Developing thinking with four and five year old pupils: the impact of a cognitive acceleration programme through early science skill development

By

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Abstract

This thesis examines the extent to which a specific learning intervention programme, based on specific early science skill development may increase development in thinking in a particular early childhood sample.

The background literature has focused on Piaget's and Vygotsky's theories of cognitive development as they relate to the intervention programme and the age group of the participants in this research study. The review discusses the need to teach thinking and the relevant literature on the intervention programme is critically reviewed.

This research study, undertaken in and adapted for an Irish primary school, involved a sample of forty four participants aged between four and six years old.

An intervention group of twenty pupils participated in the learning intervention Lets Think!-Early Years programme – based on the theory of cognitive acceleration. The learning intervention programme consisted of fifteen lessons based on the early science skills of classification, seriation and causality. The remainder of the group were the non-intervention group.

All participants underwent three pre and post intervention tests and completed a pupil questionnaire. Local teachers completed a teacher questionnaire on questions relating to the research question and this combined with the researcher's observations recorded in a reflective journal provided the data to be analysed.

A comparative analysis of responses obtained from the above tests, questionnaires and reflective journal, suggest that pupils from the intervention group displayed a greater improvement in their thinking ability in comparison to the non-intervention group, with the factors of gender and age of the pupils having a significant effect.

This finding indicates that a cognitive intervention programme through science may have a significant immediate and positive effect on the rate of the early year's pupil's cognitive development.

Declaration

I hereby certify that this material which I now submit for assessment on the programme of study leading to the award of Degree of Master of Science is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

Signed: ______________________ ID NO:_______________________

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Date:_______________________

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Ethical Considerations

Ethical codes of practice were observed throughout this research undertaking. The requirement of obtaining informed consent from the parents/guardians of potential participants in both the intervention and non-intervention schools, prior to the commencement of the research was the first ethical issue observed in this study.

Consent forms were included in the explanatory letter, which were sent to each pupil in the class. An earlier letter was also sent to both schools' Boards of Management requesting permission to carry out research in the school. Copies of these letters of permission have been included in Appendix F. Parents/guardians gave a very positive response (100%) to their children's participation in this research study.

It was also considered important to ensure that the young participants did not feel intimidated by the research process. All data collection procedures were explained to participants before any data was collected and the series of intervention lessons were referred to as the "Put on Your Thinking Cap" Science Club, which concluded with a presentation of certificates created by the researcher to pupils involved, see Figure (i). An example of the certificate created is included in Appendix B.

Figure (i) Presentation of "Thinking through Science" certificates

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Chapter 1. Introduction to the study

"If thinking is the most fundamental human skill, what are we doing about it?"

(De Bono, 2002)

This chapter will begin with a statement of the research question and associated aims before outlining the structure of the thesis as a whole.

1.1 Aims and Objectives of the Research Study

The research question for this thesis is: 'Can the "Let's Think! Early Years" (LTEY) programme increase the Piagetian levels of Irish children?' In order to answer this question, it was necessary to administer instruments to determine the Piagetian levels of a sample of children in an Irish classroom, conduct a science intervention based on the LTEY programme, and determine the Piagetian levels again. Thus a quasi-experimental study was done based around a 'pre-test – intervention – post-test' structure. Furthermore, a non-intervention group who have not experienced the intervention were compared to the intervention group who did. I hypothesise that the levels will increase more and/or significantly in the intervention group.

The general non-specific aims of this research project are:

- To adapt the LTEY programme to an Irish primary classroom context. If it is found that the LTEY programme does indeed raise Paigetian levels, then it is an important tool in improving the general education of the children in school. However, the cultural / social contexts of where the programme was developed and the point of implementation are different. Thus, the programme needs to be adapted.

- To promote the thinking ability of four and five year olds through the medium of developing early science skills. The LTEY programme addresses specific thinking skills or 'schemata'. It is anticipated that the programme, by addressing specific schemata, will show an improved efficacy in working with those specific schemata.

1.2 The Structure of the Thesis

Chapter One introduces the research question. It sets out the main aims of the study. This chapter also includes an outline of the structure of the research study.

Chapter Two critically reviews literature and previous research into the subject of developing thinking in early years through science. The history, development of and rationale for teaching thinking as part of the present Irish Curriculum is described. The issue of early childhood being an appropriate age to teach thinking skills is also focused on. This chapter also looks at guidelines for selecting a model of instruction of thinking.

Chapter Three focuses on the theoretical foundations behind the selected LTEY intervention model and the practicality of it in the early years classroom.

Chapter Four reviews the research methodology and the rationale for choosing a classroom based semi-quantitative approach to achieve the aims of this research. It describes the particular data collection techniques used during the research process including the conduction of three pupils' tests both before and after intervention, the use of pupil and teacher questionnaires and the researcher's reflective journal. The reasons for choosing these methodologies and the methods of analysis are explained. Chapter Four provides an overview of the learning intervention programme and highlights the methods of evaluating the effects of the LTEY programme. The adaptation of this programme to the Irish Curriculum is also examined. The timetable of data collection is outlined and research issues relating to possible limitations of the study are also addressed. As this study involved individuals, due consideration was given to ethical issues. These have been already highlighted and outlined on page (vii).

In Chapter Five the findings of the study are presented. The data gathered from the pre-intervention and post-intervention testing is categorised and presented in accordance with whether the pupil was a member of the intervention or non-intervention school and displays gender and class details. This segregation of categorised responses into two distinct groups (intervention/non-intervention) was considered necessary if the research question was to be addressed. Post-intervention tests were conducted using the same test materials, protocols and procedures as had been used in the pre-intervention tests. The results of the categorised responses are presented in both graphic and descriptive forms. A critical reflection of the intervention programme is also presented. The final part of the chapter analyses the findings of the Researcher's Reflective Journal (RRJ). Pupils' and teachers' attitudes to teaching thinking are analysed and the advantages and disadvantages of the approach, from their viewpoint are described

The final chapter of the thesis, Chapter Six, examines the link between the research findings and the research question placing the findings in the context of the theories relating to developing thinking through science in early years. The significance of the study for the individual researcher, the school situation, and for the educational community in general is examined. This chapter concludes with recommendations for teachers, schools, policy and further research and limitations of the study are outlined.

This chapter has laid out the rationale for this study featuring the research question, an hypothesis and the aims for this study and an outline of the structure of the research study was provided.

Chapter 2. Teaching thinking-An historical overview

"The ability to communicate through speech and the ability to move beyond the here-and-now through thinking are among the most striking achievements of childhood."

(Das Gupta & Richardson: 1995: vii).

2.1 Introduction

Chapter Two discusses the need to teach thinking and to validate the claim that teaching thinking is a valid and primary aim of education, particularly in the Irish Curriculum. It examines how basic thinking develops and how 'teaching for thinking' might enhance pupils thinking ability by studying some appropriate scientific theories of cognitive instruction. This section also discusses the use of basic science skills as a medium through which we can develop thinking in children. It considers what the appropriate age could be to begin formal instruction in thinking while also making the case for its development in the early year's classroom. The literature review concludes with a look at general guidelines for selecting a model for instruction of thinking leading onto the creation of more specific guidelines for an instruction programme which will achieve the prime aims of this research study.

2.2 Rationale: Making the Case for Teaching Thinking

This section looks at research discussing what the practice of thinking actually is.

2.2.1 The practice of thinking: what does it mean?

> *"Thinking is something that we do when we try to solve problems; it involves processing the information that we have available to us – either from the external world or from within our own memories. Thinking allows us to take things we know or observe and turn them into new ways of understanding."*

The above is the understanding by Adey *et al.* (2001:2) of the meaning of the actual practice of thinking. De Bono (1976) meanwhile distinguishes thinking from knowledge and intelligence. He defines it as "*achieving a desired mental state or result*." He points out that 'thinking skills' encompass "*knowing what to do, when and how to do it, what tools to use and the consequences*."

There is little agreement among psychologists on what constitutes thinking and no one has developed a compelling taxonomy of thinking skills for use in educational programs according to Suhour (1984). Without a doubt, writers describe and classify thinking skills in different ways. Fisher (1990) for example, describes three aspects of skill in thinking: critical thinking, creative thinking and problem solving. In the advancement of these three aspects, he gives special importance to the development of skills like sequencing, classifying, asking the right questions, analysing questions, predicting, rearranging and decision making.

2.2.2 How children's thinking processes develop

Children's thinking processes develop at different rates; some children are better than others at the information-processing activity refered to as "thinking" and can process complex information more quickly, Adey *et al.* (2001:2). They continue to point out that some children "*seem more fluent in their use of language; others have a better spatial sense*" highlighting that there are clear differences in performance even at an early age.

<u>Thinking and Learning:</u>

According to the Collins English Dictionary the term Cognition "is the mental act or process by which knowledge is acquired, including perception, intuition, and reasoning". The LTEY programme (2006:4) defines it as "*the* *process of acquiring knowledge and the ability to make sense of a situation."* Therefore cognitive development is the enhancement of this process. From literature on Cognitive Psychology, it is clear that we have to understand children's conceptual development if we are to help them to learn and that includes understanding how thinking can help children learn.

An important goal of the Irish Primary Curriculum is "*to enable children to learn how to learn"* (NCCA,1999: Introduction:7) and according to Adey *et al*. (2001:9) *"Children who think better, learn better*". Therefore, the curriculum is demanding that we learn how to think better. Adey *et al.'s* findings come from both the theoretical foundations of and the experience from work with older children in the original CASE project for 10 to 14 year olds. This experience shows that "*gains in cognitive development lead to gains in academic achievement*" and children "*are better able to derive meaning from the mainstream curriculum in all subject areas,*" pointing out that enhanced thinking ability transfers to other subject areas allowing for a deeper understanding of all subjects.

Mc Guinness (1993:305) has identified three conceptions of thinking and learning that are directing research and practice in teaching thinking skills. An understanding of these conceptions can help educators teach thinking skills, as they form the foundations of many programmes to teach thinking skills. They are:

1) Thinking as Information Processing.

The concept of thinking as 'information processing' suggests that as we think we are retrieving information from either our long- term memory system or short – term (working memory) system. Input or information from the environment is stored momentarily in the sensory registers where it is assigned meaning. This is known as the process of recognition or perception. From here, recognised information continues to the short-term memory. As human's short-term memory can only hold about seven items of information at a time, information enters the long term memory for permanent storage. Wakefield (1996:405) points out that many neurobiologists maintain that the long-term memory may be limitless but access to the information may be difficult.

The role of metacognition is important in understanding how we think, how we process information received. Metacognition can be described as knowledge about one's own cognition or an awareness of one's own thought processes. Metacognititve skills are monitoring skills which are activated during learning and instruction and enable us to check out answers, or check to see if we have relevant knowledge encoded in our memory, which could be retrieved to aid answering questions or in problem-solving (Gage & Berliner:1992:310). Bloom (1956) in his taxonomy of cognitive goals, values the quality of metacognition, namely the ability to be aware and critical of one's own thought, as a 'higher-order' thinking skill. According to Mc Guinness (1993:311) *"increasingly, the emphasis is on talking about thinking in social contexts - in pairs or groups - rather than solitary learners reflecting on their own thinking."* The learning intervention programme "LTEY" in use in this research study embraces this group work and encourages metacognition as one of its five pillars of cognitive acceleration or to develop thinking in children. Robertson (2006:8) believes that if young children learn to capture their thoughts as they occur, this helps them to be aware that they have ideas. She highlights that the experience of having to think hard in the activities in this intervention programme, provides an excellent opportunity for children to begin reflecting on their own thinking processes.

By developing a child's way of thinking this way, McGuinness (1993:307) maintains it will develop general thinking skills that can be transferred beyond the context in which they were acquired. From the author's point of view, thinking skills can be transferred. He also states that traditionally information-processing approaches have been the major influence guiding research and practice activities to teach thinking skills.

2) Thinking as Making Judgements.

The concept of thinking as 'making judgements' signifies that this is more about thinking philosophically and expressing these thoughts, through the medium of dialogue. McGuinness (1993:310) links this way of thinking to the term 'Critical Thinking'. Halpern (1997:4) regards critical thinking as the "*use of those cognitive skills or strategies that increase the probability of a desired outcome. It is used to describe thinking that is purposeful, reasoned and goal-directed.*" McGuinness (1993:310) maintains that "*Critical thinking is as much an attitude of mind and a disposition to respond as it is a deployment of successful information processing strategies.*" Paul (1987:140) advises teaching critical thinking so that children explain, understand and evaluate their own misconceptions, and thus allowing children to discover and challenge their own self-centred tendencies. Obviously this is a level of thinking too advanced for the egocentric early year's child in this study to achieve; however the building blocks can be laid for future deeper development, through encouraged self-reflection of their work and discussion in the early year classroom.

3) Thinking as Sense Making.

The concept of thinking as 'sense making' indicates that thinking comes about in the struggle to make sense of a question; it is in the struggle to make sense that learners construct their own knowledge and therefore think! This 'sense-making' can arise from some sort of action as in interaction with material, peers and teacher. According to Bruner (1974) the thinking and learning comes about because it is necessary to "*go beyond the information given*" (Cited in McGuinness: 1993:310). Posner *at al.* (1982) suggest that students must feel dissatisfied with their current conceptions before they can change them. This approach to developing thinking is based on the constructivist principles outlined later in this chapter. Driver (1989) and Adey (1992) have put this approach to developing thinking into practice successfully. This concept of thinking requires teachers to become more of a 'mediator' guiding the children with open-ended questions, interrogation and confrontation.

In summary, these three views of thinking and learning are directing current research into creating programmes to enhance thinking skills. Although appearing very deep to be suitable for an early years child, in this particular research study, the learning intervention programme in use to develop thinking in that age group, the LTEY programme, does in fact embrace elements of all the above views at a level they can understand as we will discover in Chapter 3.

2.2.3 How teaching for thinking actually develops pupils thinking ability – The pedagogy of cognitive acceleration

Having considered the way in which children's thinking abilities develop now it would be useful to focus on how these abilities might best be nurtured or accelerated. This process of moving children towards higher levels of thinking through participating in carefully designed activities is described by the "Lets Think through Science" (2003:4) creators as '*Cognitive Acceleration'*. Adey, Robertson and Venville (2001:3) recognised that "*pupils thinking abilities develop with age and experience and…occurs naturally during the course of children's maturation, as they interact with the physical and social world around them."* They stress that we as educators have little control over the physical maturation process but have an immense control over the child's environment, indicating that the creation of a stimulating environment for the development of thinking abilities is the key to cognitive acceleration.

Scientific theories of Cognitive Development

Throughout the twentieth century, burgeoning attempts to create scientific theories of cognitive instruction led to the growth of a number of individual and often contrasting concepts of instruction. Mc Guinness (1993:309) highlighted that the work of constructivist theorists such as Piaget and the Gestalt psychologists stressed the organised nature of knowledge and the role of mental constructions and inventions in acquiring knowledge and developing thinking. Interest in developing a cognitive basis that promotes thinking in learning and instruction was also expressed by theories of associative connectivism and behaviourism such as those of Thorndike in the 1920's and Skinner in the 1950's. As was appropriately summarised by Mc Guinness (1999) from the findings of the review into thinking skills by the UK Department of Education, most attempts to teach thinking are based on some formal examination of the nature of thinking, but what they are all trying to accomplish, irrespective of their specific theoretical foundations, is to develop the person's thinking to a qualitatively higher level.

In view of the fact that an element of early childhood development is the major focus of this research study and that the participants of this sample are aged between four and six and a half years old, it was considered necessary to review a number of theories of developmental processes relating to this age group. The theories of Piaget and Vygotsky were considered most appropriate for this sample, particularly as they were the theories that the LTEY learning intervention programme, in use in this study, were based on. In this way, the link between how children's thinking processes develop and how this can be accelerated by introducing a programme for teaching thinking will become clearer.

