difference pre-test between the schools. However, the importance of this was low since both schools reached the same mean score on the immediate post-test. Therefore school 2 (test) either made a more significant improvement to the immediate post-test or the same improvement as school 1.
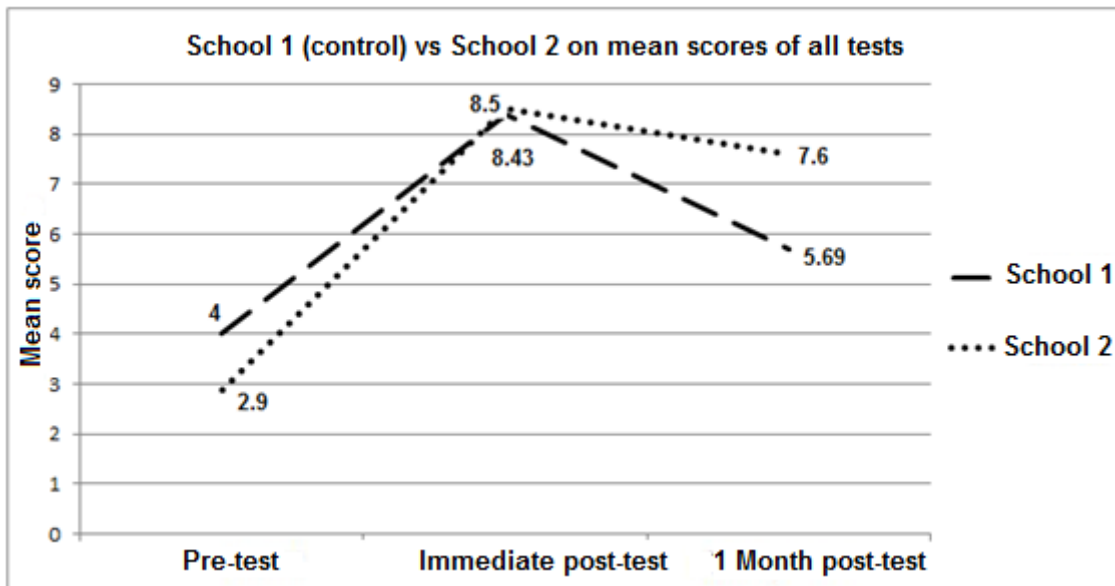
Figure 17. Pre-test, immediate post-test and 1 month post-test means for school 1 and school 2

T2 Comparison

Un-paired t-test

An unpaired t-test was then performed on both schools' immediate post-test results.

The T2(school1) (M=8.43, SE=0.51) to T2(school 2) (M=8.5, SE=0.38) was not considered to be statistically significant (t(71)=0.48, p>0.05 (p=0.62), r=0.06). Therefore, both schools attained the same knowledge gain in the immediate post- tests.

Mann-Whitney U test

The Mann-Whitney U test supported the results of the un-paired t-test that there was not a statistically significant difference between the immediate post test scores for both schools (Median S1 = 8; Median S2 = 9; U=515.5; P=0.559; r=0.06).

Power

The observed power was 50.7%

Comment

The effect size was extremely low, and the 95% probability value was greater than 0.05. This, together with the mean scores of 8.5 and 8.43, suggested that there was no difference between the schools on the immediate post-test. However, since the power was low (50.7%) a definitive conclusion could not be derived, but relative to the other data it seemed reasonable to conclude that there was no difference.

Un-paired t-test

An unpaired t-test was then performed on the one month post-tests for both schools. The T3(school1) (M=5.69, SE=0.44) to T3(school 2) (M=7.6, SE=0.35) was considered to be statistically highly significant (t(69)=3.22, p<0.05 (p=0.001), r=0.43). This showed that the large gain by both schools was retained statistically significantly only by school 2. This was also evident on the means graph for all test results (figure 17) and on the trend graphs (figures 14 and 15).

Mann-Whitney U test

The Mann-Whitney U test supported the un-paired t-test results showing statistically that the large gain by both schools was retained only by school 2 (Median S1 = 6; Median S2 = 8; U=293.5; P<0.05 (p=0.002); r=0.372).

Power

The observed power was 66.8%

Comment

The effect size was large and the 95% probability value was less than 0.05 which suggests that there was a significant difference between the 1 month post-test results. Moreover,

since there was a significant difference between the median scores for the 1 month post-tests, this supported the view that there was a highly significant difference. However, the power was low (66.8%) and so doubt remains. Nevertheless, all other data indicates a highly significant difference.

Can a more productive learning method be developed which will significantly increase the knowledge uptake by primary school children in a chemical safety intervention?

School 2 (test) appeared to have a greater knowledge gain than school 1(control) from pre-test to immediate post-test: 34.8% for school 1 and 43.3% for school 2. However, school 2 started at a lower level in the pre-test and so this may have been due to regression to the mean. Therefore, the result was unclear. The results suggested that the null hypothesis should be rejected, but further studies would be required utilising a greater sample size in order to give a definitive answer. What was clear from the results was that there was a highly significant knowledge gain for both schools pre-test to immediate post-test. For both schools the effect size was large and the power was over 80% (88.9% for school 1and 97% for school 2).

If there has been an increase in knowledge uptake has this been retained over a 1 month period?

For school 1 (control) from pre-test to 1 month post-test there was a significant improvement in knowledge gain which was 13.7%. However, the effect size was only medium, and the fall-back over the month was 21.1%. The power, however, was below the standard 80%, though only just so at 76.1%. For School 2 (test) from pre-test to 1 month post-test a 36% improvement was retained, and the fall-back after 1 month was only 7.3%. The effect size was large, and the power was over 80% at 96.7%.

The results appeared unequivocally to support the rejection of the null hypothesis. This study seemed to demonstrate clearly that the teaching to learning styles / active learning methods produced a far larger retention of the knowledge gained. However, there is one caveat. The un-paired test between the schools for the 1 month post-test, whilst giving a large effect size, had only 66.8% power which was below the standard 80% power. All other indicators agreed that the null hypothesis should be rejected, but this result should be treated with some caution. A greater sample size in future studies would provide more certain results.

5.5 Crucial misconceptions

In the pre-intervention summative assessments it was evident that many of the participants had several misconceptions regarding some of the symbols used in the GHS system. These are detailed in table 37. The 'exclamation mark' and 'health hazard' symbols were usually not understood by the participants. In the case of the 'exclamation mark' most responses were that no answer was given. The few responses that were given stated that the symbol meant the chemical could 'drip on you'. There were consistent misconceptions. For example the health hazard symbol was consistently viewed as indicating that the chemical could cause a 'heart attack'. The skull and cross bones symbol was consistently viewed as the pirate flag. Again, few responses were given for the corrosive symbol and the environmentally hazardous symbol. Of those that were given most viewed the corrosive symbol as meaning 'wash your hands'. The environmentally hazardous symbol was viewed as 'good for the environment' and 'leisure park'. The symbol producing the largest number of correct answers, with no misconceptions, was the Flammable symbol.

Symbol	Number of crucial misconceptions	Crucial misconception	Description
'Skull & Cross bones' – Acutely toxic	17	**Pirate flag**	**Children are familiar with this symbol as the 'Pirate flag'. Thus seeing this symbol on a bottle of liquid may indicate 'Pirate drink'. What child wouldn't want to taste 'Pirate drink'?**
'Dead fish & Tree' – Environmentally Hazardous	12	**Good for the environment**	**It is not clear to the children that the fish and tree are both dead. This symbol is misconceived as a symbol for 'Leisure Park' and 'Wildlife area'.**
'Dissolving Hand & Metal' - Corrosive	7	**Wash hands**	**Some children view this symbol as 'a bar of soap' plus 'water dripping' plus a 'hand' as so misconceive it as meaning 'use this chemical, where this symbol appears, to wash your hands'**
Long term Toxic	21	**Heart attack**	**This symbol is commonly misconceived to mean 'will give you a heart attack' as the position of the 'star shape' within the silhouette suggests chest pain.**
'Exclamation mark' – Irritant / Sensitizer	3	**Will drip on you**	**A few children misconceived this symbol as meaning 'can drip on you'.**

Table 37. Illustrating the misconceptions found in the study

Chapter 6: Discussion

6.1 Introduction

The purpose of this study was to ascertain whether the use of alternative teaching methods could increase the knowledge uptake and retention of chemical injury prevention information and so increase the efficacy of chemical injury prevention programmes.

This study has revealed that when greater attention is focussed on how to teach injury prevention programmes the outcomes can be significantly improved.

I begin this chapter with a discussion looking at the various categories of evidence and discuss the results obtained in the study. Finally I discuss the various factors that affect children's understanding of hazard symbols and analyse the misconceptions found in the study.

6.2 Chemical safety intervention

For a child injury prevention education programme to be successful, at least three hierarchical components are necessary (Waters et al., 2001). First, the children should be taught a target safety message in the programme. Second, the required knowledge should be conveyed by the programme and this knowledge gain and retention checked. Thirdly, use of this knowledge outside the school setting should be taught by the programme so that children have an appreciation of what to do should they encounter hazardous chemicals in normal settings.

6.2.1 Results

The results show that both programmes were successful, in terms of knowledge gain, for

teaching the safety message, the term definitions and the symbol meanings.

More individual positive reinforcement (for example praise) was used and more individual competition seen when using the traditional teaching method, as was the case in the teaching to learning styles part of the experimental group. In the active learning part of the experimental group however, there was more group reinforcement and group competition.

6.3 Evidence

The term intervention can relate to a curriculum, stratagem, educational practice or programme (Johnson, et al., 2004). In order to facilitate educational practitioners in the task of distinguishing educational studies that are supported by empirical evidence from those that are not, the United States Department of Education produced a report in 2003 written by Boruch, et al. (2003) This report defines the parameters to distinguish between the various levels of evidence. In fields such as medicine and psychology the 'gold standard' for the evaluation of an intervention's efficacy are considered to be well designed and implemented randomised controlled trials. Studies that, to determine the effects of the intervention, randomly assign individuals to a control group or an intervention group are termed randomized controlled trials. The results of studies can be classified into various evidential levels defined as contributing no evidence, possible evidence and strong evidence of efficacy (Boruch et al., 2003).

6.3.1 Strong evidence

It is generally accepted, and there is credible evidence to suggest, that randomized control trials are, relative to other study designs, superior in measuring the true effect of an intervention when properly designed and implemented. A school based educational study must use well designed and implemented randomised control trials in two or more typical

school settings. Therefore, there are no systematic differences, in any characteristics (unobserved or observed), except one, which is that the control group does not participate in the intervention and the intervention group does participate. The process of randomly assigning individuals to either a control group or intervention group ensures this. Therefore any outcome difference between the control group and intervention group, assuming the trial is properly carried out, can, with confidence, be ascribed to the intervention which is not affected by other factors (Boruch et al., 2003).

6.3.2 Possible evidence

Possible evidence can be established by several types of study design. For example randomised control trials where they fall short of the strong evidence criteria even though the quantity and quality of evidence is good. Another example is comparison group studies when the comparison and intervention groups are matched closely in various characteristics such as demographics, academic achievement and a range of other characteristics. Valuable in generating hypotheses about 'what works' are well-matched comparison-group studies, however randomized controlled trials need to be used to confirm their results (Boruch et al., 2003).

Relative to the 'gold standard' of randomized control trials comparison group designs are considered to produce valuable conclusions if the control group and intervention group are closely matched in such factors as prior test scores, demographics, methods used to collect outcome data and time period in which they are studied. The overall conclusions, on whether or not an intervention displays efficacy, yielded by such well-matched comparison-group designs are usually correct. Establishing 'possible' evidence regarding an intervention's effectiveness can be achieved using well-matched study designs. These

types of study have a valuable role to play, especially in education, allowing the generation of hypotheses that can be confirmed using randomized control trials. The study is designated as not being supported by meaningful evidence if the criteria for strong evidence and possible evidence discussed above are not met (Boruch et al., 2003).

When an intervention is not supported by 'strong' evidence the question then arises of whether it is supported by 'possible' evidence. This depends on the quality of any non-randomized studies that have been done and a consideration of any flaws in the study design, however this can be a difficult conclusion to reach and relies on considered opinion.

When trying to decide whether the intervention is supported by 'possible' evidence there are many factors to consider. The comparison and intervention groups should be closely matched on a number of factors. In the domain of education, studies should have two groups closely matched relative to academic achievement and prior test scores. Characteristics such as gender, ethnicity and age should also be closely matched. The study time period should be approximately the same (for example the children in both groups are in the age range 7-11 years old and are in the same academic school year and not sequential years). The outcome data collection method should be the same, for example both groups being administered the same test in the same way.

Children who had the choice to participate or not in an intervention should not be included in the control group as they may differ, systematically, in characteristics such as their enthusiasm, and other factors, relative to those who chose to participate. The variation in enthusiasm and other factors could skew the estimation of the study's effects. The control

group should be composed of participants who were not given the option of whether to participate in the study. The lower the attrition rate the more confidence can be placed in the results and studies should have valid outcome measures. It is essential that tests for statistical significance are reported.