The next section of the literature review will outline some of the learning theories put forward by Piaget and Vygotsky. It is widely recognized that there are considerable differences in some of Piaget and Vygotsky's learning theories, for example the role of the instructor in the learning process (Das Gupta and Richardson: 1995:13-15). The aim of this research is not to compare but to present significant elements of the learning theories put forward by both educational psychologists who are deemed to have relevance and application to the development of thinking and science in early childhood learning.

Piaget's Theories Contribution to the development of thinking in Early Childhood Development.

Jean Piaget's (1896-1980) work provides a rich resource for understanding cognitive development. Most of Piaget's studies focused on the same three factors as this research study deals with, those of the development of thinking in children, the early years child and science education. He was one of the first to put forward vehemently, with extensive supporting proof, that children's knowledge and thinking is different in kind from that of an adult, evolving and changing over the years (Bliss: 1993: 20). However St. Paul had made this assumption centuries before Piaget, evident from this eloquent quote from the epistle; "when *I was a child, I spoke as a child, I understood as a child, I thought as a child: but when I became a man, I put away childish things" (*1 Corinthians 13: 10-12). Piaget used his own devised research approach known as the *clinical method* to acquire data which gave him evidence of the above. In this approach, Piaget talked informally to children in an effort to establish their current levels of knowledge and thinking ability. *"He usually devised some interesting activity or task for the child to do as the focus of the conversation but above all he listened to and valued what the children said*" (Bliss: 1993:39). Driver (1989:481) further pointed out Piaget's belief that children's thinking is often significantly different from the views of adults and certainly those of their science teacher. This is important for teachers to note when attempting to develop pupils thinking in the classroom.

Piaget also put forward the notion that intellectual development is not merely a matter of learning *more* things, but of growing into different *ways of thinking* 'schemata' about the observed world. The LTEY intervention programme in use in this research study, provides activities to help children to develop these general 'ways of thinking', which are basically reasoning patterns (schemata) identified by Piaget as general ways of thinking that can be applied in many different situations e.g. "*the schema of Classification describes a general cognitive ability to put into groups objects that have some characteristic in common*" (Robertson: 3).

Piaget is noted for his opinion that children's thinking develops through distinct stages acquired from detailed analysis of children of different ages. Furth (1974:26) declares that Piaget's 'stage' or 'periods' as he called them "*refers to differences in the structure of thinking*". Piaget perceived cognitive growth or learning to think, as a gradual but continual process that he believed progressed over a series of developmental[1] stages. Beard (1980:57-75) states: "*each stage allows the child to handle problems logically that are progressively more difficult. One can only graduate to the next stage along by having mastered the previous one*" (Cohen: 1983:30). Piaget would have categorised most of the participants involved in this study as belonging to the intuitive sub-stage of his pre-operational stage of development, which extends from 4-7 years, with the view to encourage their development at their own pace, into the stage of concrete operations.

Children at the *pre-operational* stage of development, as the term suggests have yet to acquire fully logical (operational) thinking (Wadsworth: 1989:59-73). According to Adey *et al.* (2003:4) the child with pre-operational thinking is not yet able to use simple mental operations reliably e.g. he/she may agree that two rows of beads have the same number, as one bead has been put in one row and a corresponding bead in the other row, but when we push the bead in one row close together and spread those in the other row further apart, she will now claim that there are more beads in the longer row. This may appear rather simple, but for a child of perhaps four years old who is not yet using concrete operations, the

[1] Piaget conceptualised cognitive development as an accumulative process that can be divided into four broad stages:

a) The stage of Sensor-Motor Intelligence (0-2 years).
b) The stage of Pre-Operational Thought (2-7 years).
c) The stage of Concrete Operations (7-11 years).
d) The stage of Formal Operations (11-15 years).

According to Piaget each child *must* pass through the stages of cognitive development in the same order. A child cannot move intellectually from the pre-operational stage to the stage of formal operations without passing through the stage of concrete operations concrete world can look an unexpectedly dodgy place. Piaget used the term 'concrete operations' to describe mental operations involving the world of material things. The ability to classify a pile of objects into sets of different colours and different shapes requires mental operations, which children usually acquire between the ages of four and six. Before this they are pre-operational and are far more likely to use a set of coloured shapes to make patterns and pictures than to classify them (Robertson:2006:3). Adey *et al.* (2003:4) state that *Concrete operations* skills are acquired over many years; those who are able to perform concrete operations successfully will confidently handle situations that require three or four independent pieces of information to be held in the working memory or active 'processing' space of the mind. Some psychologists claim that children in the pre-operational stage can only handle two items of information at once. However, as Robertson (2006:3) asserts, this capacity increases with age and experience and Piaget encourages us to increase this experience to maximise the development of children's thinking into the early stage of concrete operations, from around five years old. Piaget resolutely believed that only pupils, who had reached the stage of formal operations in their cognitive development, had the ability to evaluate scientific hypotheses or solve scientific problems (Brown *et al*; 1997:13).

However Piaget was criticised. Some critics including Cohen (1983) felt that Piaget's method was too clinical and experimental, "*even his own children seem curiously to come to life only as experimental creatures"* (1983:82). Piaget's particular focus on the development of thinking and perception connected to problem solving caused Cohen (1983:83) to further criticize that "*to read Piaget is sometimes to be left feeling that all a child does is to think and think about* *problems"*. However it is widely agreed by researchers that Piaget's theory of stage development has proven valuable in some aspects of education, particularly providing educators with general pointers of what level of thinking children of a similar age are able for, and providing a new way for educators to think about teaching and learning (Bliss:1995:141).

Many educators have used it as a tool for providing guidelines in various curriculum development projects, particularly in science, for example the Science Curriculum Improvement Study, and School Council Science 5-13 (Bliss:1993:32). Many recent science educational series also have their basis on Piaget's stage theories, including the UK's Nuffield Science (1993) Star Science (1993) and the CASE Project publications, the LTEY which is being used in this particular research study. The recent Irish Primary Curriculum's (1999) division of the early science syllabus into two categories – Junior / Senior infants and First / Second Classes can also be linked to Piaget's intuitive sub-phase of pre-operations and his stage of early concrete operations respectively. It must also be pointed out that Piaget's concepts have encouraged a large international trend in the conduction of research into children's understanding in science since the 1970's, as is well reviewed by Driver and Erickson (1983:37-60) although little research is evident concerning early science skill development. He has also inspired much research into the development of the early child by his focus on the progress of their thinking, although Cohen (1983:83) again protests that "*one is struck by the fact that he managed on the basis of a narrow theory of the development of thinking, to convince psychologists that he had a general theory of child development"*. However despite Piaget's theory being criticised in recent years it still remains the dominant theory of cognitive development. Due to

Piaget's vast experience in both areas and the fact that the learning intervention programme used in this particular research programme is based on his stages, it was deemed necessary to review the stages of cognitive development of participants in the immediate study from a Piagetian perspective.

<u>Piaget and Vygotsky: Different views regarding children's development of 'ways' of thinking.</u>

- Piaget's Views

How do children progress from one 'Piaget' stage to another and hence develop their thinking ability? Piaget views three processes as crucial according to Siegler: *assimilation, accommodation* and *equilibration*. "*Assimilation refers to the way in which people transform incoming information so that it fits within their existing way of thinking*" (1991:21-23). Or to put it simpler, Piaget challenged that when a learner encounters new learning, he/she tries to assimilate the new learning experience into what he/she already knows (*assimilation)*.

Wadsworth (1996:14) identified Piaget as having a fourth concept in developing thinking, that of *schemata.*[2]. Now with each new experience, the structures which he/she has already built up (*schemata*) will have to be adapted to accept that new experience, for, as each new experience is fitted into the old, the existing thought structures will be slightly altered (*accommodation*). Siegler describes accommodation as "*referring to the ways in which people adapt their ways of thinking to new experiences" (*1991:21-23), but points out that assimilation is never present without accommodation and vice versa.

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[2] "*Schemata are intellectual structures that organise events as they are perceived and classified into groups according to common characteristics*" (Wadsworth:1996:15)

Driver (1983:147) asserts that Piaget stated throughout his work, that as children learn about their environment they become better adapted to it. He referred to this process as *equilibration,* identified by Siegler as "*the overall interaction between existing ways of thinking and new experience…is the keystone of developmental change within Piaget's system*" (1991:21-23). Piaget proposed that equilibration was the internal mechanism that regulates the processes of assimilation and accommodation, thereby allowing new experiences to be successfully incorporated into existing schemata (Wadsworth:1996:20).

Piaget, according to Siegler, also claimed that equilibration takes place in three phases.

> *First, children are satisfied with their mode of thought and therefore are in a state of equilibrium. Then they become aware of shortcomings in their existing thinking and are dissatisfied. This constitutes a state of disequilibrium. Finally, they adopt a more sophisticated mode of thought that eliminates the shortcomings of the old one. That is they reach a more stable equilibrium.* (1991:23)

These three phases especially help us to understand how we as educators can accelerate the development of children's thinking. Equilibration allows external experience to be integrated into internal structures i.e. schemata; however "*when disequilibrium occurs, it motivates the child to seek equilibrium (to further assimilate or accommodate)"* (Wadsworth: 1996:19). Therefore clearly disequilibrium activates the process of thinking in the child. In order to accelerate the development of children's thinking, Wadsworth recommends that a part of the constructivist teacher's job is to recognise what provides disequilibrium or curiosity for children and how to use that in a valid way while another part is to create disequilibrium where there is none (1996:150). Amazingly a key to promoting the thinking ability of four and five year olds may be in the teacher recognising and encouraging disequilibrium.

The learning intervention programme "LTEY" in use in this research study encourages disequilibrium as one of its five pillars of cognitive acceleration or to develop thinking in children, under the title of 'Cognitive Challenge'. It is a method of questioning children to help lead them into productive 'cognitive conflict' and to produce disequilibrium. The notion of Cognitive Conflict comes from Piaget and as defined by Wadsworth "*is created when one's expectations and predictions, based on one's current reasoning, are not confirmed. It is disequilibrium"* (1996:151). Piaget suggested that experiences that are puzzling to a child, and which cannot be easily explained using existing schemata, can stimulate the development of more powerful schemata, also known as reasoning patterns or Piaget's 'ways' of thinking. Robertson (2006:4) takes from this the implication that if we continually make our demands on children easier and easier, we are actually doing them a disservice. Instead "*we should be devising challenging activities for them, and then helping them to meet these challenges"* in order to maximise the development of children's thinking.

This intervention programme also creates disequilibrium as advised by Piaget by having all its lesson topics of significant interest/curiosity to the mind of a four year old like 'My Family'. This in turn, stimulates conversation as children attempt to communicate their point of view to their peers (social interaction) provoking more disequilibrium and as a result deeper thinking. It is a vicious but productive circle in the development of a child's thinking. This 'Social Construction' is another one of LTEY's five pillars of cognitive acceleration that we will refer to later in this section.

This theory of equilibration, plainly proposes that the desire to acquire new knowledge comes from within the individual as opposed to coming from external factors (Bliss: 1993:28) and that "*all knowledge is constructed by the individual"* (Wadsworth: 1996:21). Piaget can therefore be seen as "*one of the early proponents of constructivism*[3]*, seeing children as constructing their own knowledge through their own activity*" (Bliss: 1995:147). Piaget was an advocate of creating a 'thinking' environment, a learning environment appropriately structured to encourage the constructive activity of the learner.

> *When the child is acting in the environment, moving in space, manipulating objects, searching with eyes and ears, or thinking, he or she is taking in the raw ingredients to be assimilated and accommodated. These actions result in the development of schemata* (Wadsworth:1989:20).

In the present study, most of the lessons of learning intervention were structured so that the participant's ability to think was developed further by the use of concrete materials and ensure that the participants were actively involved in the learning processes. Piaget stressed that mental and physical actions in the environment are necessary for learning and the development of thinking, in that they provide the learner with specific knowledge about the world in which they live. He resolutely insisted, though, according to Bliss that it was the individual's interpretation of the experience that leads to learning and human development (1993:28/29).

- Vygotsky's Views

Vygotsky disagreed with Piaget regarding children's development of thinking,

[3] Both Piaget and Vygotsky were *constructivist theorists. Such theories assume the active building up of cognitive processes like thinking from very simple starting points.*

in that he believed that although children develop some concepts on their own, through everyday experience, they would not develop sophisticated cognitive competencies without instruction and collaboration. He stated that "*Interactions with adults and peers, as well as instruction are essential for cognitive development*" (Das Gupta and Richardson:1995:13). Meadows concurred with this belief and added that "*the child as an individual does not have the resources necessary for the higher level of cognitive functioning but the teaching adult does"* (1993:238). Vygotsky believed that the child had a '*zone of proximal development'*[4] (ZPD) that was attainable only with the help and support of an adult or more skilled person (Das Gupta and Richardson:1995:13). Wadsworth describes Vygotsky's ZPD theory as "*with modelling knowledge by others and social interaction students can learn things they could not learn on their own*" (1989:11).

Wood *et al* (1976:89-100) used the term 'scaffolding' to describe the adult support through which the child can increase current thinking ability to higher levels of competency. This complied with Vygotsky's advised method of instruction for development of thinking. Vygotsky therefore viewed the role of adult instruction as an important, almost essential, aspect of human development and more specifically the development of thinking in children. Meadows' summary of this is that "*the developing thinker does not have to create cognition out of an unpeopled vacuum, but may adopt and eventually internalise some of the cognitive content and processes provided by others*" (1993:239).

[4] Vygotsky's 'zone of proximal development' may be defined as the difference between what a child can achieve unaided in problem-solving and what can be achieved with the help of adults or with the peer group.

‘*Internalisation’* is a core concept in Vygotsky theory in the development of thinking, achieved through social interaction. It’s a process that shapes personal thought; he states that “*the very mechanism underlying higher mental functions is a copy from social interaction; all higher mental functions are internalised social relationships*” (1988:64). To quote Meadows “*internalisation is part of the construction of consciousness through human social interaction*” (1993:240). This quote indicates that children will accelerate their ability to think by the teacher ‘scaffolding’ the learning task so the child can “*internalise external knowledge and convert it into a tool for conscious control*” (Bruner: 1985:25) *i.e.* lead them to a higher level of cognitive functioning or mature their thinking abilities. Wadsworth describes it in more basic terms:

> *When external knowledge, existing in the culture, is internalized (or constructed) by children, intellectual skills and functions are provoked to develop. Thus learning leads development* (1989:11).

Vygotsky’s recognition of the role of social interaction as a developmental force in thinking is central to his theory. Cognitive abilities, including thinking, “*are formed and built up in part by social phenomena…created through interaction with the social environment*” (Meadows: 1993: 236). Developments in cognitive psychology, like Vygotsky’s recognition of the role of social interaction as a developmental force, have encouraged new ways of examining instruction that combine analysis of learners’ mental processes with analysis of interactions designed to assist these processes. As referred to before, the learning intervention programme LTEY in use in this research study encourages social interaction as one of its five pillars of cognitive acceleration or to develop thinking in children, under the title of ‘social construction’. The LTEY programme’s author Robertson describes ‘scaffolding’ or ‘modelling’ learning as of vital importance in maximising children's thinking at such an important stage of development (early years):

> *Initially the teacher demonstrates aspects of the learning process for the children - by questioning, speculating, pondering ideas. Soon the children begin to do this more and more for one another. The teacher may use questions such as, I'm wondering what you were thinking when you did that? What would happen if…? Children quickly begin to use similar types of questions to encourage their peers to express their views and soon become open to the views of others*" (2006:4)

This 'scaffolding' of learning may be seen as a particular requirement at early childhood level where the processes of thinking are just beginning to be enhanced. In this research study the teacher provided most of the 'scaffolding' necessary in the programme of intervention to enable the intervention group to become competent, at a developmentally appropriate level in their thinking and in early science skills.