6.4 Study evidence

As the requirement for 'strong evidence' is the use of randomised control trials, which were not used in this investigation, this study cannot therefore claim strong evidence was achieved. Therefore it now needs to be determined whether the study has produced 'possible evidence' or 'no meaningful evidence'.

The schools were very closely matched. Both schools were primary, voluntary controlled, semi-rural schools. The vast majority of pupils in both schools were white British and both schools were mixed gender. Schools 1 was rated by Ofsted (2008) as grade 2 and school 2 was rated by Ofsted (2008) as grade 1. Both schools had a smaller than average number of pupils with learning difficulties. Schools 1 had a very small number of children eligible for free school meals and school 2 had an average number of children eligible for free schools meals therefore indicating that socio-economically the schools were also very closely matched.

The result of the independent t-test on the pre-test scores shows a statistically significant difference, $t(71)=2.17$, $p=<0.05$ ($p=0.03$), $r=0.25$. However as the sample size for school 1 is small, approximately half the sample size of school 2, and the effect size is small ($r=0.25$), it is likely that this is due to a few higher scoring individuals in school 1 having a

disproportionate effect due to the smaller number of participants. It could be considered, therefore, that the two schools are reasonably well matched on prior test scores.

The pupils used in the study from both schools were in the same age range, 7 to 11 years old. The teaching for both schools was performed in the same academic year. The same pre, immediate post and one month post summative tests were used for both schools. It was considered that the schools were sufficiently geographically separate that no contact was likely to occur between the pupils since all the pupils, for each school, lived locally. The attrition rate for the study was extremely low. Only two pupils were absent for the one month post-test in school 2.

The design of the study was such that schools, and pupils, did not have the choice of being in the control or test group. School 1 was designated the control school and school 2 was designated the test school.

Comparing the graphs, figure 17 showing the mean plots for each test for both schools for this study, and figure 12 scenario E showing one of the possible outcomes of this type of study, it can be seen that there are major similarities. This is often called the 'cross-over' arrangement. On the pre-test the performance of the programme group is lower than the control group. However, the performance of the programme group is the same on the immediate post-test but higher than the control group on the 1 month post-test. Unlike the graph shown in figure 12 scenario E the performance of the control group does vary from pre-test to immediate post-test to one month post-test, however the results still produce the 'cross-over'. Relative to all five possible outcomes shown in figure 12, and the explanations discussed in chapter 3, this outcome gives the clearest evidence for the

efficacy of the programme. There are no obvious threats to internal validity with this outcome. It is very unlikely that selection-maturation is responsible as it would have to be postulated that the programme group happened to start maturing as the control group stopped maturing – which is very unlikely. Also it is unlikely that selection-regression was responsible as this may explain why the programme group approached the control group but not why it crossed over.

Therefore, on balance, it is reasonable to postulate that this study has produce clear 'possible evidence' which could be confirmed with future research using randomised control trials.

6.5 Contributions to the field

The major contribution of this work relates to the use of two pedagogies which significantly 'intermesh' and complement each other and has produced a far greater retention of the knowledge gained relative to traditional teaching. It has accomplished this by using teaching to learning styles, using the VARKT learning styles, and active learning for a chemical safety intervention for 7-11 year old children using the new GHS system. The two pedagogies were chosen relative to the output from the Delphi study. The evidence for the conclusions is both quantitative and qualitative in nature. The quantitative part of the study uses participants' test scores as the basis for testing with several statistical techniques since this is a useful and scientifically accepted measure of success and formal hypotheses could be tested. Whilst the qualitative part of the study reviews the participant's misconceptions which is required to modify the participant's understanding for chemical safety.

As discussed in the literature review Tutty (2000) states that far too much emphasis is placed on whether or not the programmes should be offered rather than whether the programmes work. This research has focussed absolutely on the latter and reinforces the fact that research can produce programmes that incrementally produce greater efficacy. It supports research performed by Koelen et al. (2001) who states that the use of non-traditional research methods, or combinations of methods, should be viewed positively and used in health promotion.

This research has done just that by assessing the efficacy of using two pedagogies, used consecutively within the test intervention, which has given a significant increase in the retention of knowledge by the children in the age range tested.

Gibson and Leitenberg (2000) stated that it is more important to be able to gage whether the method of teaching a particular curriculum is more productive, and therefore of more value, than another method since it allows intervention efficacy to gradually increase. The results of this study also support the results of many research studies such as those of Smialek (2010), as discussed in the literature review, who states that learners whose styles are congruent with the teaching style are inclined to remember information for longer. The VARKT learning styles were used, switching between each style periodically, to attain the required balance. The results of this study seem to be inconsistent however, with the results of the research performed by Kratzig and Arbuthnott (2003), discussed in the literature review, which found that there was insufficient evidence to establish that the retention of learned knowledge is due to learning styles. Nevertheless Ford (1995), Ford and Chen (2001) and Chen and Macredie (2002) performed three comparatively small but meticulous empirical investigations of mismatching and matching learning styles and found

on all three studies that matching was correlated with longer retention of the knowledge gained which the results of this study support. Relative to the mass of literature regarding learning styles, reviewed in the literature review, it is clear that learning styles directly impact learning and retention of that learning in memory. Learning styles can enhance how information is received, processed and stored in the brain. They can affect the level of concentration shown by learners and can be a crucial factor in determining which stimuli will be ignored and which will be focussed on.

The results of this study also seem to be consistent with research findings such as those of Stephens (2006), as described in the literature review, and support the view that active learning has a long-lasting and constructive effect on children's learning in primary school. This study enabled children in the test group to question, clarify, consolidate and apply new knowledge which supports the view of an expanding mass of research discussed in the literature review which demonstrates that this approach enhances the learning and retention of knowledge. The use of numerous tasks and activities and allowing children to administer all the elements within the process and identify if and when the task requirements have been accomplished seems to have had a significant effect on the retention of knowledge and may have had an effect, to a lesser degree, on the uptake of knowledge. The results gained by the use of these techniques supports the work of Koens et al. (2005) and Kolb (2000), as discussed in the literature review, who stressed that learning by experience and providing enriched contexts for learning have a significant positive effect on learning retention.

In order to retrieve knowledge from a sematic network there must be a process of spreading activation (Anderson et al., 2001). When the node activation threshold level is

exceeded the contents of the node can be recalled. Activation of linked nodes then depends on the activated node and linked nodes strength of the association. The most activated nodes will be those where there is a strong association (Anderson et al., 2001).

The main finding from this research is that using the two pedagogies greatly enhances the long term retention of gained knowledge. From the research of Craik and Tulving (2004) the strength of memory does not depend on how long information is processed but rather on how deeply information is processed and that connecting items to other related information will increase retention. In this study teaching to the VARKT learning styles was used to provide the single preferred sensory input. However, the second part of the intervention, the use of active learning, supplemented the multisensory input which stimulates multiple sites in the brain which increases attention and retention of information. The use of multisensory input can therefore be viewed as multisensory learning and is crucial to the learner's success in efficiently storing and retrieving knowledge. Therefore this research supports the study of McNamara and O'Reilly (2002) as discussed in the literature review. Using multiple channels, maximises information processing which results in maximal stimulation to the brain and increased storage.

The brains ability to process and store information in an ordered manner, therefore enhancing its retrieval, is the result of associating new informtion with existing information consciously. This will then facilitate the information being used in novel situations. The storage of information must facilitate future retrieval. Therefore the learner must, by paying active attention, make connections with knowledge already in long term memory which will then facilitate the restrucuring of old and new information together.

Prior knowledge is crucial to children in determining performance (Scardamalia and Bereiter, 2003). However, there can be, for example, errors in encoding, caused by not separating irrelevant from relevant data or by missing important data (Peirce, 2003). Children do not lack reasoning ability they only lack experience and knowledge. Due to their inexperience children will, with the limited knowledge they possess, tend to arrive at incorrect conclusions or derive meaning incorrectly - misconceptions (Bransford, et al., 2005). Knowledge is interrelated and so, consequently, new knowledge that is connected to prior knowledge has a better retention (Kendeou and van den Broek, 2007). Kintsch (1998) also states that prior knowledge will guide learners towards information that confirms what they already know and are comfortable with. Therefore it is crucial that new knowledge is correct and corrected before entering long term memory. The probability that knowledge will be retrievable increases relative to the number of additional linkages that are created (Kendeou and van den Broek, 2007).

When students categorise new knowledge inappropriately misconceptions arise (Chi, 2005). For example, the skull and cross bones being the pirate flag. Chi's (2005) research demonstrated that misconceptions can be enduring and deeply entrenched even though pupils have learnt new information and this information is inconsistent with their prior knowledge. Therefore the researcher made substantial efforts to correct misconceptions in the learning style phase and the active learning phase of the intervention therefore facilitating the correct concept linking.

Misconceptions research has highlighted the fact that traditional teaching, even when performed in a clear, well-designed manner, does not aid learners overcome misconceptions in the long term (Chi, 2005). Misconceptions research has also changed

classroom instruction with the more effective active learning stratagems, which have been shown to be more effective in helping students overcome misconceptions, being practiced (Chi, 2005).

In order for the new, correct knowledge to be semantically processed and applied instead of the old misconceptions, learners must have deep, meaningful learning (Houts et al., 2006). Research suggests that any misconception involves multiple knowledge domain misunderstandings. Each domain contains different kinds of knowledge and therefore these domains and the relationships between domains, should be the focus of attention.

Deep understanding comprises several interlocked levels of knowledge, for example recalling facts, using new vocabulary and problem solving (Houts et al., 2006). Active learning encourages these to facilitate deep understanding. When learners can develop their own model of a concept they can more accurately create explanations and predictions. Direct hands on experiences have been shown to help learners develop such concept models (Houts et al., 2006).

Throughout the experimental course formative assessment was used. This enabled the teacher to guide the pupils, via group and one to one interaction, towards the important aspects of the course enabling the learners to synthesise an experience whilst emphasising reflection and action. This one to one interaction enables immediate feedback between learner and teacher. This concurs with the model suggested by Koens et al. (2005), discussed in the literature review, which stresses the significance of supplying enriched contexts for learning. Koens et al. (2005) also stated that compared to learners traditionally taught learners taught in an environment incorporating small group

learning learn at a deeper level and retain information longer which mirrors the results found in this study. There are also other significant advantages such as pupils acquire superior teamwork and communication skills.

6.6 Misconceptions

A misconception can be defined as incorrect reasoning which results in an incorrect conception or the incorrect linkage to an existing concept which produces an incorrect meaning (Merriam-Webster, 2011).

Pictograms have a number of recognized advantages, for example they can potentially be interpreted more quickly and more accurately than text. Consequently, they can aid the understanding of hazards for children and can act as 'instant reminders' of a hazard.

Conversely, the potential exists for significant confusion. This can lead to several scenarios, for example an incorrect meaning being assigned to the symbol, the connection being made to the wrong concept, an incorrect assumption being made leading to either an incorrect meaning or a meaning diametrically opposite to the intended meaning.

6.6.1 Understanding pictograms

Pictures and symbols have been described as having a binary nature as they are objects in themselves, colours and marks on a page, but refer to something else, for example a scene from the world (DeLoache, 2004). The literature suggests that there are at least four components that represent an established understanding of this binary nature. Firstly, the capability to perceive the referent from the real world represented in the picture.

Secondly, that pictures can represent an actual example or instance in reality, for example a real scene from the environment. Pictures do not just represent prototype or generic exemplars of subject matter from the world.

Thirdly, the depiction of the subject matter found in pictures is different than real world subjects, for example pictures serve a different purpose and are physically different from the subject they refer to. Any changes to the referent or the picture do not affect each other. Fourthly, the first three characteristics of pictures binary nature are all comprehended simultaneously.

Therefore a child is not limited to think about the picture either as a representation of another reality – the referent – or the picture as an object in itself, but is conscious of both components simultaneously.

A particular referent from reality can be represented or the pictures can be of examples of generic referents. Perceiving the one-to-one correspondence of the picture to the referent is essential, once the depiction has been recognised, in order to fully understand the representational relationship between a picture's contents and a real referent.

Studies following the development of the four components related to gaining an established understanding of the binary nature of pictures allows the mapping of this developmental path in children.

The processing of symbolic information is a complex issue. Even though image processing of pictograms has many advantages there are some issues related to intended meaning

interpretation.

A process of interpretation needs to be used to deduce the meaning of a pictogram, this interpretation has to be constructed using context and knowledge and involves both visual and subjective factors (Piamonte et al., 2001).

McDougall (2001) argues that an images relationship with function should be distinguished from its cognitive effect and that the main determinant of comprehensibility is semantic distance rather than concreteness. In their initial encounters with pictograms children may be helped if the representations are of real life situations but what is more important is the formation of strong systematic relationships between symbols and functions (McDougall, 2001).

Symbols by their very nature have multiple meanings, they are polysemic. During the interpretation of hazard symbols children not only need to infer what the hazard is but also which objects are involved. Another important factor which aids the comprehension of pictograms is the context in which they are viewed. Incorporating pictograms in their real context aids comprehension.

The connection between different components is not provided by most symbols. Therefore the pictogram is more than the sum of its parts (Grill-Spector and Kanwisher, 2005; Bishop and Donlan, 2005). There is a problem with multiple meaning since static images cannot convey possible instances or more than one event. A direct representation of the object is given in the figurative pictogram. The object represented is evoked without ambiguity is the intention, for example the 'flame' symbol to indicate flammable. Only certain aspects of

the concept are given in the abstract pictogram to evoke the meaning, for example the 'health hazard' symbol denoting long term toxic. Finally there is no resemblance to reality in the arbitrary pictograms, for example the 'skull and cross bones' denoting acute toxicity. A more developed description of figurative pictograms has been developed by DeLoache (2004) who classifies them as either the use of specimens or typical examples; similar images; symbolic representations or abstractions, to represent meaning.

Learning the meaning of pictograms is usually done rapidly by children, even if the pictograms are not immediately recognisable. Therefore the function of the pictogram then becomes the stimulation of recalling that knowledge. The critical success depends on this knowledge entering long-term memory and being easily retrievable.

6.7 Pictogram misconceptions found in the study

6.7.1 Skull and cross bones symbol

There was a very common misconception relative to the 'skull and cross bones' symbol. Seventeen children misconceived this symbol.

A symbol is a graphic representation of a concept. The concept of the 'skull and cross bones' symbol pre-exists in the child's mind, created by books and other media, such as film and television, that the 'skull and cross bones' symbol is depicted on the pirate flag and therefore means 'pirates'. As the symbol is abstract the meaning cannot be deduced. Consequently a link is established to the 'pirate' concept. This is depicted in figure 18. As figure 19 demonstrates this has a profoundly negative effect on safety. If the 'skull and cross bones' symbol is seen on a bottle of liquid this may imply 'pirate drink'. As children

possess an innate curiosity the chance to taste 'pirate drink' could not be resisted with exceptionally dire consequences.

Figure 18. Showing the 'skull and cross bones' misconception
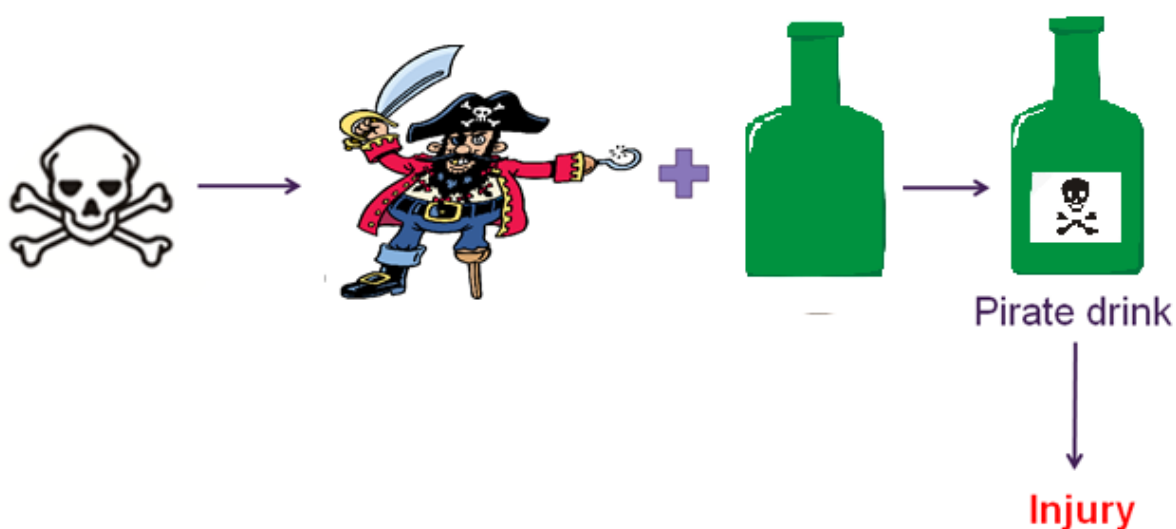
Figure 19. Showing how the 'skull and cross bones' misconception could result in child injury

6.7.2 The exclamation mark symbol

Usually used after an exclamation, the exclamation mark is a punctuation mark which is used to indicate high volume, such as shouting, or strong emotion such as 'Stop!' or 'Watch out!' . The exclamation mark is used on warning signs to warn or draw attention to a hazard.

Most participants could not provide a meaning for this pictogram. Three participants produced an incorrect answer which was that the chemical could 'drip on you'. This symbol

is abstract. The symbol becomes meaningless if the integrated information is not understood by the child. Children will then try to link the information to a pre-existing concept in order to deduce the intended meaning, which is often incorrect, therefore leading to a misconception. Figure 20 shows this misconception. The child deduces that the exclamation mark appears to be a liquid 'dripping' and arrives at the meaning 'can drip on you'. Figure 21 shows the potential for injury as the only hazard deduced is that of physical 'dripping'. In fact this symbol can be used for several types of hazard such as skin and eye irritation, respiratory tract irritation, etc.

Figure 20. Showing the 'Exclamation mark' misconception

Figure 21. Showing how the 'Exclamation mark' misconception could result in child injury

6.7.3 The 'health hazard' symbol

This symbol produced the largest number of misconceptions – twenty one. The pictogram is a symbolic representation. Children seem to recognise the silhouette as a scene from reality, a shadow or silhouette of a person. They also recognise the star shape shown on the chest of the silhouette and recognise that this is critical to the meaning. The children

then endeavour to construct associations between the visual image and prior knowledge. Using their prior knowledge they associate the single star shape on the chest with the single organ in the chest cavity, namely the heart, and assume that the symbol must signify that the material 'can give you a heart attack'. This misconception is shown in figure 22. However, since there is an association with a hazard, and the hazard is more acute than the true hazard meaning, it cannot be stated that this misconception could cause more injuries, as shown in figure 23.

Figure 22. Showing the 'long term hazard' symbol misconception
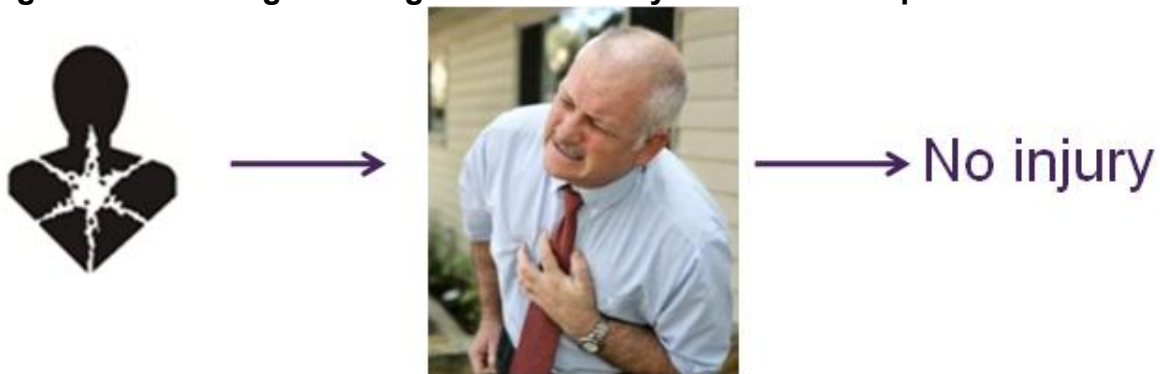
Figure 23. Showing how the 'health hazard' symbol misconception would not result in child injury

6.7.4 The corrosive symbol

Seven participants had a misconception relative to this symbol. The corrosive symbol is an example of the use of specimens and typical examples to provide meaning. However, if the child does not understand the meaning they will endeavour to deduce this by dissecting the symbol into its fundamental elements. This misconception is shown in figure 24. The symbol is broken down into a liquid pouring container and a hand as these are easily recognisable. The first misconception is that the liquid is water. The learner

constructs new connections and relationships amongst these objects which subsequently leads to the linking of this symbol to the concept of 'wash hands'. The black rectangle in the symbol then reinforces the accuracy of this link as it becomes 'obvious' that this is a bar of soap. The potential for injury from this misconception is extremely large as shown in figure 25 since the child may view a bottle with this symbol on as 'hand washing liquid' with very serious consequences.
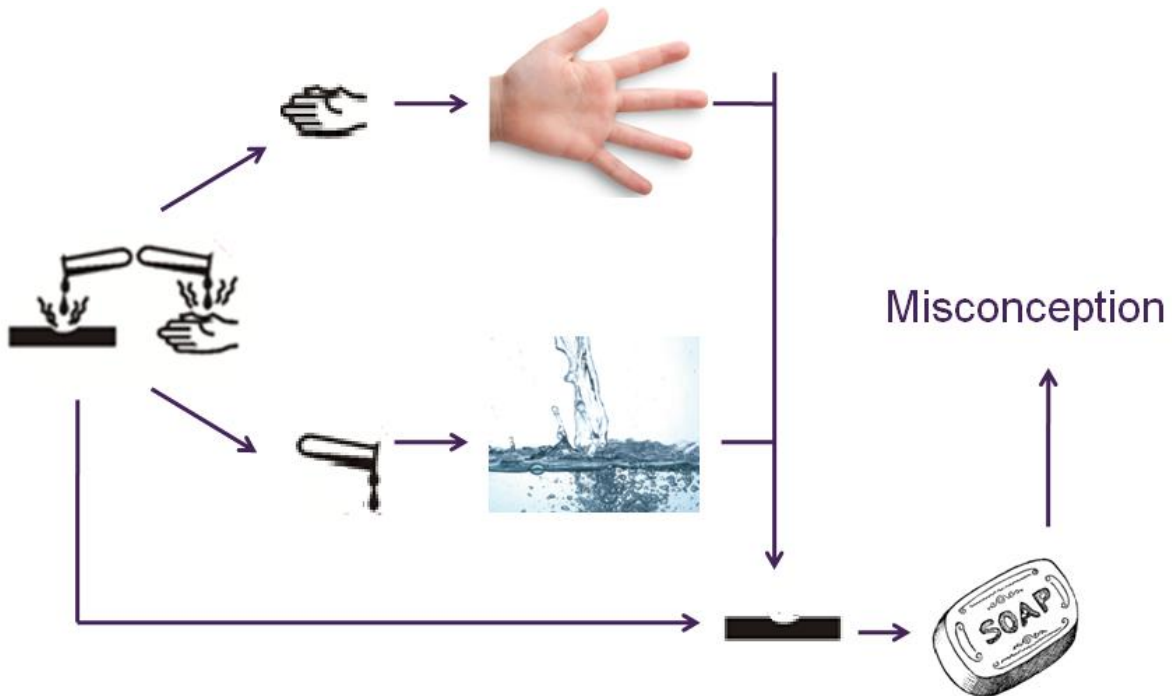
Figure 24. Showing the 'Corrosive' misconception

Figure 25. Showing how the 'Corrosive' misconception could result in child injury

6.7.5 The environmentally hazardous symbol

Twelve children had a misconception of this symbol. The environmentally hazardous symbol is an example of using similar images to create meaning. The symbol consists of an upright tree displaying no leaves and a fish which may be lying on its side. Generally, those children who had misconceptions realised that the symbols primary message referenced the environment. Again, the symbol is dissected into its fundamental elements of a tree and a fish by the children, as shown in figure 26. Since children have no specific reason to question whether the tree is dead, since the absence of leaves may denote autumn, and the fish may not be lying on its side but rather leaping out of the water, the child assumes that they are both alive. Therefore the conclusion arrived at by the children is that this is 'good for the environment' and may denote 'water park'. In this misconception there is no association with hazard. However, the hazard is not directly to the child but rather to the environment. As shown in figure 27 the risk is that the child may misuse the chemical in a way which may damage the environment, for example by pouring it down the drain.
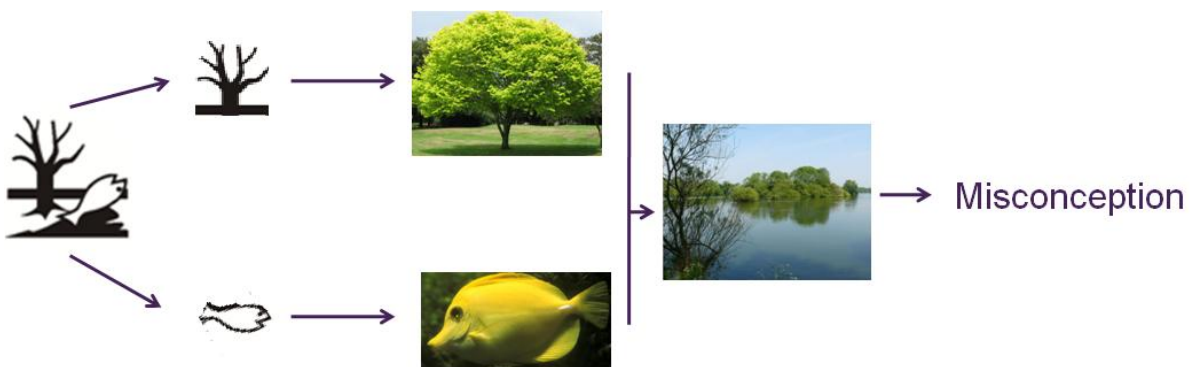
Figure 26. Showing the 'Environmentally hazardous' misconception
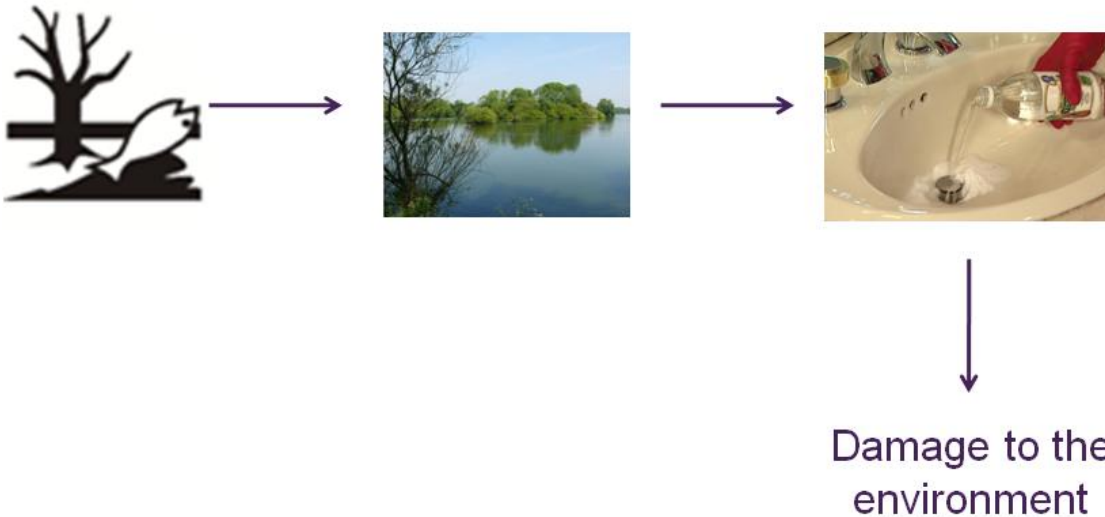
Figure 27. Showing how the 'Environmentally hazardous' misconception could result in damage to the environment