<u>Piaget and Vygotsky: working together in the acceleration of children's thinking.</u>

Vygotsky's theory of human development may be seen to correspond in some respects with Piaget's stage theory. Both educational psychologists agreed that human development is made up of both continuous and discontinuous stages and that transitions in development are the result of changes in the organisation of mental structures (Das Gupta and Richardson:1995:14). Both Piaget and Vygotsky see children as active participants in their own thinking development, but Vygotsky puts more stress on the important role of social interaction as the 'motor' of developing thinking, "it mediates the child's constructions" (Wadsworth:1989:12). For Piaget, interaction with peers, adults, criticism and discussion, is a source of necessary disequilibrium which contributes to the development of a child's thinking. Regarding the specific role of instruction in the development of a child’s thinking ability, Piaget believed that the influence of instruction was not an important factor although the teacher is required as a mentor. However Vygotsky believed instruction was fundamental to reach the highest levels of thinking, the teacher’s role is to model or explain knowledge and the child then constructs their own. He argued that *“purely abstract levels of thinking are only prevalent in technologically advanced societies which emphasise formal instruction*” (Das Gupta and Richardson:1995:14).

Vygotsky’s theory also contrasts with Piaget’s in terms of the relations between language and the development of thought. For Vygotsky “*acquisition of language from the social environment results in improved thinking and reasoning*” (Wadsworth: 1989:11). However, Piaget saw language as facilitative but not necessary to develop to a higher level of thinking; in his opinion action is more important.

Wadsworth points out that, in terms of using the theories of Piaget and Vygotsky as the basis of a programme to promote the thinking ability of the early year’s child, despite important differences, their similarities are more striking and in many ways their work converges.

In summary, this section of the literature review concentrated exclusively on the links between human development and the development of thinking. It attempted to illustrate the relevance of aspects of Piaget’s and Vygotsky’s human development theories to this particular research study. It is acknowledged that several other factors including language, emotional and physiological factors also exert influence on the development of children’s thinking. It is accepted that several other educational psychologists also contributed alternative cognitive development theories. However, the theories of Piaget and Vygotsky were reviewed because they most aptly described the developmental processes of the participants in this study and, as referred to earlier, particularly as they were the theories that the LTEY learning intervention programme, in use in this study, were based on.

Piaget, as has already been noted was one of the first educators to put forward the theory of constructivism[5]. In this immediate study, the non-intervention group that was not exposed to the learning intervention can perhaps be seen, to advocate Piaget's notion of the individual construction of knowledge /thinking.

The learning intervention programme of this present study can be seen as a strategy advocating Vygotsky's notion of assisting the participants of the intervention group along their zone of proximal development in developing thinking in early science skills.

Other Scientific Theories in the development of thinking in Early Childhood Development.

The challenge for the neo-Piagetian psychologists has been to define the real source of cognitive development in order to help develop the best programme of instruction to develop thinking in the early child. Wakefield (1996:158) remarks that recently, these psychologists have focused on working memory, which can be described as a memory structure that corresponds to consciousness and increases in capacity throughout childhood. Robertson (2006:3) who created the LTEY programme, defines working memory " *as part of our mental system that processes information as it comes in, making sense of it before it is used or*

[5] The theory of constructivism sees the individual as constructing their own thinking/knowledge through their own activity.

stored…Working memory has a limited capacity and can only handle a few pieces of information at a time.”. Neo-Piagetian psychologists such as Case (1991) assert that younger children cannot solve problems that older children can due to developmental limitations in the capacity of the working memory (Cited in Wakefield 1996:186). Some psychologists claim that children in the ‘pre-operational’ stage can only handle two items of information at once in working memory. However this capacity increases with age and experience. Concrete operations require a working memory capacity that can handle three or four independent pieces of information (Robertson: 2006:3). According to Wakefield (1996:186), neo-Piagetians including Case, can accept many of Piaget’s fundamental concepts regarding stage like limitations on complexity of thought, while focusing on memory structure, as opposed to logic, as the source of these limitations. This is also useful in explaining differences in thinking ability between different children and devising activities designed to stimulate the development of thinking.

Wakefield highlights the role of the environment in helping to distinguish novice from expert thinkers, re – emphasising the learning that comes from experience (1996:292). Fisher, Dewey and many others stress that the development of thinking skills requires the ethos of a ‘community of enquiry’ in the classroom. Fisher (1998:25) advises that this is where the teacher takes on a non-didactic role, as facilitator, mediator and participant in discussion; there is support, someone to listen, praise and advise; there is structure, in terms of lesson plans; there is order, a disciplined and anxiety free environment, where pupils feel happy when challenged and in which there is time to reflect, review and revise opinions. As educators, it is our responsibility to create such a classroom atmosphere in order to enhance children's thinking abilities.

2.2.4 The need to teach thinking - Why teach thinking?

The need to teach thinking is not a recent one. Educationalists have requested renewed interest in thinking and problem solving for years. As far back as 1967, Raths *et al.* (1967) criticised the lack of emphasis on thinking in the schools. They noted that "*memorization, drill, homework, the three Rs (and the) quiet classroom" were rewarded while… "inquiry, reflection (and) the consideration of alternatives (were) frowned upon"* (Cited in Carr: 1988:69-73).

There are numerous developments that have contributed to the present day awareness that teaching thinking is vital for the benefit of society in general and is an undeniable prime aim of education. These developments include:

a). A realisation of the changes in society;

b). A re-evaluation of the main educational concerns for life in the twenty first century;

c). The assumption that thinking skills will develop automatically through subject activities;

d). Changing views of intelligence.

Each of these will now be discussed.

a). <u>A Changing Society</u>

There is a growing awareness that society has changed and part of the need to teach thinking has arisen from this change. Society has always experienced changes since the early days of humanity, becoming more complex with cultural, social, economic and political changes. Man has always had to re-evaluate and design new approaches to best deal with these changes and for the general benefit of society. Ornstein (1980) affirmed this by suggesting that the changes in modern society have propelled the pressing need to teach thinking skills:

> *Solutions to the significant problems facing modern society demand a widespread, qualitative improvement in thinking and understanding. In view of the increasing pressures imposed on our society…we need a break-through in the quality of thinking employed both by decision-makers at all levels of society and by each of us in our daily affairs*.(Ornstein, 1980)

In the twenty-first century this view is also applicable to our way of life, which looks for a new range of cognitive skills involving all aspects of intelligence to meet the demands of the changing context. Nisbet (1993: 283) agrees with this view and argues that "*the changing social and economic demands of our modern way of life oblige our educational systems to aim at broader competencies than the traditional basics.*" DeBono (2001) emphasises the need for thinking in a society, which has become increasingly complex, "*the quality of our future is going to depend entirely on the quality of our thinking*". Halpern (1997:1) concurs with this view stating that the need to teach thinking skills is imperative for life in the twenty-first century as we now have the ability to destroy all life on earth. Therefore decisions we make as individuals and as a society, regarding the economy, conservation of natural resources and the use of nuclear weapons will impact on future generations. The pressing necessity on the education system to improve pupils thinking for the benefit of society is clearly highlighted further by Adey *et al*. (2001a:2) who state that:

> "*Society in the twenty-first century makes higher demands of its workforce than ever before. Tasks that used to require thoughtless labour, or repetitive work on an assembly line, are now carried out by machines rather than people. Human beings are being used to perform the functions that only humans can - interacting with other humans…or operating*

> *complex computer-guided systems…The obvious implication for the education system is that we must maximise every child's chance of becoming a good thinker."*

Nickerson (1987:32) is in complete agreement asserting that "*we are now smart enough to destroy ourselves as a species and, unless we learn to be better thinkers in a broad sense we may well do so."* Therefore there is clearly a pressing need to teach thinking skills to better prepare us for the changes of life in the twenty-first century.

b). A re-evaluation of the main educational concerns for life in the twenty first century

Teaching thinking is a valid and primary aim of education

Adey *et al.* (2001a:9) assert from their experience in practical classroom research on this topic that "*a powerful approach to raising academic standards in schools is …to spend time developing general thinking ability: this continues to influence all learning situations for many years afterwards*." They refer to the findings of the original CASE[6] project for 10 to 14 year olds to verify this, which after recording immediate cognitive gains in some students while using this developing thinking programme, further discovered that three years after, those same students achieved "*significantly higher grades than students who had not – not only in science, but also in mathematics and English*" (2001:6).

Whitehead (1932) in his "Aims of Education" expressed the view that "*in the conditions of modern life, the rule is absolute, the race that does not value*

[6] C.A.S.E is the abbreviation that refers to Cognitive Acceleration through Science Education, the research and development programmes largely the work of Philip Adey and Michael Shayer, continuing from 1981to the present, the basis of the LTEY programme.

trained intelligence is doomed." While John Dewey (1966) reminded educators that one of the most important goals of schooling is to improve thinking skills.

Since learning is a consequence of thinking,

> *"…all which the school can or need do for pupils so far as their minds are concerned …is to develop their ability to think"*

"*The traditional educational system teaches children WHAT to think and WHY to think. With the introduction of lessons in thinking, pupils now have the opportunity to learn HOW to think"* states Mizzi (2001) referring to the introduction of De Bono's thinking skills programme in Maltese schools.

With the abundance of information, that everyone from the child in the primary school to the adult on the street has to contend with on a daily basis from media and internet, Halpern (1997:3) insists that knowing how to learn and knowing how to think clearly about this information should form an important part of our education.

Widespread concern about pupils' poor thinking skills has been expressed recently by educators, journalists and the public at large. The American National Assessment of Educational Progress has reported that students show weaknesses in the logical processes required for clear communication. In another American publication, "A Nation At Risk", the National Commission on Excellence in Education noted that students have a poor command of such intellectual skills as drawing inferences and solving problems. Employers, according to Charles Suhour (1984), frequently report that young people lack the ability to think through problems and offer alternative solutions. Several third level colleges have noted with concern the lack of problem solving, decision making processes and critical thinking among their students, which could have been developed in their earlier education. These same skills and others were pinpointed by the Education Commission of the States (US) in 1982 as considered indispensable for the future along with evaluation and analysis, organisation and reference, decision and communication skills. The American College Board's Project Equality Booklet, *Academic Preparation For College*, called for the teaching of reasoning as a basic academic competency, along with reading, writing, speaking, listening and mathematics (cited in Suhour:1984). The need to make thinking skills explicit in a curriculum is emphasised by the 1998 commissioned review and evaluation of research into thinking skills by the UK Department for Education and Employment (Mc Guinness:1998). These highlight the increasing need to teach thinking early on in the primary school.

However, while the curriculum objectives of most schools recognise the need to develop thinking skills in children, few offer any clear suggestions as to how this might be achieved. De Bono (1976:21) concurs with this opinion as he observes that it is clear that teaching thinking skills must be the underlying aim of education and that all else should branch out from this. However he states that the worldwide attention paid to this aim is not matched by any attempt to teach thinking as a skill. In England the National Curriculum Documents (Nov 1998) also recognise the need to encourage children to think clearly, deeply and effectively as the main concern of the central curriculum subjects. It states that "*to be able to think clearly is the first thing needed towards good English.*" However there are no clear explanations about how such thinking skills can be developed methodically.

In an Irish Context

Maximising children's thinking abilities is a valid and indeed essential aim of Irish education particularly primary education. The previous Irish primary school curriculum, *Curaclam na Bunscoile*, Vol.1 (1971:12) stated that the primary aims of primary education are: "*To enable the child to live a full life as a child*" and "*to equip him to avail himself of further education so that he may go on to live a full and useful life as an adult in society"*. This is reiterated in the most recent revised Irish Curriculum (NCCA: 1999b:34) which adds that,

> *the ability to think critically, to apply learning and to develop flexibility…are…important factors in the success of the child's life. The curriculum places a particular emphasis on promoting these skills and abilities so those children may cope successfully with change.* (1999:7)

This clearly indicates that the teaching of thinking is pivotal to the entire development of the child.

The development of higher-order thinking and problem solving is also listed by the Irish Primary School Curriculum as one of its principles of learning, which validates it as a fundamental aim of primary education. "*The child is encouraged to observe, collate and evaluate evidence, to ask relevant questions, to identify essential information, to recognise the essence of a problem, to suggest solutions, and to make informed judgements*" (NCCA:1999b:16). These operations apparently help to nurture the higher-order thinking skills, which the curriculum defines as "summarising, analysing, making inferences and deductions and interpreting". The PCSP[7] in a recent newsletter re-emphasised the fact that teaching thinking is a primary aim of education by highlighting the transfer of these skills across the curriculum,

[7] The PCSP is the Irish Primary Curriculum Support Programme.

> *Higher-order thinking skills are used in all areas of the curriculum, when investigating in science, designing and making in Visual Arts, predicting an ending to a story or evaluating a piece of evidence in history* (PCSP June 2006).

The need to encourage children in primary education to think clearly and competently was further recognised by The *White Paper on Education* (1995:10) in its statement of educational aims as guidelines for policy formation and for inclusion in the daily teaching and learning practices in schools and colleges. It states that there is a need to "*develop intellectual skills combined with a spirit of inquiry and the capacity to analyse issues critically and constructively*" and to "*foster a spirit of self-reliance, innovation, initiative and imagination*". The *Green Paper on Education* (1992:32) in its statement of educational aims reiterated this need:

> *Fostering intellectual development and the attainment of one's full educational potential…Developing a spirit of inquiry for the critical and constructive analysis of issues…Developing expressive and creative abilities to the individual child's full capacity…Providing students with the necessary skills to equip the, for work and to enable them to function effectively in society…Fostering a spirit of self-reliance of innovation and of enterprise.*

Part of the initiative to show the need to teach thinking in the Irish curriculum, originated from a reassessment of the educational priorities for life in the twenty first century and how the curriculum might pay attention to these priorities. The present drive towards "*fostering a spirit of self-reliance of innovation and of enterprise,"* (The *Green Paper on Education* 1992:32) makes a thinking curriculum a necessity. Teaching thinking encourages pupils to think for themselves and equips students with a variety of strategies including observing, evaluating, questioning and predicting and the application of these abilities to a variety of academic and real-life situations.

Another significant reason to teach thinking in the Irish primary school comes, as mentioned earlier, from an awareness of changes in Irish society in the twenty first century, which will require Irish citizens to have a broad range of cognitive skills to deal with the demands of an ever changing and challenging situation. The *White Paper on Education* (1995:10) emphasises that the aim of education is "*to provide students with the necessary education and training to support the country's economic development and to enable them (the students) to make their particular contribution to society in an effective way*". In the "Celtic Tiger" economy of Ireland there is a need for an education system that encourages pupils to use their initiative, to exercise their creative, analytical and practical thinking skills and to be able to respond effectively and with imagination to changing circumstances and situations. If our educational system is to help develop the person, the local area and the Irish economy financially and socially, then developing thinking in the early years of education has an integral role to play in developing such skills as predicting, comparing, evaluating and problem solving.

Clearly the above prestigious documents in Irish primary education identify the need to develop thinking in children as a significant objective of Irish primary education; however it also noteworthy that there are no clear statements among the five documents about how such thinking skills can be developed systematically. The recent 1999 Curriculum in particular while recognising the importance of developing "*higher order thinking and problem-solving skills…summarising, analysing, making inferences and educations and interpreting figurative language and imagery*…" does not offer any greater clarity as to how these skills should be explicitly developed in the various subject areas.

c). <u>The assumption that thinking skills will develop automatically through subject activities.</u>

Does thinking need to be taught?

Piaget's theory has given educators a new way of thinking about teaching and learning (Bliss: 1995:141). Piaget, according to Das Gupta and Richardson (1995:12), argued that Cognitive Development or the development of thinking "*is a spontaneous process. Cognitive structures develop without any direct teaching from adults*." He suggested that this idea is disliked "*because of it's slowness, whereas direct teaching seems desirable because it can speed up development"*. As noted earlier in this literature review, Piaget's theory was based on the assumption that the child's own actions in the world were crucial to development and in this way "*the individual is seen as developing in isolation*" (Das Gupta & Richardson: 1995:8).