The misconceptions that children possess need to be made explicit before conceptual change can take place. It is vital to reveal the children's misconceptions as the first step. These misconceptions, if undetected, can act as barriers to further learning and put the child in imminent danger (Duit and Treagust, 2003).

6.8 Cognitive dissonance

The social psychologist Leon Festinger was the first person to describe the cognitive dissonance theory in 1957. This work has been updated since then, notably by Neighbour (2005) and Logan (2007). The unease that is felt when there is a discrepancy between prior knowledge and new knowledge, or the interpretation of this knowledge, is termed cognitive dissonance. When new concepts need to be accommodated cognitive dissonance may occur and this conflict may require development and resolution if the person is to assimilate new concepts (Neighbour, 2005).

In the context of a learning environment, if a child is required to assimilate a new knowledge concept which contradicts their prior knowledge they are likely to resist the

assimilation of the new concept. The strength of the feeling of unease that cognitive dissonance creates is relative to how strongly the conflict is between the dissonant concepts (Gawronski and Strack, 2004).

It can require a great deal of effort, by the teacher, to mitigate these dissonances as the children have acquired their prior knowledge over an extended period of time. Over time the child constructs and develops concepts and linkages between these concepts. These concepts and linkages allow the child to quickly retrieve familiar knowledge that creates a feeling of comfort and security. However, this tends to have the effect that the child will ignore new concepts that do not match prior knowledge (Gawronski and Strack, 2004).

In this study several cognitive dissonances were highlighted. For example, the environmentally hazardous symbol, the corrosive symbol and the skull and cross bones symbol. Each dissonance needed to be reconciled in the child's mind to ensure the precise meaning of these symbols was understood and accepted.

6.8.1 Environmentally Hazardous symbol

Twelve children thought that this symbol meant 'good for the environment' and 'water park'. This is a diametrically opposite view to the actual meaning of the symbol which is 'hazardous for the environment' and 'will kill plant and animal life'. The misconception was that the fish and tree shown in the symbol were alive when in fact they were a representation of a dead fish and tree.

This dissonance was due to the fact that the children had seen pictures and drawings of fish and plants that were 'alive' and may have represented the signs for a water park or nature reserve. These two concepts needed to be reconciled so that they could co-exist in the children's memory. This was achieved in the intervention in two ways. Firstly, the difference between a sign, for water park or nature reserve, was contrasted with a symbol applied to a container. If the symbol on a container was a fish and a tree then there was a possibility that the container housed a chemical that was 'bad' for the environment, but that this was not definitively the case. Confirmation that this was the case was given by the symbol being situated within a red diamond and that the red diamond definitively denotes hazard.

6.8.2 Corrosive symbol

Seven children thought that this symbol meant 'wash your hands' and that the chemical within the container which displayed this symbol should be used as a 'hand wash'.

The children had no prior cognitive concept of this symbol to retrieve from memory. Consequently they decode the symbol by separating out its constituent parts to see if they can retrieve any linked concepts relative to these parts. They immediately activate the concept of 'hand' and so recognise the 'hand' part of the symbol. However they ignore the fact that part of the hand is missing. They also activate the concept of 'liquid' and the fact that a liquid is dripping onto the hand. The concept of 'water' as a liquid is then activated as water is the concept they are very familiar with. The activation of these two concepts together then spreads and activates the concept of 'washing hands'. This is then confirmed as the concept of 'hand washing' usually involves a bar of soap which is then identified in the symbol (although this is actually a piece of metal demonstrating that the

corrosive chemical can also corrode metal). The accommodation of this symbol with their prior knowledge is then complete and so the symbol becomes part of their prior knowledge.

In the intervention these linkages needed to be re-assigned to a new concept - the concept of 'corrosive'. Firstly the concept of 'corrosive' was explained to the children by using concepts that they would be familiar with. This was achieved by using certain descriptive phrases such as 'eating away', 'destroying skin' and 'feels like being burned by fire'. Secondly, the various parts of the symbol were elucidated, explaining that the liquid was not water but a corrosive chemical and that the solid was not soap but a piece of metal, however the hand was indeed a hand but part of it had been 'eaten away' by the chemical. Finally the symbol being situated within a red diamond also denotes that the chemical within the container is hazardous was reinforced.

6.8.3 Skull and cross bones

Seventeen children thought that this symbol meant 'Pirates' or 'Pirate flag'. The children had very strong linkages to this cognitive concept and therefore the concept was easily and quickly retrieved from memory. In the intervention a new concept needed to be constructed which would co-exist with the concept of the 'skull and cross bones' meaning 'Pirates'.

During the intervention the children were questioned more deeply regarding pirates behaviour. Under deeper questioning the children conceded that pirates were 'horrible' and 'nasty' people and would 'kill'. This was then linked to the new concept that some chemicals were 'horrible', 'nasty' and could 'kill'. This concept was then expanded using

the words 'toxic' and 'poisonous' and related to the 'skull and cross bones' symbol. Finally, the symbol being situated within a red diamond also denotes that the chemical within the container is hazardous was reinforced. Therefore the two concepts can co-exist without dissonance. That a 'skull and cross bones' symbol on a flag or hat meant 'pirates' but on a container meant 'Toxic' and 'Poisonous'.

6.8.4 Health hazard symbol

Twenty one children thought that this symbol meant 'can give you a heart attack'. Surprisingly this was the largest misconception found in the study. As the single 'star shape' in the image was in the centre of the chest of the human silhouette this strongly linked to the concept of 'heart' as this was the single organ children had prior knowledge of in the chest cavity. Children, in this age range, understand the concept of 'heart attack' and meaning chest pain and leading to death. Therefore the linkage was made to the symbol meaning 'can give you a heart attack'. The children had very strong linkages to this cognitive concept and therefore the concept was easily and quickly retrieved from memory.

In the intervention a new concept needed to be constructed which would replace the concept of the symbol meaning 'heart attack'. This was achieved by contrasting the 'sharp pain' of a heart attack with the imprecise and 'fuzzy' image of the star shape in the silhouette. This then lead to a description of some chemicals slowly moving around the body and having a hazardous effect slowly over a long period of time. The analogy was made with cigarette smoking causing effects after many years. Therefore a new long term toxic concept was created which linked to the symbol and to concepts such as smoking.

6.8.5 Exclamation mark symbol

Only three children had a misconception regarding this symbol. However the question regarding the symbols meaning was very poorly answered. The exclamation mark is a punctuation mark and will have been seen by children at the end of sentences to indicate high volume (shouting) or strong feelings but even this concept does not seem to have strong linkages. Therefore the children seemed to search for a matching concept which three found as 'can drip on you'. Therefore in the intervention a new concept needed to be constructed which would co-exist with the concept of the exclamation mark meaning high volume or strong feelings.

The concept of the exclamation mark meaning 'Irritant' was made by describing a rash which may occur due to a chemical causing skin irritation. The irritation, being so painful, would cause shouting whilst scratching the rash. Also the concept of the symbol being situated within a red diamond also denotes that the chemical within the container is hazardous was reinforced.

In the intervention test group active learning and the use of the tactile and kinaesthetic learning styles allowed the children to co-create knowledge by clarifying interpretations, sharing ideas and questioning assumptions and this was critical for learning to be transformative. As this study has demonstrated cognitive dissonance can be dangerous in the area of child safety. Dissonance can be eliminated by acquiring new concepts that replace prior concepts or by acquiring new concepts that co-exist with prior concepts because both concepts are rationalised and the linkages adjusted.

Chapter 7: Conclusions and Messages from the Study

7.1 Introduction

In the previous chapter I provided a detailed discussion of the findings of this study. In this chapter I will close the discussion by reviewing the study limitations, drawing conclusions, reviewing the subject of child injury prevention, both generally and with an educational perspective, and making recommendations. The recommendations are both specific to this study and also general to the area of child injury prevention as my study of this area has highlighted. The study aim was to identify more productive methods of teaching home chemical safety interventions to primary school children, aged 7 to 11 years old, in order to increase their knowledge uptake and increase the retention of this knowledge using the new GHS chemical hazard warning system. The conclusions from this investigation are deduced from empirical evidence from the findings and an examination of the literature.

7.2 Study limitations

7.2.1 Intervention

While my results are suggestive of the potential benefits of using active learning / teaching to learning styles to enhance the safety education of children, a number of procedural limitations are present and should be addressed. The present findings must be interpreted with caution as this study used small samples. The overall small sample size could have an effect which may limit the comparisons both within and between schools.

In the preliminary organisation of this study, 45 schools were approached with a view to their participation. However, only two schools agreed to participate. The main reason given for non-participation was that the schools were 'too busy'. As the National Foundation for

Educational Research (2009) states "*it is becoming harder to find schools that will take part in research. NFER is aware of the burden on schools and how difficult it is for teachers and other school staff to find time for themselves or pupils to participate, because of busy timetables*" (NFER 2009).

I also approached the Primary School Teachers Association (PSTA) to try to elicit their support as a 'lever' to get more schools to participate, however they did not respond. Thus as the schools that did participate were predominantly white, British and middle class this did not give the hoped-for scope with regard to ethnicity and poverty. These areas will need to be addressed in future studies, however larger studies would require significant funding in order to increase the sample size. The reliability of these findings would be enhanced by using larger sample sizes.

It could be said that as the study was performed in the naturalistic school setting this could detract from experimental control. However, moving children to different locations was not a feasible option, also the reassurance of the children's teachers helped to establish rapport and confidence between myself and the children. I could not be left alone with the children at any time for ethical reasons. I found it extremely difficult to get schools to participate in this study.

It is possible, although unlikely, that children from each school differed on important factors, for example pre-treatment knowledge. However I am not aware of any systematic differences between schools. However as can be seen in the graph plots of means, figure 21, even if there were differences the test school still outperformed the control school in the one month post-test. It is not known if any parents were knowledgeable about chemical

hazard identification and the new GHS system and if that knowledge reinforced the children's knowledge between the immediate post-test and the one month post-test.

The evaluations used in this study determined individuals knowledge gain. It is unknown, in real life situations, whether children will be more or less likely to be affected in the presence of their peers as the study did not use 'mock' real life situations. This concern could be addressed by future research.

This study conducted teaching with multiple participants in three short sessions due to school imposed time constraints and limited resources. Future programmes might have greater efficacy with more sessions and/or longer sessions allowing the children greater opportunities to practice what they have learned. I believe that the use of more and/or longer sessions could be an important aid in the development of a teaching intervention, however this does highlight the issue of the practical application of the programme. Demonstration of the programme efficacy, I believe, is the first step in developing an effective chemical injury prevention programme.

7.2.2 Delphi study

I will now comment on several limitations to the Delphi investigation. All facets of the execution of the Delphi procedure were the sole personal responsibility of the investigator. Since I interpreted all findings, examined and analysed all data, created all surveys and enlisted all participants, aspects of the investigation could have been affected by my unintentional biases. Agreement was attained for all of the questions, apart from one. In the two rounds the response rate varied between 53% and 62%. The response rates, although appearing rather low, are similar to those obtained in other Delphi investigations

(De vet et al., 2005). Since considerable time investment was necessary from the participants this could explain the low participation rates. Two questionnaires in three months were expected to be completed and indeed the study could have asked for a third to be completed. An exclusive set of experts, which could have established partiality, could be the result of the low response rates. I assume, nevertheless, that possible partiality is restricted, due to this particular sample, given that saturation appears to have been attained, and the participants supplied an assortment of potentially significant components. However, I cannot totally exclude the risk that potentially significant components may have been overlooked. The majority of non-respondents did not offer an explanation for their lack of participation, but several stated lack of time. An additional limitation might be that I endeavoured to get data concerning a variety of factors of a very broad field. The depth of information gained may have been sacrificed by the range.

When designing this study I researched several methods to assimilate the views of educational experts on finding the best pedagogies to use in the chemical safety intervention phase. These were; face-to-face interviews, focus groups and the Delphi technique. Having considered the respective advantages and disadvantages of each of these methods I decided to use the Delphi technique in this study. However, since the Delphi technique was particularly time-demanding and consensus was achieved in just two rounds, in retrospect, I should have evaluated other methods such as the nominal group method and the real-time Delphi method which are more time-efficient.

The nominal group method is a variation of the focus group (CDC, 2006b). Information is gathered by asking questions posed by a moderator with each participant being asked individually. The ideas generated by all participants are then prioritised by each group

member. The result is a set of prioritised recommendations that the group agrees. The advantages are that the domination by particular group members that tends to occur in focus groups is prevented; ideas are prioritised democratically; and only a single session is required (making it time-efficient). There is still however, the major problem of assembling the group at the given time and the risk of frustration and boredom of participants whilst waiting to be asked their views. Another disadvantage is that the participants do not have much time to reflect on their answers (CDC, 2006b).

The real-time Delphi technique is a computer-aided advanced form of the Delphi technique (Gordon, 2009). The use of computer technology increases the efficiency of the Delphi process as sequential rounds are not required. Participants are still geographically remote and anonymous. There is continuous analysis of the results and completion within a few days. Each participant can join the study remotely by logging on to the computer application via the internet. When they do so they are presented with a screen for each question posed which contains a likert scale response; the mean of all responses so far; the reasons other have given for their responses and a window where they can add their thinking for the answers they have given. They can log in and out of this system whenever they want over a few days until the study is completed. The main disadvantage to the real-time Delphi method is that access to the IT system is required which may incur a considerable cost. Another disadvantage is that participants may log on to the system only once, complete the survey and not log on again to reconsider their answers in the light of others' comments. However, the speed and flexibility of this system are major advantages, and this approach could have been considered (Gordon, 2009).

7.3 Key findings

The main aim of the research reported in this thesis was to discover whether the use of more productive pedagogy's could significantly increase the knowledge gained in a home chemical safety intervention by children, in the 7 to 11 year old age range, and whether use of these pedagogy's would significantly increase the retention of this knowledge. The hypotheses (identified in chapter 3) and study objectives (identified in chapter 1) and key findings will now be summarised.

Hypothesis 1

H_1 : the method identified will significantly increase the knowledge uptake of the GHS system.

H_0 : the method identified will not significantly increase the knowledge uptake of the GHS system.

Key finding

There was a statistically significant difference between the control and experimental schools pre-test scores. The effect size for this, however, was small (r=0.25). This may be due to a small number of high scoring individuals skewing the effect due to the small group size in the control school.

Both control and experimental schools however, showed highly significant improvement in the immediate post-test scores with large effect sizes, r= 0.69 and r=0.78 respectively. There was no statistically significant difference between the immediate post-test results for both schools.

Therefore it cannot be claimed that the experimental intervention increased knowledge gain to a higher degree than conventional teaching. There was a greater knowledge gain

by the experimental school however, but this may be due to regression to the mean and the small sample size and small effect size dictates that this needs more confirmation. Therefore the null hypothesis was accepted.

Hypothesis 2

H_1 **: The method will stimulate retention of the increased knowledge for at least 1 month**

H_0 **: The increase in knowledge will not be retained for the expect period of 1 month**

Key finding

The statistical tests demonstrate that the large gain in knowledge by both schools in the immediate post-test is only significantly sustained after 1 month by the experimental school. This study clearly demonstrates that the use of the teaching to learning styles and active learning methods produce a far larger retention of the knowledge gained. Therefore the null hypothesis was rejected.

Objectives 1 was: To evaluate the teaching and learning method, identified by use of a Delphi survey, by comparison with a traditional teacher centred approach using chemical safety interventions to primary school children. This objective was achieved.

Objectives 2 was: To identify and correct any misconceptions and resolve any cognitive dissonance which may prevent or hinder assimilation of new concepts. This objective was achieved.

Key finding

Making sense out of new information is a process of learning. It is a 'sense making' activity. This is achieved by trying to connect new information to prior knowledge therefore producing relationships amongst ideas.

As the child uses their prior knowledge then understanding develops from the construction of meaning out of new information. Their knowledge about the topic expands quantitatively as the new information is made sensible. However this knowledge becomes more elaborated and differentiated and so also increases qualitatively.

The conceptual knowledge is therefore structured into a representation. The ability to act and think flexibly with what is known is a definition of understanding that is held by many researchers. It is thought that having the facility to employ the idea in a variety of ways, rather than simply building an idea, is true understanding. How concepts are 'represented' in the child's mind is the view of deep understanding from the cognitive sciences. How these concepts are interconnected is even more important (Atherton, (2010). In more abstract situations representations are in the form of models but in the form of images in simple situations. Every concept has a deep meaning in itself and a deep understanding requires the capacity to recall numerous connected concepts at one time. The learner is filled with a feeling of senseless thinking when connections between interrelated concepts are not seen. When sense is made of new materials then connections are made between different concepts (Ester, 2006).

Associations should be actively constructed, by the learners, connecting the knowledge and experience to the visual in order to successfully understand (Grabowski, 2004). Ryan and Patrick (2001) found that this was enhanced by the exchange of ideas in the classroom.

Traditional teaching does not help children in the application of concepts, or create a deeper understanding, relative to the real world, it only helps pupils gather facts (Gallagher

2000). Gallagher (2000) also states, "The vast majority of effort is devoted to helping students acquire information. Only a small part of class time is devoted to helping students make sense of the new information and make connections amongst the various components of these elements of knowledge in a way that leads to understanding" (Gallagher, 2000).

Knowledge building pedagogies have been adopted by many educators leading to a much deeper understanding, by the children, of the subject matter they are engaged in learning (Scardamalia and Bereiter, 2003). Understanding is a knowledge building and a meaning making activity. A learner constructs new connections and relationships amongst facts by virtue of knowledge building practices. Chemical injury prevention is based on knowledge building, and in order for children to comprehend this they need to debate and review their chemical hazard understanding.

Children are forced to perceive conceptualizations from different points of view through knowledge building, as their misconceptions become apparent (Paavola et al., 2004). Discussing a problem with other children helps to produce a deeper understanding (Hatano and Oura, 2003). Inadequacies of understanding become more prominent through this kind of process.

Drawing, as used in active learning, was described by Algozzine and Douville (2004) as a way of improving knowledge acquisition. Posters were produced to combine drawing with words and represent the main ideas. The drawings generated ideas and produced feedback from others.

Different groups of children collaborate in the interpretation of keywords and pictograms in different ways. Meanings are tied together into more complete constructions using group tasks. Understanding the process of image formation is facilitated using labels and captions in the drawings. The effectiveness of the teaching is increased by using annotated drawing to communicate their understanding.

7.4 Significance of the study

The study aim was to identify more productive methods of teaching home chemical safety interventions to primary school children, aged 7 to 11 years old, in order to increase their knowledge uptake and increase the retention of this knowledge using the new GHS chemical hazard warning system.

Empirically, this study contributes to more effective health education teaching leading to greater knowledge uptake and retention which could potentially lead to the number of unintentional injuries experienced by children declining. Currently there is very little evidence regarding how to teach health education interventions: most work seems to point to what to teach and to whom. The intention of this research study was to start to reduce this knowledge gap. This study is the first to use two pedagogies within a child safety intervention to increase the retention of gained knowledge and to identify and rectify the misconceptions of the children. As school children are taught home chemical safety both in primary and secondary schools then there would be an ever-growing child population with this chemical safety knowledge and the potential safety that it should provide. However, as these children become adults there would be an ever-growing population of adults with this chemical safety knowledge. These adults could then teach their own pre-school children, enhancing their safety even before the age of the children in this first study.

This study should provide a useful guide for policymakers, intervention designers, planners and researchers in establishing more productive, more efficient ways to teach safety interventions to children. This efficiency may then be expressed as schools having a larger amount of time available to deliver the normal school curriculum or it may be expressed as an opportunity to deliver more interventions within the same period of time.

7.5 Key issues arising from the research

The findings of this study indicate that, regardless of the age range, there is a requirement to make teaching materials engaging relative to content, making activities concise and short relative to the time required to complete an activity and that activities should engage children in a playful and interactive manner.

There are however, some real world questions. Whilst the findings of this study support the use of games and play to enhance the teaching of the safety curriculum it remains an issue whether being playful regarding hazardous chemicals is appropriate. Also, if the safety curriculum is conveyed using games this may produce some dilution of safety message. The current data, it is hoped, will be of value to practitioners and researchers in developing educational programmes. My results also show that learning styles need not constantly match teaching styles. Teachers should not feel compelled to match the two but should use as many diverse styles as possible. Instead a positive effect on satisfaction and learning outcomes can be achieved by planning teaching activities which allow the engagement in active learning of children of every learning style sometime during the programme.

These results support the findings of (Prince, 2004) which showed that there was enhanced learning, retention of knowledge and learner satisfaction by devising active learning coursework that encouraged the use of diverse learning styles.

Children found some of the activities easier than others and it is assumed that this is related to their particular preferred learning style. Indeed this would support research performed by Ogden (2003) who found that engaging children with different learning styles in different instructional activities facilitated the children's learning relative to their strengths but also provided opportunities to cultivate strengths in other areas and that the teacher centred method should be modified to support this approach.

This investigation has found considerable support for active learning / teaching to learning styles when used in child safety interventions. The preliminary information provided by this study will hopefully set the stage for more extensive studies in the future, preferably randomised control trails, to provide strong evidence. Some of the benefits found in this study, such as student engagement, would probably not be considered controversial. However some of the benefits may be surprising such as the size of the improvements which have resulted from the use of the active learning/teaching to learning style methods. The traditional assumptions about injury prevention education may be challenged by other findings of this study and these should be highlighted. For instance, if activities are introduced to the programme then the children will remember more content. The evidence from this study indicates that far more consideration needs to be given to 'How to teach' and that child injury prevention should use non-traditional teaching models. Active learning and teaching to learning styles have broad support in the educational literature. Injury prevention programmes should endeavour to be aware of, and make use of, these

different instructional methods and the teaching used in these programmes should be informed by the literature on what works. The two teaching and learning methods used in this study have a great many advantages over traditional methods. They are also highly complementary to each other. Together they help children organize the contents better, enhance the absorption of the material and, as this study shows, retain the knowledge longer. They also can be manipulated to fit the changing patterns of concentration.

7.5.1 Active learning / Teaching to learning styles

Great attention has been directed towards active learning over the last decade. Active learning often polarizes teacher's opinions and is perceived as a drastic change from the traditional teaching method. Sceptics regard active learning as an educational vogue. However, it has many advocates who were willing to try alternatives to traditional methods.

Collaborative learning, which is any instructional method where children will work in small groups together and have a common goal, was one type of active learning used in this study (Smith and MacGregor, 2001). Therefore all group based instructional techniques, which includes cooperative learning, can be viewed as encompassing collaborative learning. Some researchers however, take the view that there are different philosophical roots between cooperative learning and collaborative learning and this differentiates the two (Akella, 2012). Both however emphasise student interactions instead of learning as a solitary activity.

In cooperative learning learners are assessed individually but are in structured groups that pursue common goals (Feden, and Vogel, 2003). The focus is not on competition to promote learning but rather on cooperative incentives and this is the principal factor in all

cooperative learning (Ashman and Gillies, 2003). In deep learning the learner answers and asks questions, understands the material and can explain the material in their own words. Deep learning is encouraged by active learning rather than surface learning as tends to be the case with traditional teacher centred methods. A range of learning styles are also catered for by using active learning. If children with particular learning styles are not actively involved then the quantity of information they can process is limited. Therefore, to give the learners the best attempt at processing and retaining information, it is beneficial for the teacher to teach to as many learning styles as is practicable especially when active learning is not taking place. Learning may be enhanced, but more specifically the retention of knowledge is enhanced, by using diverse learning styles and using active learning.

7.5.2 Injury prevention in schools – the comprehensive approach

A wide variety of child injury prevention stratagems are used in schools providing a comprehensive approach. All these approaches focus on learning and health even though they may vary is scope, content and method of implementation. They all endeavour to be successful in preventing child injuries. The individuals' capacity and resources for preventing injury are increased by strengthening their knowledge using comprehensive approaches. A community approach, which reaches groups with resources and information on injury prevention, is also incorporated within comprehensive approaches. Also incorporated is the education of teachers who can then become effective advocates of programme change and who also gain an enhanced understanding of injury prevention being able to communicate injury prevention messages to larger groups of people. By implementing comprehensive educational approaches to child injury prevention in schools all these objectives can be accomplished.