Vygotsky had a different view; in his book, he stated that Piaget:

> *assumes that development and instruction are entirely separate, incommensurate processes, that the function of instruction is merely to introduce adult ways of thinking, which conflict with the child's own and eventually supplant them.* (1962:116-117)

Vygotsky's own argument was that "although children might develop some concepts on their own through everyday experience, they would not develop purely abstract modes of thought without instruction" (Das Gupta and Richardson: 1995 :13, 14). Vygotsky believed that instruction is necessary to reach the highest levels of thinking and his stress on the role of the adult as 'teacher' inspired research into the role of teaching in developing thinking. He alleged that only with the help of an adult could a child achieve his *ZPD* as referred to earlier. Vygotsky's advised method of instruction was for development of thinking by "*a* *method of 'arranging experience' rather than didactic teaching*." (Das Gupta and Richardson: 1995:15).

Fisher (1990: vi) points out that there is often an assumption that thinking skills and dispositions will develop automatically through instruction in the various curricular areas. However, thinking skills and dispositions need to be clearly, systemically and explicitly developed within the context of the curricular content areas. Dewey (1956:152) argues that there is not enough recognition of past research into what schools can or need to do for pupils to develop their abilities to think. His definition is that "*thinking is the method of intelligent learning…and rewards mind"*. It is in the opinion of this researcher, in agreement with Fisher, that the teaching of thinking skills should not and must not be left to chance. Fisher (1990:viii) further expands on this opinion by stating that "*Children are often expected to learn scientific, mathematic, moral and aesthetic skills and concepts without being helped to develop the tools of critical, independent and rational thought…learning to think should not be left to chance"*. Clearly thinking skills are the basic building blocks to developing further more complex skills and should be taught to children early in their education.

The teaching methodology and lesson structure of the daily classroom in Maltese primary schools was studied by The Edward De Bono Institute in relation to developing thinking in children and it was discovered that there is a big focus on learning the mechanical skills of the three R's but children are not learning the higher level skills of thinking (De Bono: 2002). De Bono puts the following question to us "*Is it enough to assume that the teaching of the traditional subject matter will produce an improvement in thinking skills?"*(2002). Perkins (1987a:62) agrees and highlights that children although achieving in the three R's are continuously having difficulties with solving word problems in maths, making deductions and writing persuasively. This suggests that thinking skills are not developing automatically through mechanical activities in the basic subject areas but need to be specifically taught. Research indicates that a large amount of time is spent on a daily basis on mindless rote and fact based work while thought and reflection was neglected (Perkins: 1987a:42). A recent Irish report on reading in the primary classroom highlighted that most 3rd class pupils can read a passage and answer factual questions, but they have considerably more difficulty answering questions that require drawing some sort of inference from the passage. They also had difficulty in identifying an author's main points in summarising a passage. This indicates that thinking is not developing instinctively through general curriculum activities and requires a more specialized position in the curriculum for it to develop.

Clearly a thinking curriculum is a necessary and desirable one; there is an obvious need for existing curricula to openly tackle the role of teaching thinking skills and to make clear methods of developing children's thinking skills.

d). <u>Changing views of intelligence</u>

Intelligence and teaching for thinking

Educators in the twenty first century are posed with a quandary: they are supposed to help pupils to perform with intelligence in solving life's problems, yet scholars differ as to *what* intelligence actually is or *how* best to measure it according to Sylwester (1998, 1). As a result, attention is now being directed to ways of raising intelligence through teaching for thinking. Oxford Brookes University maintain that IQ has become less well regarded as a sole or reliable indicator of ability, different kinds of thinking skills have become more highly regarded as indicators.

However, going back again to the question of what actually is intelligence? Synderman and Rothman (1987) found that there was agreement on three abilities or aspects of intelligence; the ability to deal with abstract thinking or reasoning: the ability to solve problems and the capacity to acquire knowledge or the ability to learn (Cited in Gage and Berliner, 1992). Interestingly, these are abilities that are promoted when teaching thinking. Estes (1982:171) fused these aspects of intelligence together in his definition of intelligence as being "*adaptive behaviour of the individual usually characterised by some element of problem-solving and directed by cognitive processes and operations*" (Cited in Gage and Berliner, 1992). This is a further reference to the connection between developing thinking and developing intelligence. Thurstone (1938) regarded intelligence as a function of seven primary mental abilities; verbal comprehension, verbal fluency, number, spatial visualisation, reasoning, memory and perceptual speed (cited in Resnick 1987:2). A number of these abilities are aimed at being promoted in the intervention programme in this research study, suggesting a strong association between developing thinking and developing intelligence, the latter being a primary aim of education.

Anastasi (1986:19) however, suggests that intelligence "*is not an entity within the organism but a quality of behaviour"* (cited in Gage and Berliner, 1992). While Das Gupta and Richardson (1995) state that "*According to Piaget, intelligence influences all acts of thinking - perception, language, number and morality, to name a few"* and reveal that "*he saw the development of intelligence as an evolutionary process"* (1995:7). This is contrary to some psychologists view that intelligence is a fixed attribute which is mostly inherited, which Resnick asserts is an old idea that has come under increasing attack (1987:2). Blagg (1991:2) refers to the work of Vygotsky as one which led to new developments in this idea. The Vygotskyan approach that intellectual development is an outcome of educational experience now prevails over the more biologically - based Piagetian premise. As referred to above, Vygotsky (1978:87) maintains that higher - order thinking is an internalisation of social discussion and that higher - order thinking skills are developed through the medium of language. Although, in Wakefield's opinion (1996:188), the lack of a defined role for maturation remains a weak spot in his theory.

The role of social interaction as an important developmental force in changing a child's cognitive skills is now being recognised alongside language. According to Blagg (1991:6) active learning approaches that intentionally attempt to develop cognitive skills are now being encouraged over a passive acceptance approach to children with learning problems. This signifies that the participative intervention programme used in this study to specifically develop thinking in children is strongly encouraged. Das Gupta and Richardson themselves, perceive intelligence as a social construct, created through social activities, rather than as a fixed entity within the individual. Piaget also believed that the social context was important for development (1995: viii).

Other definitions of intelligence include emotional, social and sensory skills. Even with the lack of agreement about the nature of these aspects of intelligence, there appears to be widespread agreement that intelligence is more than mere brain power and there appears to be a strong element of thinking skills predominant in recent definitions. Changing conceptions of intelligence therefore appear to have fuelled the present awareness that teaching thinking is an important aim of education.

The "*Lets Think through Science*" programme (2003:3) declares that two of the most important features of intelligence are that, a) it can be applied across all areas of academic learning (described as 'general thinking ability') and b) that it can be developed over time (therefore it can be learned), both of which generally are the basis of most cognitive acceleration programmes. Children with a well-developed 'general thinking ability' (see a) above) according to this programme are particularly good at making mental connections, an underlying 'general' intelligence is present allowing easy transfer of knowledge from one context to another. Clearly this suggests that introducing a programme designed to develop children's thinking skills to these children would have maximum benefit to their learning in all curriculum areas as they would have the ability to transfer their application of new ways of thinking to learning other subjects. The acquisition of this ability to transfer learning is a central feature of the Irish Primary School Curriculum. It states that "*one way to judge the effectiveness of learning is to look at the child's ability to apply what he or she has learned in dealing with problems, choices, situations and experiences that are unfamiliar*" (NCCA:1999b: 16). The "Let's Think" programme's developers also make the point that 'general thinking ability' can be developed through education (see b) above) which encourages the belief therefore that thinking can be taught and that the weaker child's 'general thinking ability' can be improved leading to better academic achievement. This proposes that introducing a programme designed to develop children's thinking skills should help maximise the intellectual capacity of both the weak and the able child, which is one of the main functions of schooling. Fisher (1990, 1991: iv) also advocates the improvement of the thinking potential of individuals as he states:

> *Much of education is focused on the achievement of certain basic skills, rather than on the potential that might be achieved. Perhaps our present mental and intuitive capacitates are only a shadow of what they might be. Perhaps it is possible to teach people to be more effective thinkers, to be more intelligent. The movement to teach children thinking skills stems from the belief that thinking can be learnt and taught…*

This belief is reinforced by Oxford 'Brookes' University, who teach that developing thinking skills is an important focus in the education of both gifted pupils and the underachieving able. They highlight that many gifted pupils in different areas of the curriculum have superior thinking skills in common. Therefore they encourage teachers to aspire to develop these skills in their pupils to the best possible advantage as "*research shows that work on thinking skills improves pupils' ability to generalise and to transfer knowledge and skills*." They further point out that work on thinking skills and metacognition in particular, may help potentially able pupils (i.e. the underachieving able) to become able thinkers.

2.3 Teaching thinking in primary schools through early science skill development

2.3.1 Different programmes of teaching thinking

As referred to earlier, although there is widespread support for the concept of a "thinking curriculum" both internationally and within the Irish Curriculum, there is no clear agreement on the methods of pursuing this end. Three main approaches can be identified, two of which can be referred to as the "*infusion* versus *separate*" debate. There are those who advocate teaching thinking as a separate programme, additional to existing curricula and those who believe that it should be infused across all aspects of the curriculum. Nisbet (1993:285) declares that *separate* thinking programmes emphasise a 'skills approach' in order to "*analyse the process of thinking into skills and strategies and provide training and practice in the hope that these will prove transferable*." In contrast, the *infusion* approach adopts methods of teaching to promote thinking by means of a problem-solving approach emphasising the application and integration of knowledge (Nisbet:1993:285).

Separate course for thinking involve programmes which are content-free and give practice in procedures for dealing with practical problems, such as DeBono's CORT material (1976). Infused approaches to teaching thinking involve programmes which blend thinking skills through the content of the subject area being taught. Examples include Sternberg's *Triarchic Theory of Intelligence* (1984). A third model for delivering thinking skills is identified as interventions that can target *subject-specific learning* such as science, mathematics and geography. This is the model used in this particular research study, using The CASE Lets Think programme of developing thinking in early years through the medium of developing early science skills. Mc Guinness (1999) advises that "*whatever approach is adopted, the methodology must ensure that the learning transfers beyond the context in which it occurs*." All approaches to teaching thinking involve a movement away from formal whole class didactic teaching to active group learning, adopting a problem solving approach, making the process of communication clearer and giving learners increased responsibility for their own learning within a framework of support.

The issue of which approach to use has been much debated, however each approach has much to offer to fuel the journey towards developing thinking in children. The 'infusion' approach to developing thinking through early science skills is in use in this study. Raths *et al.* (1967) maintained that "*thinking cannot be divorced from content; in fact thinking is a way of learning content."* (cited in Carr:1988:69-73). Spache and Spache (1986) believed that "*skills taught in isolation do little more than prepare students for tests of isolated skills*" (cited in Carr:1988).

There are many advantages of infused approaches; Nisbet (1993:286) highlights the advantage of the infusion of thinking into the curriculum without having to add an additional subject to an already overloaded syllabus. It also offers a greater likelihood of transfer of thinking skills to other areas of the curriculum as it is skills developed in context. In their report, Atie *et al.* (2001) pointed out that one of the recommendations of the recently published National Minimum Curriculum of Malta was the introduction of Thinking Skills *within* the curriculum. The CASE and CAME[8] projects were aimed at the development of general thinking, using the subject areas as convenient contexts for this purpose, they made no attempt to cover the content of any particular science or mathematics curriculum. The 'Let's Think!' and 'Let's Think!-early years' also aimed to promote thinking skills although their connections with science are indirect.

2.3.2 Why develop thinking through early science skills?

As referred to above, maximising children's thinking abilities is an essential aim of Irish education mentioned in the Irish Primary School Curriculum

[8] CASE refers to the programme 'Cognitive Acceleration through Science Education' (1984-1987).CAME refers to the programme 'Cognitive Acceleration through Mathematics Education' (1993-97), both initially focused on 10 to 14 year olds and were created by researchers at King's College London to promote higher-level thinking.

(NCCA: 1999b:34). Developing science skills is also an essential aim, as one of the general objectives of the curriculum is to enable the child to "*develop and apply basic scientific and technological skills and knowledge"* (1999b:36). The curriculum points out that these skills should be "*appropriate to children of different ages"* (1999b:34). The curriculum therefore realises that "*although individual aims and objectives may appear to focus mainly on one aspect of the child's development, it is recognised that all areas of child development are inextricably linked,"* (1999b:37) suggesting that the curriculum encourages the development of skills like early science and thinking skills together.

The curriculum also, as mentioned earlier in this research, advocates the development of the higher-order thinking skills which bear a marked resemblance to the skills encouraged in working scientifically which involve children in "*observing, asking questions, predicting, hypothesising, investigating and experimenting, interpreting results and recording and communicating results"* (NCCA:1999c: 17). It reiterates that the extent to which children can develop the skills of science will depend on their age. This suggests therefore a natural link between teaching thinking and early Science Skill Development.

Piaget himself used the subject science as the medium through which he both observed and developed thinking in pupils. This promoted Wakefield (1996:186) to argue that "*Piaget's ideas have been widely applied to the development of logic through mathematics, science and social studies, but have not been extensively applied to explain the development of cognitive skills through the language arts."*

The CASE project from which The 'Let's Think!' and 'Let's Think!-early years' programmes for developing thinking evolved from, have themselves preferred to use the curricula area of science as the channel to enhance thinking ability in children. Adey *et al.* (2003) sees developing thinking through science as an opportunity for exploring scientific thinking. He asserts that "*Science is as much a 'way of thinking' as it is a body of knowledge. Focusing on scientific ways of thinking will give pupils a deeper access to the content material*." In his description of the CASE programme, Adey (1999:7) explained that there was a good theoretical reason for using science as the subject to work through, as the schemas "*application to science…is fairly straightforward, and so science presented itself as a most obvious gateway to the development of high-level thinking.*"

2.4 Teaching thinking in early childhood education

2.4.1 The appropriate age to teach thinking skills

What is the most favourable age at which to teach thinking? This is a problem which educators have long grappled. Nisbet (1993:287) suggests that the most appropriate method for teaching thinking will differ at different ages and with individual differences depending on such factors as previous experience, attitudes and motivation. Dewey (1944:102) had a similar view almost fifty years earlier; he viewed the mind as a process of growth, constantly changing, presenting distinctive phases of capacity and interest at different stages, in each individual. He identified three main periods of growth in children, the first stage occurs from four to eight years of age, the second occurs from eight years of age and it is suggested that the teaching of thinking skills occurs at this stage. Dewey distinguishes the third period of growth where primary education ends and secondary education begins. In the researcher's view, Dewey's assertion that development of thinking skills should occur at the primary level, is valid and that the teaching of thinking deserves adequate attention, time and resources at the primary level. However the author tends to agree with Nisbet's belief that any primary school age is appropriate if thinking skills are taught with the appropriate methodology taking into consideration their specific ages.

The Irish Primary School Curriculum (NCCA:1999b:34) establishes that in pursuing the aims of primary education, one of which is to develop children's "*ability to think critically*," the factors of the child's age, intellectual ability and stage of development need to be considered. This suggests that the skills to be developed have to be appropriate to the child's age. "*The achievement of these aims entails the… development of a variety of concepts, skills and attitudes appropriate to children of different ages and stages of development in the primary school."* This statement thereby reinforcing the view, that the appropriate age to develop pupils thinking ability is actually every age in the primary school but to develop skills appropriate to the specific age being taught.

Furthermore the Curriculum encourages the developmental nature of learning, "*having dealt with particular…skills at a simple level, the child should have the opportunity to return to them at regular intervals in order to deepen his or her understanding*" (NCCA:1999b: 14). This proposes that to further develop the child's thinking skills, a programme of teaching thinking should be introduced at various class levels throughout the child's primary education, so that thinking skills can be built upon in a spiral approach.

As referred to earlier, Piaget described particular ages of cognitive development. However Cohen pointed out that Piaget scorned those who wanted to affix an age for each stage "*What was crucial was that the child had to go* *through the stages in a fixed sequence…so that stage by stage, his thinking and his actions blossom until he can reason like an adult*" (1983:30,31). Das Gupta and Richardson reiterate this by declaring that "*Piaget argues that people pass through them at different rates and therefore the ages attached to them are not very important"(*1995:9). For the same reason, Furth recommended Piaget's theory in his Schools for Thinking in the late 1970's because his theory recognised "*meaningful stages in development and at the same time respects the tremendous range of normal variability*" (1975:28) that is, Piaget's theory understood that each child develops their thinking ability at their own level or timeframe . This reinforces the argument that the ages are a proposal rather than a fixed statement for each child. However in spite of this, ages have tended to become affixed to the periods. Piaget's theory of stage development has been valuable in providing educators with general indicators of what children of a similar chronological age can realistically be expected to learn and understand. It is also important to remember that, as highlighted by the Aquarian Teachers Group, a research group at Loughborough University, as well as general stage of development, a great deal must depend on family and school experience too.

The LTEY programme (2006:6) refers "Age five" as being a "window" for cognitive growth as children move from Pre-operational thought to concrete operational thought; it could be an opportune time to accelerate their thinking abilities. This research study is focusing on this transition period. Adey *et al* (2001b) in their creation of the original CASE project, a parallel cognitive acceleration programme, identified another 'window' for increased cognitive development which operates between the ages of 12 and 14 years and showed striking results. Evidence of brain–growth spurts at about 11 in girls and 12 in boys, which may be part of a physiological maturation programme developed to prepare adolescents for the intellectual demands of adulthood, is the theory that Epstein (1990) presents for this age being important. Adey (1999:10) explained why the CASE project targeted this age as being a further critical time for promoting better thinking, "*the main reason is that for the great majority of students this is the age of preparation for formal operational thinking*," yet another transitional stage and based on Piaget's suggestions. Interestingly Adey points out that in their survey "only a small proportion of children actually attained the ages of cognitive development described by Piaget. He implied that this indicated a deficiency in the quality of stimulation provided for the majority of children at home and in school, which he suggested "*should be remediable by providing appropriately designed stimulation at the right ages.*" Therefore knowledge of the appropriate age to teach thinking skills could be necessary in order to maximise their potential.

2.4.2 Why teach thinking in early childhood education? - making the case for teaching thinking in early childhood education

The main purpose of undertaking this research study was to evaluate the extent to which thinking ability can be enhanced in early childhood pupils, as a result of their exposure to a programme of learning intervention based on developing basic science skills. Research has shown that the early years of a child's educational experience are crucially important in the child's developmental experience. Many Irish children begin formal schooling from the age of four and according to the Irish Primary School Curriculum, (NCCA: 1999b: 34):

> *"The rate of maturation and development, and the pace of learning, is greater during these years then at any subsequent period in the child's life. The child's experience of learning in the early years therefore will have a profound influence on later learning."*

Consequently, the introduction of an appropriate programme designed to develop children's thinking skills in this prime time for learning, the early years in school, could enable pupils to benefit more fully from the learning experience that the curriculum has to offer both in these early years and built upon throughout their schooling years.

As referred to above, the LTEY programme (2006:6) refers "Age five" as being a "window" for cognitive growth, which was observed as a result of the development of the earlier "Let's Think!" programme for the development of thinking in five and six – year-olds published in 2001. The authors noticed that some children could be helped by having access to such a programme earlier. Robertson (2006:11) reported the findings of an evaluation into the earlier "Let's Think!" programme as being; children who think better, learn better and advised that in order to set children on this path "*we can engage them in challenging activities in the Foundation Stage so that they have the opportunity to make as much cognitive gain as possible."* Adey (1999:38) insisted that *"potentially the rewards of starting the cognitive acceleration process in the first years of schooling for all of the children's subsequent schooling are enormous."* According to the "Let's Think!" authors Adey, *et al.* (2001a:4), there are theoretical reasons for assuming that the early years of four and five years is a crucial time for promoting better thinking. They state that "*at this age, some children are making the transition from 'pre-operational' to 'concrete' operational thinking, as described by Piaget*" and that a programme designed to develop children's thinking skills as they are at this transitional stage aims "*to give them a boost as they climb the first rungs of the 'cognitive development' ladder.*"

2.4.3 The links between the human development of the early child and the development of their thinking ability

<u>The role of social interaction in the development of thinking in the early child.</u>

Piaget, it must be noted, regarded the interchange of ideas among people or social interaction as a factor contributing towards the early child's development of thinking. This factor may be seen to have particular relevance to this research study. As referred to earlier, Piaget would have categorised the sample of this immediate study as being at the pre-operational stage of development. He categorised pre-operational thinking and behaviour as *egocentric* where the child cannot take the role or see the viewpoint of another. As a result the child never questions his own thoughts because as far as he/she is concerned, they are the only thoughts possible and consequently must be correct. Piaget noted that a child's interaction with others means children are increasingly put into situations where their egocentric thinking might conflict with that of their peers or others. The presentation of conflicting ideas may prove instrumental in leading them to question their own (egocentric) thinking. This in turn, as referred to earlier, may provoke *disequilibrium*[9] and lead to the accommodation of the opinions of others (Wadsworth: 1989:16-17).

[9] *Equilibration* is the state of balance between assimilation and accommodation. *Disequilibration* is the state of imbalance between assimilation and accommodation. When disequilibrium occurs it provides motivation for the child to seek equilibrium to further assimilate and accommodate. Disequilibrium activates the process of equilibration and a striving to return to equilibrium.

The learning intervention in this study involved much interaction between the instructor and the participants in the intervention group. There was much group work, and discussion and debate were actively encouraged as part of the programme. The post-intervention analysis will attempt to establish whether these social interactions have provoked ‘disequilibrium’ and led to the accommodation or development of new thinking abilities in the area of early science skills.

The role of Hands - on Activities in the development of thinking in the early child.

Vygotsky placed significant emphasis on the role of the more skilled instructor arranging or ‘scaffolding’ experiences that would assist the development of the child’s thinking, particularly in the early child. These ‘arranged experiences’ include the provision of hands-on, concrete activities that provide scope for language, thought and motor development. ‘Scaffolding’ techniques including verbal prompts, instructions and demonstrations gradually lead the child to a stage where they feel confident in undertaking activities on their own (Das Gupta and Richardson:1995:14).

Piaget, like Vygotsky, stressed the importance of the provision of hands-on activities in developing children’s learning. Wadsworth asserted that Piaget believed a child could only acquire physical knowledge and develop a higher level of thinking about an object - size, shape, weights and so forth - through hands - on manipulation of the object with his or her senses. This individually constructed knowledge is constructed into schemata. Further exploration by the child on the same object at a later stage, may lead the child to ‘discover’ new physical knowledge about the object. This new knowledge would result in the modification and refinement of existing schemata and thus lead to the accommodation of new concepts about that object and a promotion of the child's thinking ability (1989:21).

2.5 Guidelines for selecting a model for instruction of thinking skills

Despite widespread agreement on the need to teach thinking skills and the availability of a large number of programmes to boost thinking skills in primary schools, no one model for instruction is recommended over another. How does a school choose the right programme, one which is compatible with one's school's and student's needs? Mc Guinness (1999) asserts that the more successful models or approaches for classroom instruction of thinking skills "*tend to have a strong theoretical underpinning, well designed and contextualised materials, explicit pedagogy and good teacher support.*"

Developments in cognitive psychology like Vygotsky's recognition of the role of social interaction as a developmental force in thinking, have encouraged new ways of examining instruction that combine analysis of learners' mental processes with analysis of interactions designed to assist these processes. These are things that have to be considered when selecting a model for instruction of thinking skills.

A number of general issues in contemporary research are identified as useful to aid the search for a model for teaching thinking skills. These include:

- the appropriate age to teach thinking skills,
- the "infusion versus separate" debate and

- the theoretical basis underpinning the programme which you, as researcher, wish to follow.

Sternberg (1984b:47) identified a further range of general guidelines to assist in the selection of programmes to teach thinking. He suggested (among others), a programme that:

- has a solid theoretical grounding and outlines the way it will be taught,
- explains the role of the teacher,
- recognises the importance of metacognition,
- teaches children when and how to use the strategies taught, in order to achieve skill transfer,
- is attractively packaged and
- uses activity-based, discovery learning techniques.

Many of these factors have already been looked at in this literature review and have been taken into consideration when selecting the learning intervention model for this particular research, into developing thinking in the early year's child, through early science skills, in an Irish primary setting.

However in order to achieve the specific aims of this project, the researcher believes that materials should additionally be evaluated in terms of their:

- practicability and usefulness for busy teachers,
- effects on pupils,
- potential for providing cognitive stimulation, while at the same time remaining related to the development of early science skills,
- potentiality of adapting it to an Irish classroom situation,

- possibility for building upon this with a follow on programme,
- provision for teaching for transfer of thinking skills to other contexts,
- suitability for instruction to early year's children, while still
- embracing much of the theoretical foundations mentioned earlier in this literature review, that can accelerate the development of thinking in the early years child.

Despite all the research that has been carried out in the area of developing thinking skills and the variety of programmes to enhance thinking skills on the market, a programme for instruction that is suitable for four and five year old children, that has embraced current research, is difficult to find. In addition to matching the above criteria the following factors from the Irish Curriculum suggested that the LTEY programme for developing thinking in four and five year olds could be an extremely suitable programme to research:

"*It is a fundamental principle of the curriculum that the child's existing knowledge and experience should be the starting point for acquiring new understanding*" (NCCA:1999b: 14) declares the Irish Primary School Curriculum. The focus of the LTEY programme material is the above, based on familiar fairytales, the family, toys, the house etc, all topics the early child can easily identify with. Moreover, *"the curriculum incorporates the use of talk and discussion as a central learning strategy in every curriculum area…thus deepening the child's understanding"* (1999:15) and the LTEY programme uses talk and discussion in each lesson as its main medium of developing pupils thinking. The methodology used in this programme involves a lot of collaborative learning and group work also to expand children's thinking skills, which is advocated by the Irish Curriculum. "*Children are stimulated by hearing the ideas and opinions of others, and by having the opportunity to react to them*" (1999:17). Furthermore different teaching methods are required from those employed normally, when teaching for the stimulation of thinking in the LTEY programme, requiring the teacher to become more of a 'mediator' guiding the children with open-ended questions. This encouraged the use of this programme, as the issue of the use of a variety of teaching methodologies is extremely prevalent in Irish education at the moment. Both the 'Curriculum Implementation Evaluation' (2005) and the 'Primary Curriculum Review' (2005) stated this to be an area in need of development. The Irish Primary School Curriculum also asserts that:

> *To provide learning experiences for the child that are relevant to the challenges of contemporary society, the teacher needs to adopt innovative approaches to teaching…It is important, therefore that the teacher is committed to a process of continuing professional reflection, development and renewal* (NCCA:1999b:21).

Many programmes attempt to teach thinking but few are grounded in a solid theoretical basis as recommended by Sternberg (1984b). The LTEY Programme for developing thinking with four and five year olds however, is a psychological model based on the work of Piaget and Vygotsky. Wadsworth (1989:184) highlighted doubts that could be cast on the application of Piaget's theories of stage development, to the development of thinking in a class situation. He argued that this arose from the acceptance that children develop at different rates and that there are broadly varying potentialities for learning in any group at any given time. However the LTEY Programme appears to allow for this, encouraging and enabling each individual child to aim to improve their thinking skills at their own distinct level.

The decision to choose Science Skills as the curricular area for instruction and infusion was motivated by both my own interest and enthusiasm in and knowledge of science and the active science based classroom methodology used in the LTEY programme. The researcher became aware that the approach to teaching the relatively new Irish curricular subject science was largely didactic through textbooks, particularly with less confident science teachers. This tended to overemphasise analytical thinking to the detriment of other aspects, particularly creative and practical thinking skills. Science naturally lends itself to developing a wide variety of thinking skills, including developing reasoning and critical judgement and this LTEY programme's teaching approach appears to embrace this. This programme could also help further develop the teachers' method of science instruction.

Results from intervention programmes adopting this specific model for older children have shown success in enhancing children's thinking as we will see in the next chapter, and this has helped the author decide on the LTEY programme for review.

2.6 Conclusion to Chapter 2

The above literature review examined what thinking actually is and how it develops; it looked at the link between thinking and learning and how with this better understanding of thinking, we can focus on how to accelerate children's thinking. This chapter went on to study a variety of trends that have contributed to our present awareness that teaching thinking is a primary aim of schooling. Issues such as the changing conceptions of intelligence, an awareness of the changes in society, a reassessment of the educational priorities for life in the twenty-first century, the assumption that thinking skills will develop automatically through activities in the various subject areas have been discussed to highlight the need to teach thinking skills and to validate the claim that teaching thinking is a valid and primary aim of schooling.

Chapter Two has discussed the different approaches available to teaching thinking and focused on looking at the advantages of teaching thinking through the specific curricula area of science. The contentious issue of the most appropriate age to teach thinking skills was examined. The case can be made for the teaching of thinking skills at all levels of education, primary, secondary and tertiary. It is the researcher's opinion that the teaching of thinking skills should occur in the primary school and that the most appropriate method will differ at different ages and with individual differences, such as previous experiences and attitudes. The case was made for the teaching of thinking in early year's education and it was decided that this would be advantageous as long as it was encouraged to be a spiral approach being built upon as the children progress through primary schoo,l as recommended by the Irish Curriculum.

Chapter Two concluded with a discussion of some general critical principles for the selection of a model for teaching thinking skills. These guidelines, taken from Vygotsky, Mc Guinness and Sternberg, influenced the creation of other more explicit guidelines to this particular research study, in order to teach thinking skills specific to the early year's child in an Irish primary setting through the medium of early science skills. The resulting criteria have been applied and influenced the choice of the "Lets Think - Early Years" programme as the learning interventionist programme to be used in this research study.

Chapter 3. An Intervention to teach thinking based on the CASE teaching methodology

"The movement to teach children thinking skills stems from the belief that thinking can be learnt and taught."

Fisher 1990: iv

3.1 Introduction

In Chapter 2 the importance of teaching thinking skills was examined together with how a child's thinking processes develop and how their development may be accelerated. There was a special focus on research pertaining to developing thinking with four-to-five year old children (Junior and Senior Infants) through the medium of developing early science skills. Guidelines were analysed for selecting a model for instruction of thinking skills and based on these, reasons were put forward as to why we chose the CASE based "Lets Think-Early Years" model as our Learning Intervention Programme for this particular research study.

It is the intention of this research to adapt Robertson's LTEY programme (2006) in an interventionist programme suitable for the Irish primary school, which will focus on developing thinking in the field of early science skill development with four and five year olds. Adey explains that "CASE is described as an 'intervention' because it is a process of intervention in 'normal' cognitive development" (1999:14).

3.2 The theoretical foundations behind the "Lets Think- Early Years" CASE model for teaching thinking

LTEY is an innovative and flexible programme, designed to fit in any early year's curriculum that helps teachers to promote children's thinking abilities and has been proven to be effective in the classroom.

- <u>The origins of this initial Programme and the Early Child version of the Programme.</u>

-What is CASE?

The abbreviation CASE condenses the phrase Cognitive Acceleration through Science Education and refers to a series of research and development programmes largely the work of Philip Adey and Michael Shayer, continuing from 1981 to the present, located at the Centre of Advancement of Thinking at King's College, London. According to King's College, Cognitive Acceleration (CA) *"is a method for the development of student's general thinking ability (or general intelligence)*". Originally developed for secondary school science departments, the methods have now been extended to other subjects and to younger children.

The CASE project is well known for its work investigating the possibility of raising general levels of thinking amongst average children aged between 10 and 14 years and academic achievement. *"Let's Think!-Early Years*" grew directly from "*Let's Think!"(*Adey *et al*: 2001) which in turn developed from the original CASE project. It has used the same principle, to develop a set of activities and teaching methods, which promote young children's thinking in an indirectly science context.