7.5.3 Injury prevention curricula

The results of many previous educational injury prevention programmes have been disappointing and this has reflected poorly on injury prevention curricula. It is believed by many educators that the efficacy of on-going school based education is likely to be greater than single exposure programmes. The results of this study will hopefully add value to the efficacy of future curricula by increasing knowledge retention in fewer sessions. Teachers with knowledge and experience of teaching to learning styles and active learning should be used to assist in the implementation of programmes.

7.5.4 Development of accountability and standards for school success

The UK economy is now in a situation where difficult choices need to be made by educational leaders which will affect the priorities of schools that are already faced with multiple competing demands (Adelman and Taylor, 2002). The student academic performance requirements are currently the main focus of educational leaders. Schools are reducing the time they devote to non-assessed programmes and increasing the time for assessed instruction as they are more likely to be assessed in these academic areas.

7.5.5 School and community programme integration

There are many questions regarding the integration of interventions with ongoing programme delivery in schools. There are also questions regarding the success of particular programmes and the factors that influence that success. The programme model should be planned for the long term and adjustments made over time or it is unlikely that the implementation will endure. It will probably need to be integrated with ongoing school programmes (Adelman and Taylor, 2008).

There are significant concerns however, regarding the school-government coordination of programmes and how this relationship can be developed (Wandersman and Florin, 2003). There are many factors to consider in this partnership such as financing, organization, technical assistance, management and training, and if any one factor malfunctions it could jeopardise the programme. Programmes may keep, or even raise, the quality of implementation if this partnership functions well. It may also be beneficial to produce various networks, for example an educational network, that could recommend changes based on evidence. The use of networks where all involved parties could input may also increase the sustainability of programmes.

7.5.6 Education and legislation

An effective solution to injury prevention, it has often been stressed, is legislation. This however, depends on whether it requires repetitive action or is a one off, single event that offers passive protection. The placing of hazard warning labels, for example, on containers of chemicals is required by legislation. Having the knowledge to understand these labels however, is in the realm of education. Child resistant containers, to prevent harm, are intermediate between the two of these. When used correctly both offer a measure of passive protection. Therefore, in this process, education has a role in implementation. The introduction of PSHE is one of the advances there has been in school based interventions in recent years. But developing effective models for implementation, diffusion, and sustainability raise new issues regarding improving programme effectiveness.

In the last decade there has been a growing literature on implementation and increases in the number and breadth of evidence based programmes (Greenberg et al., 2001), as a

result of significant developments in school-based prevention.

In order to promote sustainability there is a need to produce high quality implementations. This could be achieved by greater integration with schools as effective programmes undergo translation from research to widespread practice to ensure the building of required structures and processes. A greater degree of cooperation is required with schools in the application and development of injury prevention programmes in order to obtain further advances. This would allow teachers to learn from researchers and researchers to learn from teachers. Prevention programmes can play a vital role in increasing child safety and preventing injury and much greater attention to this collaboration is required and is a central part of this stratagem.

7.5.7 Identifying 'What Works'

There is more than one learning outcome from the teaching methods employed in this study. Therefore a broad range of outcomes needs to be considered when trying to identify 'what works'. For example, the initial uptake of knowledge and the level of retained knowledge. There are also other unmeasured factors to consider such as the level of motivation shown by the children and the enjoyment they experienced. Deciding when an improvement is significant is another problem that needs to be addressed when determining 'what works'. Many studies state that improvements have been made, however they fail to state that the improvement is usually very small (Colliver, 2000). Any improvement should be significant. The technique of active learning consists of a wide range of methods and a wide variety of learning styles can be used when teaching to learning styles. This had the potential to make this study very over complex and unviable.

By focussing on the five main learning styles – VARKT and the core elements of active learning simplified the use of these methods.

There are practical limitations to interventions which implement educational practices. What worked for the populations examined in educational investigations is enlightened by learning theories. It may be considered simplistic however, to claim that similar results can be produced using the same educational methods in other schools as many variables cannot be controlled.

The larger the population that the intervention was tested on then the more extensive the data set. The greater the data set then the more likely it is that this will resemble other populations. The larger the reported gains the greater the support for the intervention and the greater the chances are that the intervention will be successful.

Support for all of the forms of active learning / teaching to learning styles examined has been found by this study even though some of the results are lower in strength. Some other findings, that contest conventional assumptions about injury prevention education, are also worth highlighting. If active learning and teaching to learning styles are introduced to the teaching session students will retain more of the content over a longer period of time. Many current interventions, in contrast, try to pack a great deal of material into a given session. This has the effect of only being able to use traditional teacher centred approaches due to time limitations relative to content. The traditional assumption that children working alone will gain greater achievement is called into question by the support demonstrated in this study for active learning. The evidence this study has produced supports the view that interventions should use active learning/teaching to learning styles

in their course structures. Designers should be conscious of these special teaching/learning techniques and endeavour to have their programmes informed by what works.

7.5.8 Characteristics of successful and unsuccessful educational programmes

There have been many educational interventions, over the years, focussed on behaviour change in children. Some of these campaigns had some degree of success and some were unsuccessful. There were many reasons why some of the campaigns were unsuccessful. For example they used traditional teaching styles, used leaflets and posters and used one-off sessions. They also tried to address too many topics relative to the duration of the programme. In some of the interventions the programme material was not suited to the target group and too many messages tried to be imparted (Klassen et al., 2000; Towner et al., 2001).

Duperrex et al. (2002) stated that where campaigns had some degree of success interventions were appropriate to the children's needs, were very specific and targeted. It is very much less likely that the intervention outcomes would be achieved the more complex the course and course material were.

7.5.9 Child injury prevention accomplishments

Some progress has been made, in the last two decades, which has formed a practical foundation to the field of school based injury prevention (Greenberg et al., 2003). An understanding of the protective factors related to later outcomes needs to be addressed by the analysis of longitudinal data (Collins and Sayer, 2001). The method, study design and analysis need to be given greater attention. Practical and replicable intervention models

should be created by programme developers and these should be documented. Crucial for legitimizing prevention efforts will be the use of randomised control trials providing the potential for producing strong evidence. In the future it is probable that organisations and agencies will only provide grants for empirically validated programmes. The intervention design process could be helped by governmental agencies publishing a 'what works' guide which would provide the criteria from empirically validated studies.

7.5.10 Childhood injury prevention programmes – improved outcomes

Child injury prevention programmes can have lasting benefits, apparent even in adulthood, or they may only be effective during or immediately after the intervention. Programme efficacy depends on whether children in the programme group perform better than children in the control group on measures such as knowledge gain and whether this knowledge is retained at later ages.

Generally the effect size on average for these studies is around 0.3. This indicates that the programmes, on average, do have a small to moderate effect. In fact this study has an effect size of 0.49 which shows a moderate to large positive effect.

Fade-out is a phenomenon that can be observed in child evaluation achievement scores. The difference in scores between the control group and treatment group reduce over time and can become insignificant. It is speculated that unless an intervention is maintained over time then the gains produced by the programmes may reduce as children get older. Indeed Aos et al. (2004) found a steady fade-out pattern in test scores in the treated groups over time.

However, the effects of child interventions can continue into adulthood (Karoly et al., 2005). Indeed there is evidence that points to the fact that some interventions can have long lasting effects. Karoly et al. (2005) also found that better outcomes were produced by more intensive programmes and that if these were repeated on a reasonably regular basis the effects were long-lasting. There is probably a minimum level of programme duration and also a maximum time period between repeat interventions. It is also likely that that there will also be a maximum level of programme duration beyond which no more gain will be made. The cost of programmes is an obvious and critical factor and characteristics associated with more successful programmes are more costly. Therefore it may be that larger gains will require larger amounts of money. However, diminishing marginal returns may ensue after financial thresholds have been reached. Further research would need to find the optimal intensity of child injury prevention programmes and decide what the timing between interventions should be.

7.5.11 Efficacy to effectiveness

The next phase in injury prevention programming, as programmes start to show efficacy in controlled trials, is to study the effectiveness (Nation et al., 2003). The study of effectiveness raises several research questions which need to be addressed. Are empirically validated programmes effective in the real world is one such fundamental question. Some kind of comparison group will be required for such studies, whether using quasi experimental or randomised designs. Some questions regarding effectiveness are best done using less controlled conditions, without using comparison groups, as local circumstances vary. One of the most important questions to address is regarding the quality of the implementation and what factors can influence this. This issue has not been

afforded enough attention which has necessitated some researchers to call for the development of a method of implementation (Domitrovich and Greenberg, 2000).

The curriculum model should be the focus of research together with the implementation support system. Also the characteristics of children, teachers, any regulatory issues and any other non-programme factors should also be investigated.

Local adaptation is a central issue when studying programme effectiveness. As models are used in the same setting, over a period of time, it is likely that they will undergo some changes. Changes, such as adapting the teaching materials for local needs, may be considered positive. Curriculum incorporation with other subjects and adding components that enhance comprehensiveness may all augment the programme as long as the fidelity of the teaching and delivery are maintained. Other adjustments, such as omission of critical elements or the shortening of the teaching time, may be detrimental to the outcomes. The focus should be on the nature and quality of the adaptations (Greenberg et al., 2003). Researchers, programme developers and teachers should look more closely at these inevitable adaptations. Experimental trials would need to be conducted using varied aspects of implementation, for example level of technical assistance and teaching characteristics. There will always be natural variation when programmes are disseminated and a study of this could be used to provide some answers. How prevention programmes develop over time will be important knowledge to acquire. What changes occur and how these changes are made by schools should at least be enlightening if not sometimes frustrating.

7.5.12 System Integration - the challenge for injury prevention

There are a number of significant new challenges related to prevention initiatives concerning the association between prevention research and practice. The challenge will be to integrate universal prevention programming. Long term curricular planning needs to be developed between researchers and practitioners. Also an adequate local infrastructure needs to be produced to support prevention activities, to give technical assistance and provide teacher training. Appropriate evaluation also needs to be undertaken of the process and outcome (Greenberg et al., 2003). There is often disjointed planning between government agencies and schools. There can also be a disjointed nature relative to the models created by researchers and curriculum developers (Adelman and Taylor, 2002).

7.5.13 Widespread dissemination

There is also an issue regarding scaling up injury prevention programmes with very little evident validated research available even in case study form to guide such implementations . This is an even larger challenge than studying injury prevention programmes under real life conditions (Backer, 2000). The process of scaling up offers difficulties related to the knowledge, readiness and the efforts of the schools and also the characteristics of the programme and the model used for promotion and promulgation used (Rotheram-Borus and Duan, 2003).

7.5.14 Sustainability

Sustaining an intervention over a long time period, and therefore increasing the chances of the programme being effective, is a significant challenge. Child injury rates will only start to move downward by teaching injury prevention to multiple groups of children. A change in approach is required relative to programme integration and sustainability which may

require new and distinct concepts. Researchers need to collaborate with schools, rather than just trying to get their permission to test new programmes, to create sustainable change in injury prevention programmes and gain an understanding of support structures (Greenberg et al., 2003). There is a requirement for practical, but validated, methods to support schools in making programmes sustainable (Johnson et al., 2004).

7.5.15 Programme effectiveness – the 'elephant in the room'

The monitoring and tracking of incident rates, circumstances and causes of injuries which can result in fatal and non-fatal injuries is the injury surveillance process. Injury surveillance systems are needed to monitor injury prevention programmes and assess their effectiveness, they can also inform on specific programme requirements. The data produced by injury surveillance is used in injury prevention efforts after analysis. Needs are assessed by Public health practitioners who require the surveillance data to evaluate the effectiveness of existing programmes and assess the need for new programmes. The performance of current national injury surveillance systems needs to be considerably improved. Standards need to be set for the recording of injury data sets, specific injuries, risk factors and these systems, if there is more than one, need to be integrated. Only then can a picture emerge of the true numbers and types of injuries suffered by children. In addition, injury prevention programmes could be allied to public health departments if the standards set are compatible with other public health surveillance and therefore could be integrated with traditional public health surveillance.

7.5.16 Positive effects and financial benefits

Recognised as a promising approach by some, the educational child injury prevention intervention has the potential to improve the safety of children and reduce the costs to the

National Health Service. Many decision makers have described child injury prevention interventions as investments that will pay for themselves (Rolnick and Grunewald, 2003). The question of whether there is enough evidence that child injury prevention programmes work still remains even though the logic is compelling. This is a larger question than first appears. The efficacy of the programme, relative to expected programme outcomes, may be successful, however the effectiveness relative to the reduction in child injuries may be more questionable. However child interventions have been shown to influence a range of outcomes.

Child injury prevention programmes may cost from a modest amount to a considerable amount depending on the intensity and range of services delivered. Therefore, in terms of the benefits associated with the array of positive programme effects it is sensible to consider whether the costs are justified. In reality many of the benefits that child injury prevention interventions produce can be converted into pound figures which can then be compared with intervention costs. However we should never lose sight of the other reasons why injury prevention interventions should be undertaken such as the pain, suffering, disfigurement and death of children.