According to the Centre of Advancement of Thinking located at King's College, London, where these programmes originated from, if this new programme follows the pattern of previous CASE programmes then "*the lessons learned may benefit pupils and teachers in schools across the country and beyond.*"

- <u>Piaget's and Vygotsky's theories relevant to this study</u>

Sternberg (1987b:47) asserts that any programme to teach thinking skills should be based on a psychological theory of the intellectual processes it seeks to train and on an educational theory outlining the way in which the processes will be taught. The foundations of the LTEY programme are to focus on the development of better thinking founded on a psychological model based on the work of Piaget and Vygotsky and some of the general teaching methods that arise from this model, which are clearly outlined in the manual. Kings College, London, the research base for this programme reports that:

> *All CA programmes are rooted in the cognitive psychology of Jean Piaget and Lev Vygotsky, from which has been derived a teaching approach which challenges student's current level of thinking, which encourages the social construction of knowledge (students making knowledge cooperatively) and which encourages metacognition – students reflection on their own thinking and problem solving processes.*(Kings College Website)

The majority of children in this research study have just started school and are thinking in a pre-operational way. LTEY programme is designed specifically to stimulate intellectual growth through the transition from Piaget's 'pre-operational' thought to early 'concrete' operational thinking. As referred to earlier, some psychologists claim that children in the pre-operational stage can only handle two items of information at once. However, as Robertson (2006:3) asserts, this capacity increases with age and experience and Piaget encourages us to increase this experience to maximise the development of children's thinking into the early stage of concrete operations, from around five years old. The activities in this programme are created specifically to do this. By using help from peers and the teacher, the development of the child's vygotskyian ZPD is stretched and bridged successfully.

Piaget's theory indicates that pupils who have just started school should be thinking in a pre-operational way and intellectual growth should be taking place through the transition from 'pre-operational' thought to early 'concrete' operational thinking from around five years old. Shayer and Adey (1981) have taken these stages and sub divided them into early and late developmental levels, for example the Descriptive 'Pre-Operational' is sub divided into 1A and 1B developmental levels (Table 3.1).

Table 3.1 Piagetian Developmental levels

Developmental Level	Descriptive
1A	Pre-Operational
1B	Pre-Operational
2A	Early Concrete
2A/2B	Mid-Concrete

- <u>The different 'ways of thinking' (schemata) that aim to be developed</u>

Piaget, as stated earlier, implied that intellectual development is not merely a matter of learning *more* things, but of growing into different *ways of thinking* 'Schemata' about the observed world. The LTEY intervention programme, provides activities to help children to develop these general 'ways of thinking', which are basically reasoning patterns 'schemata' identified by Piaget as general ways of thinking that can be applied in many different situations

(Robertson: 2006:3). According to Adey *et al*. (2003) "*if pupils did not develop schemata, they would be condemned to devising a new solution each time they encountered a familiar problem in an unfamiliar situation, whether or not they had solved it before in a different context.*" LTEY has selected three important examples of concrete schemata identified by Piaget as useful at this stage of development in thinking and created activities that will help pupils develop thinking abilities related to these three schemata. These three schemata or 'ways of thinking' underlie a lot of scientific thought and much general thinking as well. They are the schema of:

1. Classification: which "describes a general cognitive ability to put into groups objects that have some characteristic in common" (Robertson: 2006:3).
2. Seriation: which "describes a general ability to put things in order" and
3. Causality: which "concentrates on the links between cause and effect".

Carr (1990) considers '*classification*' as playing a significant role in the development of logical thinking and abstract concepts from early childhood to adulthood. Gerhard (1975) asserts that "*classification skill is integral to vocabulary - concept development and therefore, to reading and retention of information*". For example, young children group concrete objects or pictures in their efforts to form abstract concepts such as 'vegetables', 'vehicles' or 'wild animals' (cited in Carr:1990). While Furth and Wachs (1974) maintain that all classification tasks require the identification of attributes and sorting into categories according to some rule and advocate integration of classification activities into content areas (they mention science as having a natural link) as being crucial (cited in Carr: 1990).

- <u>How the LTEY programme aims to stimulate the development of thinking abilities: the five pillars of cognitive acceleration</u>

The LTEY programme, which can be used as an intervention programme, comprises 15 enjoyable and stimulating activities, each of which takes 20 to 25 minutes to complete.

The approach used in the LTEY programme to stimulate thinking in children, interestingly, follows a similar approach as suggested by Fisher (1998) to motivate critical thinking. He recommends presenting a stimulus, listing questions for discussion, facilitating and reviewing the discussion, while extending the enquiry through games and finally evaluation and assessment.

Taking the above detailed Piaget-Vygotsky research on board and understanding pupils type of thinking, the "Lets Think- Early Years" programme, has designed activities that use five main drivers of cognitive acceleration. That is five conditions, identified by LTEY, that work together to maximise the intellectual growth of pupils. They have been referred to separately in part one of this section, but together are known as 'five pillars of cognitive acceleration'.

1. <u>Concrete preparation:</u> refers to the preparation phase before the challenging activity is presented in which the language and materials of the activity is introduced
2. <u>Cognitive conflict- cognitive challenge:</u> This comes from Piaget's notion of cognitive conflict as explained earlier "*where the children must*

experience difficulty for the activities to fully achieve their aim" (Robertson:2006:4), the phase where the stimulating challenge is provided.

3. Social Construction: This comes from Vygotsky's earlier explained belief that much learning takes place between children in a group, but this process needs to be well-managed by an adult resulting in an extension of the child's 'zone of proximal development. *"'Scaffolding' or 'modelling' learning is of vital importance. Initially the teacher demonstrates aspects of the learning process for the children-by questioning, speculating, and pondering ideas. Soon the children begin to do this more and more for one another"* (Robertson:2006:4).
4. Metacognition: Vygotsky and Piaget both advocated this principle, that cognitive development is helped if children are consciously aware of their own thinking and are helped to develop the ability to evaluate their own thinking. At any stage, in each activity the teacher is recommended to encourage this in the LTEY programme.
5. Bridging: This means "*linking the kind of thinking that is being developed in a particular LTEY activity to other times when that type of thinking could be useful"* (Robertson: 2006:8) *e.g.* when focusing on classification the teacher should highlight when it is used in maths at any time in the activity.

Aims and objectives of this programme

This programme aims to help four – to-five year old children, some of whom have just started school, to develop their general ability to think by developing the general 'ways of thinking' (schemata) that are important for success in all subject areas, and are especially useful in science and mathematics. Focusing on scientific ways of thinking according to Adey *et al. (*2003*)* "will give pupils a deeper level of access to the content material."

This programme also aims to provide the setting and the intellectual and emotional environment to persuade young children to talk, discuss ideas and share with each other, i.e.the "thinking environment' referred to earlier that so many psychologists recommend. The children find out through the activities apparently that sharing ideas encourages more ideas to emerge and there does not have to be only one correct answer to a problem.

- Teaching Style Required

Sternberg (1984b:47) advocates that any programme to teach thinking skills should make explicit references to the role of the teacher in developing thinking skills. The LTEY programme has constant references and guidance as to how the teacher becomes the 'mentor' guiding thinking.

The Irish Primary School Curriculum promotes learning through guided activity and discovery and the "*importance of the teacher in providing the most effective learning experiences for the child are central to the curriculum*" (NCCA:1999b:15).

Fisher (1990) suggests that to develop thinking, teachers need to give pupils opportunities to practise such critical thinking skills as estimating, evaluation, classifying, justifying and reasoning. Teachers should also, he believes, be encouraged to describe what they do when they exercise these skills and to evaluate their success.

As referred to earlier, the role of the teacher is integral in so many ways in the development of children's thinking. The creation of the 'thinking classroom' where the child is actively involved in the learning process, the teacher recognising and encouraging disequilibrium by introducing cognitive conflict and managing social construction are only some of the ways according to Piaget that the teacher contributes to the promotion of thinking in his/her classroom.

> *It is obvious that the teacher as organizer remains indispensable in order to create the situations…what is desired is that the teacher cease being a lecturer …his role should be that of a mentor stimulating initiative and research.*(Piaget:1973:16)

Vygotsky recognised the teacher's role as essential in the development of the child's thinking. He encouraged the teacher "*to arrange experience for the child, sensitively scaffolding trials and questions within a perceived zone of proximal development*" (Das Gupta and Richardson:1995:16).

Researchers at Kings College, London maintain that the secret of the success of the CASE programme lies in the pedagogy – that is the way that the teacher uses the materials. For this reason they consider that effective use of cognitive acceleration (CA) methods depends heavily on the teacher. "*Teaching for the stimulation of thinking may require different teaching methods from those employed in your normal work*" (Robertson: 2006:14). The programme recommends a shift in philosophy "*from being a 'caring' teacher, anxious to ensure that children receive all the help they need, to one who sets difficult problems, allows the children to struggle for a while and gives them more responsibility for finding their own solutions"* (Robertson:2006:14). The teacher is encouraged to become a 'mediator', questioning, observing, prompting, ensuring each child experiences some level of cognitive challenge In each activity, "*throughout each of the five pillars, the questions the teachers use are vital. It is important to ask the children challenging questions that encourage explanation and reasoning"* (Robertson: 2006:7). The teacher is encouraged to keep the focus of the reasoning on the schema of the lesson (Classification, Seriation or Causality).

The advantages for the teacher themselves are immense; teachers can get immersed into the expositional style of teaching very easily and can come to see content as merely a set of details to be learned, rather than as an opportunity for exploring thinking. LTEY sets out to redress this balance showing teachers a new way of working despite being hard work. Furthermore, teachers that are particularly unconfident with the subject of science, can see this programme as a chance to develop pupil's early scientific thinking, with its structured step by step support and guidance.

- <u>This programmes link with the Irish Early Years Curriculum.</u>

It is apparent that the method of learning during the activities of LTEY corresponds totally to the underlying philosophy of the many Irish early years curricula in which investigating and exploring through speaking and listening is promoted e.g. in the infant geography strand unit of "The local natural environment" (NCCA: 1999a:26) "*the child should be enabled to observe, discuss and investigate water in the local environment"*. The LTEY activities claim to also "*help children's speaking and listening skills, their collaborative work with others and their understanding about how best they may learn*" (Robertson:2006:13) which is the foundation of the Irish early years curricula.

Furthermore the teacher's concern of where this programme would fit in a busy curriculum is answered by its author Robertson (2006: 13):

> "*The Lets Think! Early Years activities have been designed to fit any early years curriculum. They are designed to develop thinking; they will also help to develop children's speaking and listening skills, their collaborative work with others and their understanding about how best they may learn.*"

However, although this programme's general methodology appears to be easily adaptable to the Irish classroom, Fisher's (1998:4) suggestion, of the creation of a 'thinking circle' could be included in this research's adaptation of the programme instead of selecting a group of four children at a time as recommended by LTEY.

3.3 Research evidence of the benefits of the CASE teaching methodology

Due to the fact that the LTEY programme was only recently published, few research-based evaluations have been carried out. Notable, is the original study of CASE@KS1 by Adey *et al.,* (2001) which showed improvement in Piagetian levels in children in an inner-city context. Cattle and Howie (2008) evaluated the CASE@KS1 programme in the rural context and found improvement but not as prominent as the earlier Adey *et al*., (2001). Furthermore, Cattle and Howie (2008) did not use the same instruments as Adey *et al*., (2001).

According to Mc Guinness (1999), the CASE programme, which is directed towards scientific-type thinking, is one of the most successful and well-evaluated programmes. Adey and Shayer (1994) point out that the original CASE programme for 11-14 year old pupils, succeeded in raising pupil's grades in GCSE examinations (on average 1 grade) not only in science but also in English and mathematics, two to three years after the programme had been completed. The Department for Education and Skills (England and Wales) through their Standards website reinforces this opinion by stressing that this work of Philip Adey and Michael Shayer at Kings College London in developing pupils thinking "*has perhaps the best research and most robust evidence of the impact of thinking skills in the UK.*"

In May 2000 an evaluation of the "*Let's Think!"* materials showed that children who used these activities made significantly greater improvements in cognitive development than the matched control groups (Robertson: 2006:10). These included improvements in a schema that was not part of the *Let's Think!"* programme, demonstrating there had been "transfer beyond the schemata addressed", suggesting that these activities genuinely improve children's general ability to think. The findings also demonstrated that children, who think better, learn better, "*they are better able to derive meaning from the mainstream curriculum in all subject areas"* reports Robertson (2006:11).

Clearly from these findings, the most effective approach to raising academic standards in schools is therefore to spend time developing general thinking ability as this continues to influence all learning situations for many years afterwards. Furthermore, these positive findings from research on previous CASE based programmes, encourage its use in this particular research study as an intervention programme to accelerate children's thinking ability.

However, researchers at Loughborough University have stressed that it is important to note that, the effort put in by teachers and pupils into using a thinking programme like the above, may seem to have little or no immediate effect. "*It may be only years later that the effect is shown, and then it shows typically over a* *wider area than that in which teaching was given"* (Aquarian Teachers group). In the same article the pupils in the Headstart project for pre-school education in the USA showed practically no advantage in the primary school only later. As mentioned above, the original CASE programme also didn't show immediate effects but did so years later and in other subject areas as well as in the science through which thinking had been developed.

Leo & Galloway (1996) questioned the validity of the work of Adey and Shayer (Adey and Shayer 1990, Shayer and Adey 1992a, b) in suggesting that children for whom no improvement was reported in CASE intervention studies were ignored. Results published from the Cognitive Acceleration through Science Education (CASE) project suggest enhanced cognitive development and science achievement for between 25% and 50% of children involved; other children showed less or no improvement when compared with control groups.

Leo & Galloway (1996) are correct to question whether for children failing to respond to CASE techniques, an appropriate theoretical explanation should be provided. Leo and Galloway (1996) further suggest though that further understanding of the underlying psychological processes involved in children's learning might help teachers to utilize CASE techniques for the benefit of a greater population of children. They believe that a theoretical model of motivational style "illuminates" CASE findings and provides a missing theoretical framework which helps to explain them. Adey (1996) in response points out that overall, the CASE framework does work and whether a motivational style can be used to explain the positive aspects of CASE, nonetheless, CASE does provide a means for improvement for the majority of children.

Jones and Gott (1998) have also raised a number of issues to do with the differences in the results of the schools involved in the experiment, suggesting that "the school analysis raises more questions than it answers linked to overall differences in organisation, support and motivation" (p.762), which Shayer (1999) refuted by claiming that overall results of CASE in schools confirms the findings of the original experiments.

3.4 Conclusion to Chapter 3

Chapter 3 has focused on the theoretical foundations behind the intervention programme LTEY in use in this research study. It examined the origins of the programme and briefly outlined LTEY's application of aspects of Piaget and Vygotsky's human development theories to its activities, created to develop thinking skills in early childhood pupils. The theories of these educational psychologists will be consulted later, when attempting to provide insight into the findings of this immediate research study. Chapter 3 focused on the general 'ways' of thinking that the LTEY programme claim to develop and examined the methodology through which this programme aims to develop thinking abilities in the early year's child. A few aims of the programme were observed and the style of teaching recommended for this programme was detailed.

This literature review, in general, has noted the lack of documented research based on developing thinking in the field of early childhood science education. Often reports appear to focus on second level pupils rather than early years children. This immediate research study will attempt to fill the gap in research by undertaking a specific research study based on the above exclusively with early childhood participants.

Chapter 4. Research Methodology

"Remember also that each time one prematurely teaches a child something he could have discovered for himself, that child is kept from inventing it and consequently from understanding it completely."

(Piaget: 1983)

4.1 Introduction

In Chapter 1 the objectives of the study were outlined and the rationale for choosing a classroom based, semi-quantitative project. This chapter describes the data collection techniques used during the research process and the methods of evaluating the effects of the intervention programme, LTEY, will be given. Details will be given on how this programme was adapted to the Irish Curriculum and the timetable of data collection outlined. Issues relating to the limitations of the study and ethical considerations are also addressed.

4.2 Research Methodology and Design

This research study was designed to test the main hypothesis that it was possible to accelerate the cognitive development of young children through an intervention programme based on early science skill development. The primary purpose of this research was to evaluate the implementation of a series of lesson plans and a particular learning approach (taken from the LTEY programme) that aim to develop general levels of thinking through early science skills, to four and five year olds. This purpose required the adaptation of the lessons for use in an Irish primary school setting and the assessment of their impact on both a child's thinking ability and acquisition of early science skills. The lesson plans were refined and reflected upon, strengths and improvements were noted and suggested in order to help ensure some durability and transfer of learning to other academic areas and real-life situations.

The sources used for research data and reflection included:

- Pre-intervention and Post-intervention testing.
- Pupil questionnaires
- Teacher questionnaires
- Researcher's reflective journal (RRJ: Appendix D)

4.2.1 Research settings and subjects

This research study was undertaken in two rural primary schools in the north-west of Ireland. The study focused mainly on the intervention group[10] of the sample. This group, the researchers own class, consisted of an entire mixed class of junior infant and senior infant class pupils. The intervention group size was twenty, eleven of whom were junior infant pupils, while the remaining nine were pupils in senior infants. The importance of matching the intervention and non-intervention groups at the outset of any intervention research programme was stressed by De Vaus (1991:35). Therefore much time and effort was spent on finding a non-intervention school that evenly matched the intervention school in relation to variables which could be manipulated, for example, age and gender. The gender of this sample was mixed; ten females and ten males. The variable of gender was fairly evenly distributed over the two classes, for example, junior infants: six girls and five boys. The non-intervention group for the study were taken from a neighbouring school where participants had similar social background, academic

[10]In the context of this dissertation the term *intervention group* will refer to participants exposed to the learning intervention programme. The term *non-intervention group* will refer to participants involved in the study but not exposed to the learning intervention programme.

abilities and previous science skill experience. It is acknowledged that no control could be exercised over variables such as personality difference between the two schools. Such variables could have an impact on the findings of the study. Table 4.1 displays a summary of the age, gender and class distribution of the total participants. The sample size remained stable throughout the research study as no child withdrew their participation for the duration of the research programme.

The ages of the participants ranged from 4.0-6.5 years. Over 50% (n=23) of the total participants were five years of age. All participants were attending the first or second year of their formal primary education.

Table 4.1 The Research Sample: numbers of participants

School	Junior Infants		Senior Infants		Total
	Girls	Boys	Girls	Boys	
Intervention	6	5	4	5	20
Non-intervention	8	5	4	7	24
Total	14	10	8	12	44

All members of the intervention group enjoyed discussion and activity-based schoolwork such as physical education, drama and nature study. Science skill development activities, involving active participation were, therefore, considered highly appropriate educational activities to be undertaken with the group.

All data pertinent to the research study was collected in the participant's regular classroom setting by their class teacher apart from one of the tests which required the researcher to travel to the non-intervention school. It was considered important that the very young participants were familiar with the instructor and the environment in which the research work would be undertaken. Data was, therefore, collected at the end of the first and during the second term of the school year. The learning intervention programme was also undertaken in the regular classroom setting with the intervention group for this reason.

Two schools were used in this study, one as a non-intervention and the other as an intervention school. The LTEY programme was introduced as a learning intervention programme to the intervention school as the only variable changed and then the results were compared to those of the non-intervention school where variables were kept constant. The basis of the analysis was formed from i) scores from the non-intervention and intervention school pupils on the test instruments, along with ii) pupils, teachers and administrator reactions to the programme.

4.3 Data Collection Techniques

Winter (1989) notes that the purpose of data collection is to gather information to tell us more about a situation that we usually know as practitioners and recommends that this is best achieved by a combination of procedures. This was done by having both qualitative and quantitative data, which are outlined below.

4.3.1 Quantitative data

Pre-intervention and post-intervention testing

Assessment instruments were specifically designed to determine how students performed relative to the particular programmes' instructional goals. There were two types of assessment instruments used: (a) tests to determine Piagetian levels and (b) science content tests.

(a) Pre/Post tests specifically designed for cognitive acceleration programmes concerned with Spatial Awareness and Conservation respectively (transfer tests) were cognitive tests administered to determine the Piagetian levels of the children. Spatial Awareness and Conservation are thinking skills, i.e., schema ("ways of thinking") themselves but as they are not included in the schema in use in the LTEY programme, the researcher chose these tests to provide an opportunity to measure the extent to which thinking skills developed in the main activities were transferable into a situation requiring different thinking skills but also because the tests were appropriate for the age-groups concerned. Since Spatial Awareness and Conservation were two of the pre- and post- tests, the absence of intervention activities relating to either of these schema would allow any change in general cognitive development in that area to be assessed distinct from direct learning effects resulting from the activities.

The Spatial Awareness Test was designed by Michael Shayer and is based on the work of Piaget. The fact that pupils draw their answers, and that Shayer has used this test in completing research with young children, confirms the appropriateness of this test for the early year's age group in use in this research. The spatial awareness test sought to establish the pupils thinking ability with another thinking skill / schema not developed in intervention. Shayer (2001) states its function as being "*to investigate the relationship between the optimum Piagetian level at which a pupil can function and the understanding of science which he or she can achieve.*" Participants were asked a series of questions pertaining to imagining and recording where items would be if they were moved a certain way. This test also assessed children's ability to predict positions taken by liquid levels (horizontal) and plumb-lines (vertical) in different situations. It provided an opportunity to measure the extent to which thinking skills, developed in the main activities, were transferable into a situation requiring different thinking skills and as a way of measuring pupil's piagetian level for comparison and analysis purposes.

A copy of the test, the data collection sheet created by the researcher and the marking system is included in Appendix A. Figure 4.1 illustrates the simple equipment used to carry out this test while Figure 4.2 shows the data collection recorded by one of the pupils.

Figure 4.1 Equipment used for pre-test 1

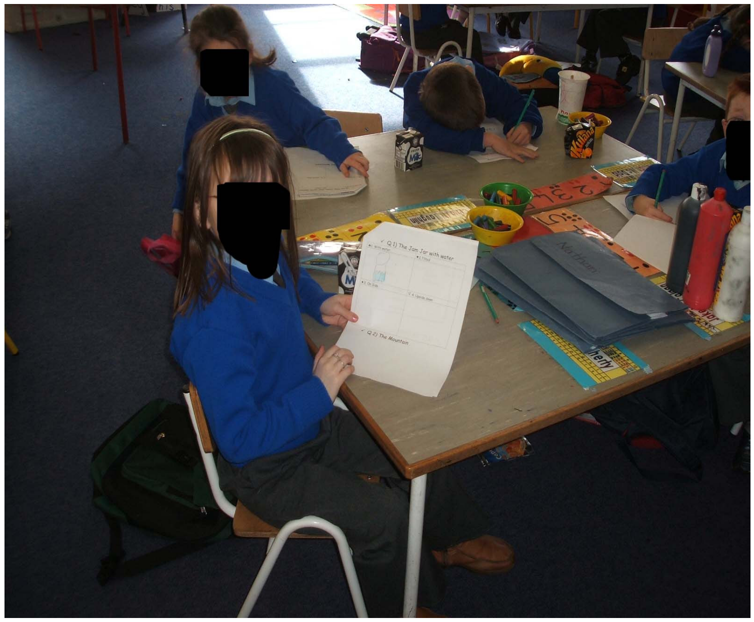

Figure 4.2 Intervention group undergoing post test 1

The Conservation Test test was sourced from the author of the LTEY programme Anne Robertson (pers. com.), who used it in her initial research for the programme. The "Conservation test" explored the randomly selected pupil's perception about the conservation of number, quantities of liquids and solids and weight, to provide an opportunity to measure the extent to which thinking skills developed in the main activities were transferable into a situation requiring different thinking skills. Because the conservation test was administered to one child at a time, a randomly selected one–third sample of children from each school were chosen for the test. The researcher did attempt to balance the gender and class location composition of the sample and it is shown in Figure 4.3 and 4.4. A copy of the test, the data collection sheet created by the researcher and the marking system is included in Appendix A.

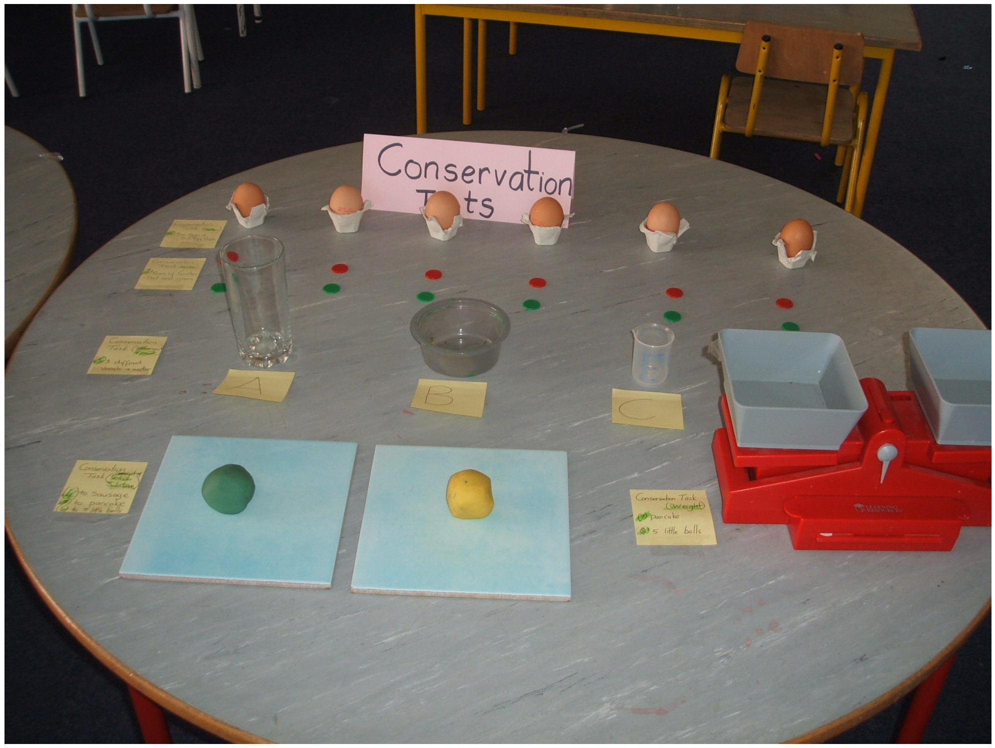

Figure 4.3 Layout of equipment for pre-test 2

Figure 4.4 Explaining post test 2

(b) A pre/post-test "Scientific Skills Test" was created to assess the pupils "Scientific thinking" (direct test). The LTEY programme of intervention aims to enhance early science development in the intervention class. Test 3 was prepared by the researcher and validated by independent individuals in the field of education by means of successfully trialling it in their own similar classrooms. The scientific skills test was created purposely to assess the pupils "scientific thinking" (direct test), the specific three scientific schema developed in the intervention activities were assessed in this test to determine the direct learning effects resulting from the activities. This test was important to determine whether the LTEY programme as an intervention helped develop pupils "Thinking Skills", and improved the pupils "Scientific thinking " in the specific areas/schemas of:

- Classification: describes a general cognitive ability to put into groups' objects that have some characteristic in common. Robertson (2006:5) highlights that identifying criteria for belonging to a set, identifying similarities and differences and explaining their thinking can be difficult for young children.
- Seriation: describes a general ability to put things into order.
- Causality: concentrates on the links between cause and effect.

These are the particular science skills focused on in the LTEY programme and an improvement in these therefore would be an indication of a parallel improvement in pupils "thinking skills". This test also independently places demands on pupils "thinking skills". Therefore, the scientific skills test also sought to establish the extent to which the intervention class exhibited increased understanding in the science schema of classification, seriation and causality compared with the remainder of the sample, the non-intervention class, who were not exposed to the learning intervention.

Eight challenging questions were designed to assess if any improvement had been made in pupils "Scientific Skills" and "Thinking Skills" as a result of undertaking the LTEY programme.

- Questions 1, 2, 3 are based on assessing the skills of Classification.
- Questions 4, 5, 6 are based on assessing the skills of Seriation.
- Questions 7, 8 are based on assessing the skills of Causality

Each question becomes increasingly challenging to the pupil. This test was created paralleling the LTEY programme, assessing each specific area/skill intended to be developed.

The researcher found it difficult to create a good balance between questions being "too easy" or "too challenging" , to make them appropriate for the different ages ranging from a "young" four year old to an "old" six year old as you might have in a typical Irish Junior and Senior Classroom. The questions/ directions are all read out by the teacher. Each question is outlined in Table 4.2. The answers to these questions are included in Appendix A. Pupil undertaking pre test 3 is shown in Figure 4.5.

Table 4.2 Question Format for Test 3

	QUESTION TYPE	AIM	SCORING	
1.	Sets	To assess classification under 3 variables -size (big/small) -shape (circle/square) -colour (yellow/blue) as seen in Figure 4.1.	12	3Q x 4
2.	Odd One Out	To assess classification; items with a common property.	12	4Q x 3
3.	The House	To assess classification; furniture into appropriate room.	12	6Q x 2
4.	Length	Sequence question based on length.	12	4Q x 3
5.	Weight	Sequence question based on weight.	12	4Q x 3
6.	Growing Up	Sequence question - Baby to Grandad.	12	6Q x 2
7.	What Moves Me?	Causality question - ‘push’ versus ‘pull’.	12	6Q x 2
8.	What Happened Next?	Causality question – Result of a particular action.	12	4Q x 3
		Front Page Data	4	/100

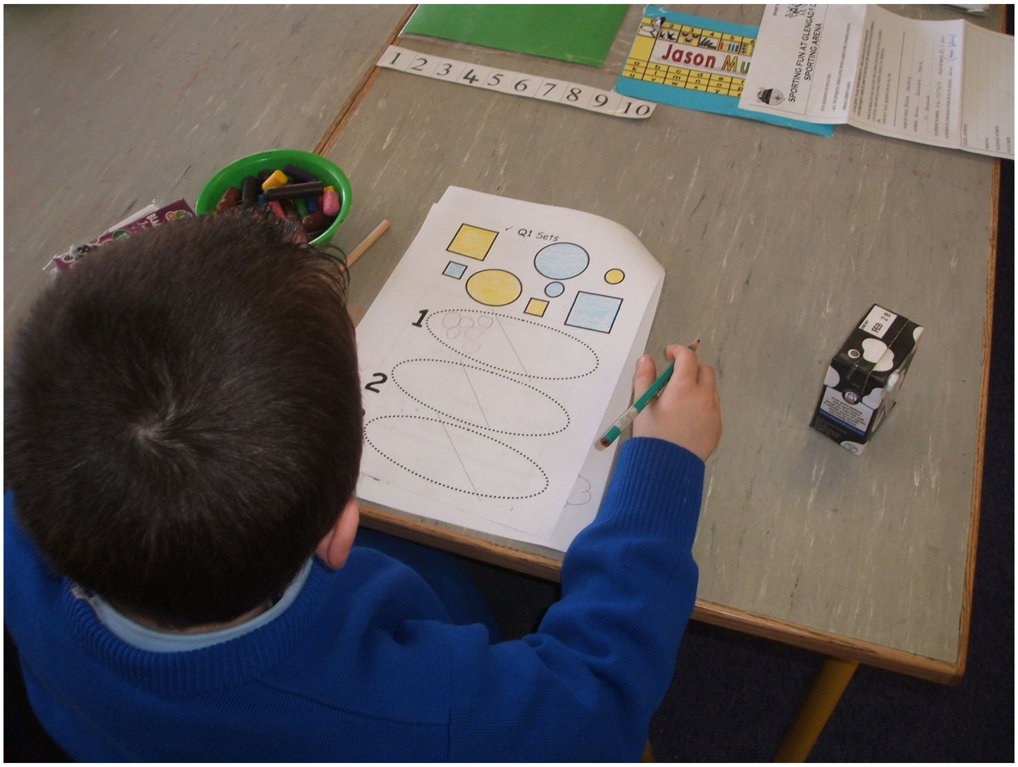

Fig 4.5 Intervention Group undertaking Pre-Test 3

4.3.2 Qualitative data

(a) Student / Teacher perception questionnaires

As part of the evaluation at the end of the intervention programme, the views of pupils and teachers regarding teaching for the development of thinking through science skills were sought. Questionnaires were chosen as the most efficient way to collect this information from teachers and pupils and to compare both the non-intervention and intervention schools. This was the qualitative area of the classroom research, where qualitative responses were obtained to specific predetermined questions. Hopkins (2002) and Mc Kernan (1991) have noted that questionnaires are a good method of providing feedback on attitudes and on class work, are easy to administer and follow up, and provide direct comparison between groups and individuals. Extensive preparation is needed to develop questionnaires, however analysis can be time consuming and children may not produce honest answers, particularly if their ability to read is not yet fully developed, as was the case in this early years study. To counteract these disadvantages every effort was made to assure children and teachers that there were no 'right' or 'wrong' answers to the questions and the researcher was interested in their honest opinions. The teacher administering the pupil's questionnaire supplied help in the reading of the questions to the weaker children. Analysis of the questionnaires was facilitated by the small number of respondents in each case.