7.5.17 The future direction of injury prevention research

There is a need for more refined programmes displaying greater efficacy as the effect sizes, shown by prevention programmes, are frequently small even though, on a variety of outcomes, they are statistically significant (Gottfredson and Wilson, 2003). It is also important that the efficacy of new models is not just compared to 'current practices' to assess their value but to existing empirically validated programmes. The quasi-experimental design method requires more work before being utilised when randomised

design use is not possible. For instance, there is an understandable reluctance by schools to have pupils placed in the control group who either do not receive any injury prevention teaching or do not receive the optimal teaching. Therefore more viable design models are required for collaboration and evaluation.

7.6 Recommendations

The following recommendations are made based on the findings of this study and my examination of the subject of child injury prevention.

7.6.1 Study recommendations - Teaching

The use of teaching to learning styles and active learning methods should be very seriously considered by injury prevention programme designers and implementers in future programmes. If these methods are utilised it should be assured that the programme teachers possess the required pedagogical experience to employ active learning and teaching to learning styles. Programme teachers should be trained to understand the new GHS system and general chemical safety. Teachers should be supported via the provision of teaching materials and manuals. If possible, guidance should be available, using mentors, to teachers within their school. Studies should teach a tailored curriculum to generate greater elaboration. Regular assessments should be performed to determine that the programmes are performing to the highest efficacy level. Any learning from the programme should be communicated to the programme designers and other participating schools.

7.6.2 Study recommendations - Research

More research, preferably as randomised control trials, needs to be performed using a

larger sample size. As more longitudinal data is required the research could test knowledge retention over a greater time period which would also help determine the optimum programme repeat time scale. This research could also evaluate the use of mock real life situations to determine whether this has a positive effect on the efficacy of the programme. All of this research would also contribute to the cost/benefit analysis and could aid in the identification of the essential components of the curriculum together with the teaching methods which give the greatest benefit relative to cost.

7.6.3 Study recommendations - Programmes

Programmes should be developed and encouraged which are data driven and include a strong evaluation component which will increase the efficacy, and potentially the effectiveness, of educational stratagems to reduce child unintentional injuries. These programmes should also be responsive to diverse populations, for example in terms of age and disability. Child injury prevention programmes should incorporate a quality improvement process. This process would continually measure the efficacy and effectiveness of educational child injury prevention programmes to produce constant improvement.

7.6.5 General recommendations

Child injury prevention efforts inevitably cost money, however it is generally accepted that the cost of child injuries to the state is greater than the cost of prevention programmes. Therefore, government should be encouraged to contribute more to implement programmes and fund additional research into programme efficacy and effectiveness. Private funding support should also be encouraged, for example from chemical companies, to develop and implement child unintentional injury prevention programmes.

A government agency should be created to oversee injury prevention. This agency could coordinate injury prevention efforts, communicate learning from research, and aid development and implementation of prevention programmes. It could also liaise with other government departments, for example the department for education, to facilitate access into schools.

A national injury data collection system should be created. If more than one system is employed the systems should be integrated. This would allow the true picture of the child unintentional chemical injury problem to be built and would also provide a foundation from which a measure of the effectiveness of prevention programmes could be gauged. This surveillance system(s) should comprise all the variables required to ensure a comprehensive view of child injury emerges.

Appendix A
Ethics study approval letter

Academic Audit and Governance Committee

Research Ethics Panel
(REP)

To	Garry Latham
cc:	Professor Greg Smith/Professor Chris Miller
From	M Pilotti, Contracts Officer
Date	9th March 2009

MEMORANDUM

Subject: Approval of your Project by REP

Project Title: Hazard comprehension of chemical consumer commodity hazard labels by children before and after training? ORGHS and chemical hazard communication to children – the art of not keeping mum (working title)

RGEC Reference: RGEC08/052

Following your responses to the committee's queries, based on the information you provided, I can confirm that they have no objections on ethical grounds to your project.

If there are any changes to the project and/or its methodology, please inform the committee as soon as possible.

Regards,

PP

Max Pilotti
Contracts Officer
MP/JH

Delphi Round One

Name : ....

Date : ....

Position :......................................

Qualifications :..

Dear Panel Members,

Many thanks for agreeing to participate in this study. This is round one of the Delphi study. The study aim is to identify more productive methods for teaching children about consumer chemical hazards using the new GHS system leading to the identification of the essential tools for learning and assessment.

In this document you are asked to consider a total of 16 questions relating to 4 areas:
- Teaching & Learning
- Assessment
- Age
- Other Factors

All of these questions relate to children of 7-11 years inclusive. Please answer the open-ended questions fully but as succinctly as possible.

1) At what age do you think that it is reasonable for children to use hazardous chemicals in the home, and why?
(For example: bathroom cleaner, solvent based glue, hair spray, deodorants)

2) How would you initially assess existing knowledge?

3) What teaching and learning methodologies would you employ when teaching about hazard definitions and hazard phrases?

4) What teaching and learning methodologies would you employ when teaching about precautions and precautionary phrases?

5) How would you relate the following hazards to children at each age?

- Corrosive

- Acutely toxic(e.g. can cause serious damage or death in a short period of time)

- Long term toxic (e.g. carcinogenic)

- Flammable

- Dangerous for the environment

6) What would you define firstly and how would you build the 'whole picture'?

7) What activities could be used to enhance the learning experience?

8) How would you assess the learning at each age? e.g. Formative / Summative

9) What do you think are the main teaching and learning methodologies when teaching about chemical hazards to different ages of children?

10) For children between the ages of 5 and 11 inclusive should these ages be split into groups to be taught and if so how?

11) Should the overall message differ relative to age? Please give examples.

12) Do you think there's a difference between the specific teaching of chemical hazards as opposed to other types of hazard? If so what are they? Please give examples.

13) How do you think ethnicity might affect this teaching and learning?

14) Do you think that gender would be a factor in teaching about chemical hazards? If so how?

15) What do you think the maximum lesson duration for each age should be and why?

16) Do you think that this should be taught in schools as a subject, as part of a subject e.g. science, or some other way? Should it be taught as a 'one-off' or should it continue through school? If you think it should continue through school how often should the lessons be repeated?

The second round of the Delphi exercise is scheduled to begin at the end of March as it will take approximately three weeks to analyse and summarise the results from this round one exercise. I will then send you a revised list of questions derived from round one.

Many thanks again for taking the time to participate.

Background material for participants

Introduction
More than 28,000 children require hospital intervention for chemical poisoning every year in the UK (RoSPA, 2002). Household chemical products (consumer products) are implicated in almost all poisoning accidents. The effect of these chemicals is far greater on children since their metabolism and behaviour differ from that of adults. This causes them to be at a significantly greater risk to chemical hazards than adults (Children's Environmental Health Network, 2005). Particularly children are more susceptible for the following reasons.

- Children's immune, digestive, nervous, reproductive and respiratory systems are developing and changing rapidly. This transformation produces periods of vulnerability. If children are exposed to hazardous chemicals at these times this could give rise to permanent damage even though the same exposure to a fully-developed adult system could result in insignificant or no damage (Children's Environmental Health Network, 2005).
- The capability of children to detoxify, metabolise and excrete chemicals varies from adults since the metabolic pathways of children are immature (Srinivasan et al., 2003).
- The child metabolism is faster and so accelerates the absorption of chemicals (Moyers 2001).
- Children have a much longer time period in which to acquire long-term medical conditions activated by exposure to chemicals as young children (Landrigan & Garg, 2002).

What is changing? (UK Health & Safety Authority, 2003)

Between 2008 and 2015 the world is changing over to one system of chemical classification and labelling. This new system will replace all the current disparate systems used around the world. In Rio de Janeiro at the 1992 United Nations 'Earth Summit' the foundations of the Globally Harmonised System (GHS) were initiated. This system encompasses the hazard classification and labelling of chemicals. Many international organisations and the United Nations have worked for more than a decade on GHS, resulting in this international convention providing a basis for a globally accepted system to address the hazard classification of chemicals and corresponding labels.

The United Nations has identified that education and training are essential to ensure the safety of people who may use or come into contact with chemicals. The requirement for guidance and the role of training and education are specifically advocated by the Globally Harmonised System (UN sub committee of experts 2001).
As David Cotton (2002) of the UK Department of Trade and Industry put it, "Without education, even the best designed label will be ineffective."
Adults are a difficult target audience to reach since no one forum exists for their education in this area, and since it is young children that are most at risk then it seems appropriate that this group be taught at school about the hazards associated with chemicals found in the home. However since chemical hazards found in the home hasn't been taught in schools before using the new GHS hazard communication system there exists a gap about how this is best taught.

Therefore it is this gap that I hope to fill using the Delphi survey.

Aim of the study

The study aim was to identify more productive methods of teaching home chemical safety interventions to primary school children, aged 7 to 11 years old, in order to increase their knowledge uptake and increase the retention of this knowledge using the new GHS chemical hazard warning system.

It is anticipated that knowledge of this new system and the use of this knowledge to identify hazardous chemicals will contribute to the safety of the children in the home environment.

No chemicals will be used in this intervention.

Examples of household chemical products found under each type of hazard symbol (this is an indicative list not a definitive list)

Toxic / Harmful
- windshield washer fluid
- furniture polish
- antifreeze
- paint thinners
- pesticides
- methylated spirits

Flammable
- lighter fluid stains/varnishes
- adhesives
- cleaning solvent
- Aerosols – including hairspray and deodorant

Corrosive
- drain cleaner
- toilet bowl cleaner
- oven cleaner
- silver cleaner
- brake fluid
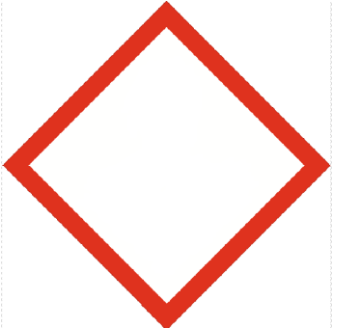
Dangerous for the Environment

- Anti mould solutions
- Pesticides

GHS pictograms

The new GHS system will introduce new pictograms. These pictograms and their meaning are shown in the following table.

	Corrosive A substance having the properties to destroy, dissolve or wear away inorganic materials such as metals or organic materials such as skin.
	Long Term Poison These types of chemicals can cause harm over a long period of time – usually years. They include Cancer causing chemicals.
	Acute Poison A substance that if absorbed, inhaled or ingested can destroy life or injure health. The terms 'poison' and 'toxic' are used interchangeably.
	Flammable A substance possessing the property to burst into flames, if exposed to other heat sources such as flames, heat or sparks.
	Dangerous for the Environment Can kill fish, plants, birds and other aquatic life

	Other Hazards For example • irritants to the skin • sensitizers (allergic reactions)
	Red Diamond **Means danger**

Definitions (U.N. Sub-Committee of Experts, 2001)

Hazard Statements

These standardised statements give a description of the hazard(s) as determined by hazard classification.

Pictograms and Precautionary Statements

The hazard information is supplemented by the Precautionary information communicated by the standardised precautionary phrases. These phrases briefly describe measures that can be used to mitigate the hazards or greatly reduce the risks from health, physical or environmental hazards.

Signal word

The term 'Signal word' acts to alert the reader to a potential hazard on the label and pertains to its relative level of severity. 'Danger' and 'Warning' are used in the GHS system

as signal words. A graphical element which aims to convey information very succinctly is termed a 'Symbol'.[sentence removed] For example the 'skull and Cross bones' symbol as shown below.

Pictogram

A graphical composition which is composed of a symbol together with a red diamond border is termed a pictogram in GHS. It is intended to succinctly convey hazard information and to be very eye-catching.

Example of a GHS hazard label for Ammonia

AMMONIA, ANHYDROUS

Danger

DANGER – Toxic if inhaled
Avoid breathing fume/ mist/vapours/spray.
Use only outdoors or in a well-ventilated area.
IF INHALED: Remove to fresh air and keep at rest in a position comfortable for breathing.
Call a POISON CENTRE or doctor/physician.
Store in a well-ventilated place. Keep container tightly closed.
Store locked up.
DANGER – Causes severe skin burns and eye damage
Do not breathe fume/ mist/vapours/spray
Wash thoroughly after handling.
Wear protective clothing – gloves/eye protection/face protection.
If SWALLOWED: Rinse mouth. Do NOT induce vomiting.
If ON SKIN: Remove all contaminated clothing. Rinse skin with water/shower.
If INHALED: Remove to fresh air and keep at rest in a position comfortable for breathing
If IN EYES: Rinse cautiously with water for several minutes. Remove contact lenses if present.
Wash contaminated clothing before re-use.
WARNING – very toxic to aquatic life.
Avoid release to the environment
Collect spillages.

Background material references

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Delphi round two

Name:…………………………………………………………………………………..

Date:……………………………….

Dear Panel member,

Firstly, thank you for completing the round 1 questionnaire. The next stage is round 2 of the Delphi exercise.

I have analysed your replies to round 1. The appended document contains a total of 28 items. It is in the form of statements taken from your answers in round 1.

What I'd like you to do is to choose how much you agree or disagree with each statement by ticking the appropriate box.

For example if, for question 1, you strongly agree with the statement please tick the box under 'Strongly agree' as shown below:

It is reasonable for children aged 12 years old and above to use hazardous chemicals in the home.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree
√						

There is also a 'comments box' under each question for any comments you would like to make.

All these questions relate to children between the ages of 7 and 11 years old inclusive.
Thank you for your participation.

1) It is reasonable for children aged 12 years old and above to use hazardous chemicals in the home.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment:

2) Existing knowledge should be assessed using open discussion question and answer sessions.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

3) The Q&A session should be conducted in a 'fun' style.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

4) When teaching the meanings of symbols and pictograms the best methodology to employ is trying to teach relative to the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

5) When teaching about hazard definitions and hazard phrases the best methodology to use is trying to teach relative to the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

6) When teaching about precautions and precautionary phrases the best methodology to employ is trying to teach relative to the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

7) Precautions and precautionary phrases should only be taught to older children (12 years old upwards).

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

8) The best way to relate chemical hazards to children is by relating the pictures to the text definition.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

9) The best way to relate chemical hazards to older children is by using photographs of the hazard and relate to text definition.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

10) Showing actual products used in the home should be defined firstly.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

11) This should be followed by basic definitions – such as 'Danger', 'Hazard', 'Harm'

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

12) The course should build slowly over time.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

13) Games should be used to enhance the learning experience and to take into account the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

14) Role play should be used to enhance the learning experience and to take into account the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

15) Demonstrations should be used to enhance the learning experience and to take into account the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

16) Formative evaluation should be used to assess the learning at each stage as the course progresses with a final summative evaluation.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

17) The main learning methodology is that the learning should be fun and address the learning styles of the children.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

18) The main teaching methodology is that only the basics should be taught.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

19) The main teaching and learning methodologies are that there should be lots of activities which address the various learning styles.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

20) In order to teach chemical safety in the home pupils should be grouped, and taught, by age.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

21) The overall safety message should be the same whatever the age.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

22) The overall message should be 'Keep away from chemicals as they can harm you'.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

23) Chemical hazards should be taught differently than other types of hazard.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

24) Ethnicity will not be a factor in the chemical safety teaching and Learning.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

25) Gender will not be a factor in the chemical safety teaching and Llearning.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

26) The maximum lesson teaching duration should be 1 hour followed by activities.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

27) Chemical Safety in the home should be linked to the teaching of science.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

28) Chemical Safety in the home should be continually taught by refresher sessions.

Strongly Agree	Agree	Moderately Agree	Neither agree nor disagree	Moderately disagree	Disagree	Strongly disagree

Comment :

[School Name]

Name : …………………………………………………………

Age :…………………

Date : ………………..

What do the following pictures mean?

....

....

....

....

....

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....

....

....

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....

....

What does the word HARM mean?

....

....

....

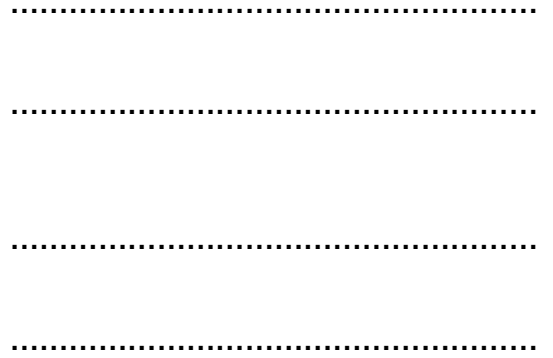...

What does the word HAZARD mean?

....

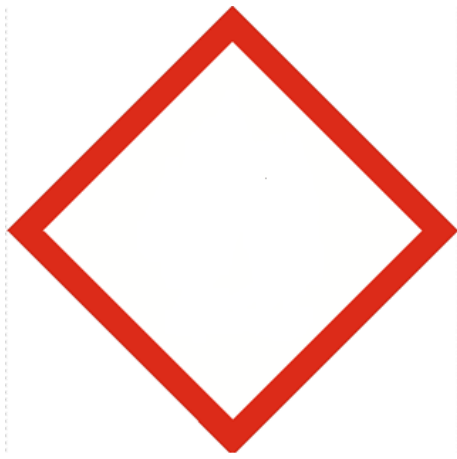...

....

....

What does the word PRECAUTION mean?

....

....

....

....

Name 3 places at home where you might find chemicals

1.………………………………………………………………...

2.………………………………………………………………...

3.………………………………………………………………...

Appendix F
Symbol identification game

Name :

Age :

Symbol Identification
Write the correct name of each hazard picture on the line provided.

_____

_____

_____

_____

_____

_____

Name :

Age :

Definition Match
Draw a line from each picture to the meaning

A chemical that can kill fish, plants and birds

A chemical that can cause a very itchy sore rash

Shows a chemical is hazardous

A chemical that is poisonous and can hurt you very quickly

A chemical that can set on fire very easily

A chemical that can dissolve your skin

A chemical that is poisonous over a long period of time

Name :

Age :

WORD SEARCH

Find the following words in the table. Mark the words with a highlighter pen.

CORROSIVE

FLAMMABLE

POISON

CHEMICAL

DANGER

RASH

SAFE
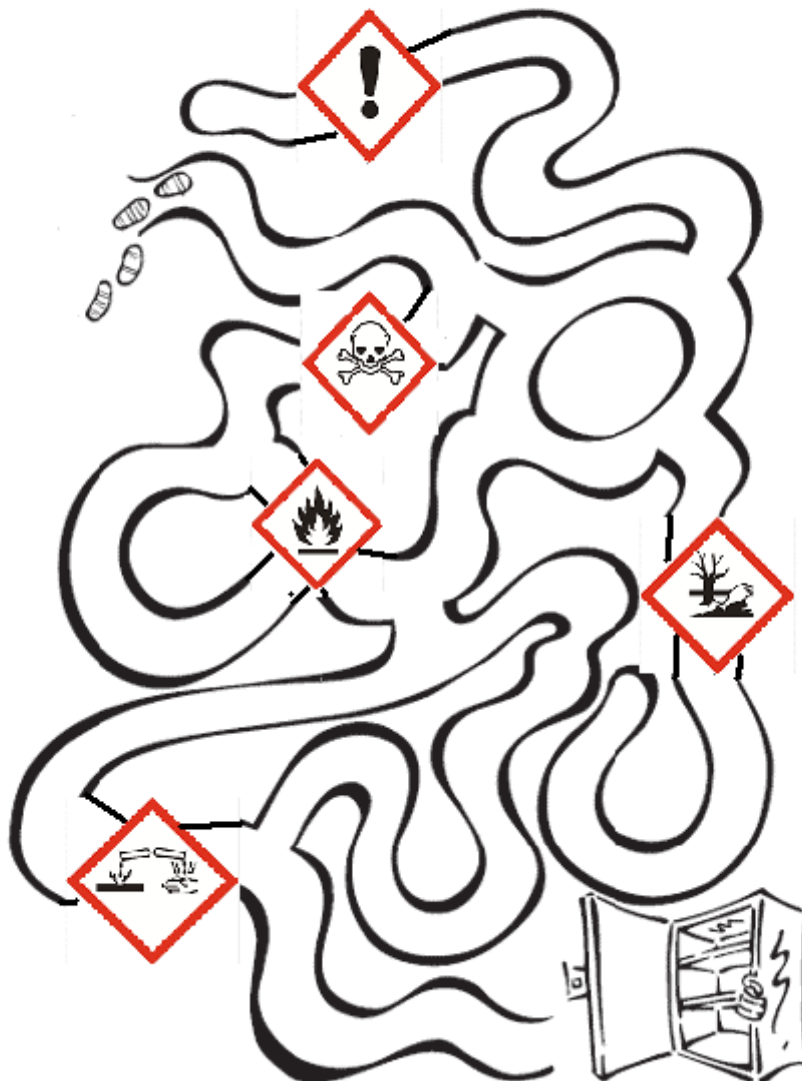
C	W	E	F	A	S	Y	G	H	S
H	H	J	K	L	E	T	G	S	X
E	F	L	A	M	M	A	B	L	E
M	O	N	C	Q	U	P	I	D	R
I	O	I	S	D	A	N	G	E	R
C	G	P	S	T	L	J	B	N	A
A	A	P	O	I	S	O	N	G	S
L	C	L	E	S	N	P	F	E	H
E	S	G	H	K	U	C	B	R	M
Z	C	O	R	R	O	S	I	V	E

Name :

Age :

Find your way to the cupboard avoiding as many of the hazards as possible. Mark your route with a coloured pencil.

(Adapted from Maze game, ToxMystery, Specialized Information Services, National Library of Medicine, USA)

Name :

Age :

|	
	A word that means hurt
	Harm
How hazard labels look now	Hazardous chemical
	How chemical hazard labels will look In the future

Can easily
set on fire

AMMONIA ANHYDROUS
EC Number 231-635-3   EC LABEL
FLAMMABLE, TOXIC AND DANGEROUS FOR THE ENVIRONMENT
Flammable.
Toxic by inhalation.
Causes burns.
Very toxic to aquatic organisms.
Keep container in a well ventilated place.
Keep away from sources of ignition No smoking.
In case of contact with eyes, rinse immediately with
Plenty of water and seek medical advice.
Wear suitable protective clothing, gloves and eye/face
protection.
In case of accident or if you feel unwell, seek medical
Advice immediately (show the label where possible).
Avoid release to the environment, Refer to special instructions/ Safety
Data sheets.

AstraZeneca UK Limited, Macclesfield, Cheshire, United Kingdom.
+44(0)1625 618900

Can poison you
in a very short
of time

Can kill Fish, plants
and birds

Can cause a very
sore, itchy rash

Kitchen Bathroom Shed Garage	
	Can poison you over a long time
Can cause chemical burns to your skin and eyes	Where you can find Hazardous chemicals at home
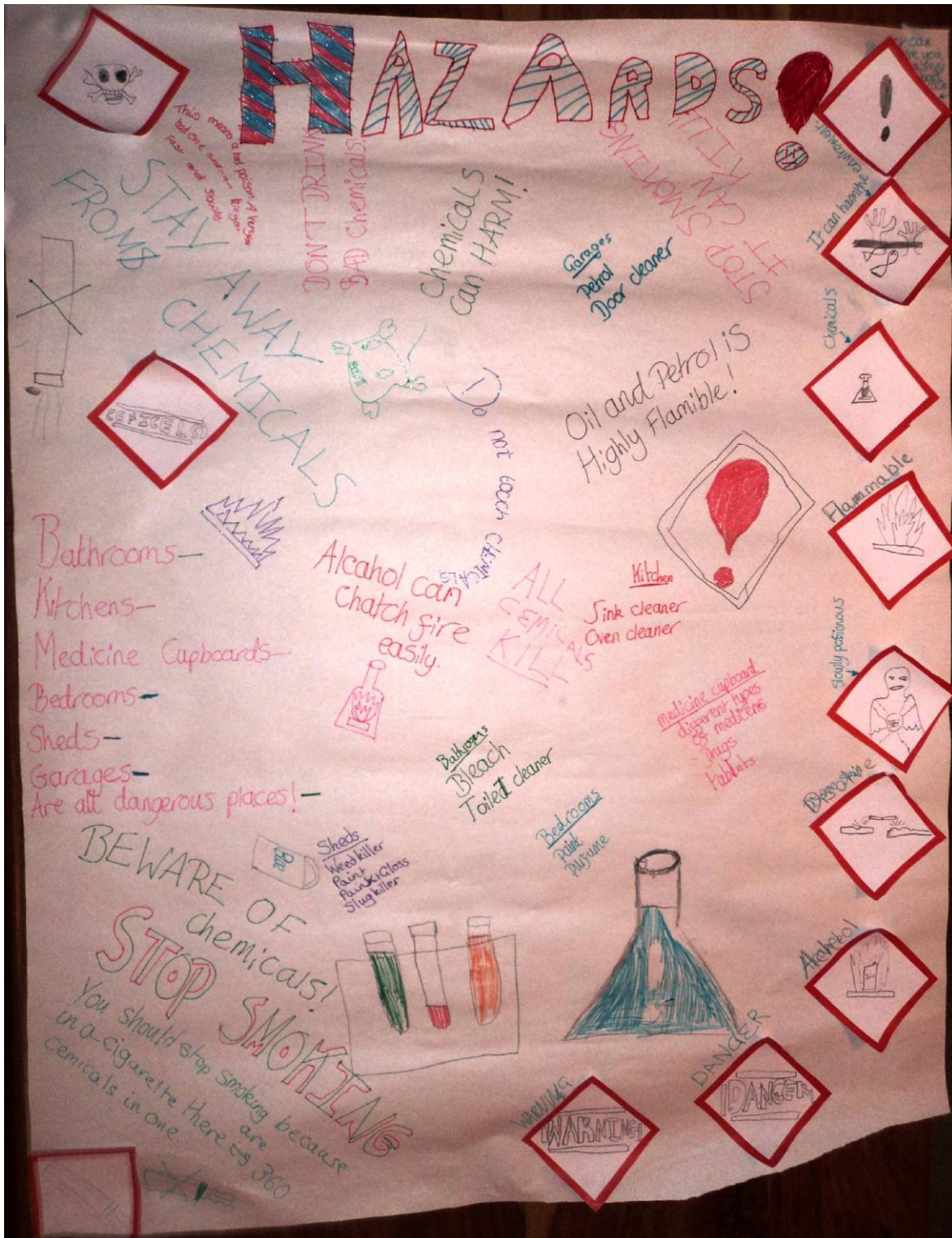
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