As recommended by Borg and Gall (1979), the first step in constructing the questionnaires was to clarify the objective: what they were to achieve. Two types of questionnaires were used in this study, a pupil questionnaire distributed to both intervention and non-intervention school pupils and a teacher questionnaire distributed to a random sample of local practising teachers who were not aware of the specific focus of this study. The general aim of the questionnaires was to use these as a quick and simple way of obtaining information, opinion and attitudes from both pupils and teachers by asking specific questions to pupils and teachers pertaining to developing a programme of thinking skills in the classroom. The more specific aims of each questionnaire will be detailed below.

Pupil Questionnaire

The Pupil questionnaire was structured very simply to make it accessible to children of such a young age. Both a blank and a completed copy of the Pupil Questionnaire have been included in Appendix B. The use of happy / sad face motifs, picture clues and a science cartoon character aided this, although teacher guidance was also required due to the pre-reading ability of some children. Hopkins (2002:117) reiterated this that "*It is important, particularly in the primary grades, to be relatively unsophisticated in the structuring of the questions…With younger children it is often more profitable to use a happy face as the criterion response to questions."* As advised by Hopkins there were generally only two choices for any question and the different options were illustrated with appropriate pictures in each case. The questionnaire was kept to a maximum of three pages, the questions followed a logical order, and each question was of a similar layout to allow the pupils to familiarise themselves with the process. The questionnaire was piloted with pupils of a similar age in a similar school, to check the language level and language was appropriate. This resulted in certain changes of terminology and layout as documented in Appendix B where the final questionnaire can be found. Pupils tested had very little or no prior-experience of science. The questionnaire was re-distributed after the Intervention programme was carried out with the intervention class and directly after the non-intervention group teacher taught a series of 'textbook' expositional style science lessons to her class. The purpose of this questionnaire was to investigate a sub aim of this study, which was to assess if the children enjoyed the science lessons of the intervention programme.

Assessing Pupil Enjoyment

The researcher felt that it was important to investigate if this programme initiated the pupils into "Science as a subject" in an enjoyable way, as it is widely acknowledged that children's first impressions of a subject area generally last.

Questions 1, 2, 9, 10, 11, and 12 particularly pertained to discovering if this science skill intervention programme is beneficial in contributing to children's enjoyment of early science skills. The non-intervention group's answers served as a comparison.

Assessing Teaching Methodology

The teaching methodology dictated by this programme in developing pupils thinking skills was also assessed by this pupil questionnaire. It helped evaluate whether this type of methodology, that is group discussion and creating cognitive challenge with the teacher as a mediator, appeals to young children and helped us as educators decide if it would be a better method of teaching science to pupils in general. Questions 3, 4, 5, 6, 7, 8, 12 were relevant to this area. Again the non-intervention group with its experience of the didactic science teaching methodology served as a comparison.

Teacher Questionnaire

The teacher's questionnaire was distributed to seven practising mainstream teachers from four local schools, teachers of all ages and levels of experience. The research sample details are displayed in Table 4.3. Both a blank and a completed copy of the teacher questionnaire have been included in Appendix C. It was what Bell (1993; 83) refers to as an 'opportunity sample' rather than a 'random sample', where any teacher available and willing were surveyed and Bell advises that we realise the limitations of such data. However the researcher feels that the sample used in this study was representative of the general teaching population with its combination of different age groups and gender.

Table 4.3 The Teacher Questionnaire: Research Sample

Years Teaching	Females	Males	Total
0-5	2	0	2
5-20	2	0	2
Over 20	1	2	3
Total	5	2	7

The main aims of the teacher's questionnaire were to establish:

- a relevance for a need to introduce a 'Thinking Skill Programme' in primary school; (Question 5B,5C)
- to help with the recommendations as regards specific ages or classes or subjects to introduce the programme if recommended (Question 5D);
- to give an insight into the experienced teachers' understanding of
    - how to develop pupils thinking processes, (Question 5A);
    - what defines pupils "thinking", (Question 1);
    - their level of experience with a cognitive development programme (Question 5E) and
    - the importance of developing pupils thinking skills (Question 4);
- to establish if developing thinking skills is a recent issue or has it always been there (Question 2);
- to discover which subjects make the most demands on pupils thinking skills or in which curricular areas the child with enhanced thinking skills would benefit the most (Question 3).

The teacher's questionnaire used a combination of question styles, from the use of open question types as in questions 2 and 5 where according to Youngman (1986 cited in Bell, 1993:76) responses can "*produce useful information but analysis can present problems*", to the use of more easily analysed structured questions. The latter included a simplified 5 point Likert-type rating scale in question 4, ranking responses for questions 1 and 3, a category question in part (d) of question 5 and several yes/no option questions. Over-wordiness, jargon and leading questions were avoided and the length was limited to three pages to ensure user friendliness. It was decided not to include a note at the beginning of the questionnaire defining the term "thinking skills" in the particular research context as it may confuse and prevent honest answers. Instead a new question (question 1) was created to help teachers come to a general understanding themselves, in the particular research context (Piaget's "Ways of Thinking" rather than the vernacular meaning of "thinking") of what "Pupils Thinking Skills" refers to and thus answer the rest of the questionnaire accordingly. The questions followed a logical order. The questionnaire was piloted before being administered and this piloting resulted in a change to the phraseology of one question and the inclusion of an extra question, which is also noted in Appendix C.

(b) The researcher's reflective journal (RRJ)

The RRJ, (see Appendix D), contains recordings of the researcher's observations, reflections and incidental anecdotes of pupils' activity, noted during testing and the intervention programme. As critical reflection on the impact of the implication of the intervention programme in the intervention class was required, the RRJ was an essential component. Mc Kernan (1991) notes that the use of reflective journals is useful as they help collect data on a continuous stream of events and this allows for a more complete picture of the research situation and ensure the generation of a sounder hypotheses. The researcher as a practising teacher has observed that at this young age, most children need the concrete representation to help them think and aren't very good at bridging from concrete to pictorial representation, which is required in the written tests in use in this study. Therefore observing pupils at work with concrete materials and recording their cognitive achievements in the RRJ was considered to be a beneficial method of collecting data.

The basic aim of the RRJ was to get a general indication acquired through teacher observation, of whether pupils thinking can be improved through following a structured developing thinking programme. This was gathered from the teacher's observations of pupils thinking activity during each intervention lesson in the intervention classroom only. The Primary School Curriculum advocates this as a suitable method of skill assessment. "*Teacher observation, discussion and questioning of children during practical tasks allow assessment of the performance of skills"* (NCCA: 1999d: 102). It recommends that this is carried out through "*informal observation of practical tasks in science"* and "*will involve the teacher in taking an active role in the learning situation. Through open-ended questions the teacher can gain an insight into the children's…use of process skills"* (NCCA: 1999d: 101). The RRJ adopted this technique and recorded these observations in an attempt to acquire a more personalised knowledge of the development of the pupils thinking during the intervention lessons. Mc Kernan (1991) believed that observational methods are naturalistic, facilitate varied time sampling and can record non-verbal behaviour, but it can be difficult to quantify the data. He recommends research methods like the RRJ as he states that they can provide clues to issues of group dynamics and other important features that many other data collection instruments are not subtle enough to pick up.

The researcher created a follow-up worksheet for each LTEY lesson plan for the intervention pupil's worksheet, both a blank and a completed copy of each have been included in Appendix E. It was felt that there were already sufficient sources for research data however these worksheets served to reinforce science conceptual learning rather than to assess development of thinking skills, as "*written records, drawings and reports of investigations…rarely supply the teacher with the information required about the level of skill used and the way in which children work*" ((NCCA: 1999d: 102). However the researcher did gather some useful opinions from the pupils while they were carrying out the worksheet activities which were recorded in the RRJ.

> "*The connected "Painting" Follow-up worksheet confirmed that over 75% of the class had learned what makes a shade darker and lighter through experimentation and did successfully subconsciously prompt some healthy discussion on classifying colour. "The darker blue could belong to the purple family also" remarked one participant*." Appendix D (RRJ, P.5)

Other objectives of the RRJ were self assessment by the teacher on how they taught using the new teaching techniques required by the LTEY intervention programme. McNiff (2002) emphasised the importance of the practitioner reflecting on their own practice, in order to grow in understanding. Through keeping a weekly detailed record it also hoped to assess whether the teaching style used in the intermediate programme benefited pupils in a wider sense, e.g. their social skill development, and to ascertain whether or not the particular teaching methodology used appeals to young pupils – the enjoyment factor! If this were so, then it could help educators realise this as a good method to teach science to young pupils.

4.4 The Learning Intervention Phase

The learning intervention programme implemented in this study consisted of fifteen, thirty minute lessons from a structured programme (LTEY) aimed at presenting cognitive challenge to 4 and 5 year old children and accompanying follow-up worksheets for each lesson individually created by the researcher, that were undertaken with the intervention group involved in the research study. The fifteen worksheets and examples of completed ones are included in Appendix E. A key feature of the process used in this intervention phase was that it should provide opportunities for children to engage in discussing and tackling problems together (social construction) and in explaining their thinking (metacognition). A list of the lessons and the specific scientific schema to be developed in each is displayed in Table 4.4 while Table 4.5 indicates a general plan of a lesson undertaken in the learning intervention. The theory that children can only acquire complete accurate knowledge of objects through first-hand exploration of phenomena was observed in this study. All participants had individual, first- hand access to manipulating concrete materials like sand, toys and brightly coloured picture cards in the 15 lessons of the learning intervention programme.

Table 4.4 List of lessons and corresponding scientific schema to be developed

Lesson Number	LTEY Activity	Early Science Skills/Schema		
		Classification	Seriation	Causality
1	Colourful Flowers	√	√	
2	Where do I live?	√		
3	What do I eat?	√		
4	My Senses	√		
5	Castles at the Seaside		√	
6	At the Seaside	√		
7	Mixed-up Stories	√	√	
8	Where are my Toys?	√		
9	How do my Toys move?			√
10	Holes			√
11	My Family: Who are we?		√	
12	My Family: Sort us Out!	√		
13	My Family: Enjoying Ourselves	√		
14	My Family :Our Birthdays	√		
15	My Family: We Watch T.V.	√		

Table 4.5 General plan of a Lesson from Learning Intervention

Purpose	Each lesson has a specific schema to develop(Classification, seriation, causality)
Materials	The LTEY kit supplies the brightly coloured resource cards.
Teaching Approach	The five pillars of cognitive acceleration (explained in chapter 2)
Introduction	There was an initial '*concrete preparation'* in which the situation, apparatus and any unfamiliar words and phrases were presented. The difficulties become apparent at this stage as attempts were made to find a solution. (Pupils discuss this in their Socratic groups) '*Cognitive challenge and Social construction'* All the pupils were engaged in constructing a new understanding. '*Metacognition'* may occur at this stage.
Activity	Often Metacognition follows the activity when pupils articulate what they did to solve the problem, what they found difficult and how they overcame the difficulties.
Conclusion	Finally there was a ,*bridging,* phase when the teacher presented other situations or asked questions designed to encourage 'bridging' in which the children apply the reasoning they used to put things in order in a new situation.(this could also occur at any stage in the lesson)
Follow-Up	Worksheet created by researcher.

4.4.1 Adaptation of learning intervention programme to the Irish Curriculum

This programme was devised from the U.K. based LTEY programme along with the infant education section of the 1999 Irish Primary Science Curriculum. The LTEY programme had to be adapted for the Irish context and to suit the ages (generally 4 to 6 years) and Irish multi-class context (junior and senior Infants) for this research study. Generally the LTEY programme is a standalone package in itself; however for this study it was decided to adapt it slightly to introduce other recommended techniques for developing thinking to help the pupils enhance their thinking abilities. Adapting the role and teaching style of the teacher was central to adapting the LTEY programme to the Irish curriculum.

Role of the teacher in adapting the programme

Central to both the LTEY learning intervention programme and the Irish Primary School Curriculum, is the principle that the primary role of the teacher is to stimulate thinking and encourage active participation in the learning process. "*Your role becomes that of a 'mediator' asking open questions that progress children's thinking without providing them with answers"* (Robertson: 2006:14). The researcher recorded in the RRJ following the first lesson, that "*My new role as the Mediator listening, observing, giving prompts, asking open questions to encourage each child to experience some level of Cognitive Challenge was challenging for me as a teacher"* Appendix D (RRJ, P.4).

Costa (1991:195) identifies four teacher behaviours that encourage, maintain and improve pupils' thinking in the classroom;

- structuring the classroom,
- questioning,
- responding and
- modelling.

I endeavoured as the researcher to incorporate these behaviours into the learning intervention programme LTEY in an attempt to further enhance pupils thinking skills.

Structuring the classroom

The LTEY programme promotes a teaching plan that involves dividing the children into groups of four where the programme is taught to a separate group each day. Due to the generally multi-class structure of Irish Infant Classrooms and the lack of teaching assistants to work with the rest of the children the practicality of this teaching structure was deemed impractical. Therefore in order to adapt this programme to facilitate a whole class teaching style instead of the grouping approach recommended by LTEY, the layout of the classroom was changed. Two large tables were placed together at the back of the room for the "Put on Your Thinking Cap" Science Club as the researcher felt this layout would best promote the strong discussion and group work element of the lessons. This new classroom layout is illustrated in Figure 4.6.

Figure 4.6 New classroom layout

In order to further create a climate for cultivating thinking, attention was also devoted to <u>grouping structures</u> within the lesson to optimise the stimulation of thinking. Given the individual needs and abilities of pupils, there was a need for a variety of organisational patterns. Some pupils prefer working in groups, others on their own. Some children seem to require a lot of help and encouragement, others less so. Sternberg and Wagner (1982:51) reported that less able pupils seem to prefer highly structured situations with a lot of direct help, while more able pupils seem to prefer less structured situations. Johnson & Johnson (1985) state that pupils working together in cooperative groups used more higher-level reasoning strategies and greater critical thinking skills than pupils working competitively and individually. Therefore a variety of grouping structures are necessary and were used in these intervention lessons to enable pupils to become actively, meaningfully and purposefully involved in the learning process and enhance their thinking abilities.

Opportunities were provided to allow students to work individually on solo tasks and co-operatively, in pairs and teams on collaborative problem solving such as planning without being constantly 'spoon-fed' by the teacher. The model I used was that of the Socratic model (Mc Kernan: 1991:171) which involves the creation of small groups with four to six members. In this study there were generally five groups of four which can be seen in Figure 4.7. The group leader in each group firstly repeats the question posed by the teacher in the whole class discussion for the groups to consider. The researcher felt it necessary to assign the term "Director" to the stronger person in each group who had responsibility for leading, allowing him/her only to ask questions to stimulate the discussion within their small group like *"Who is the oldest in the cards?"* but not move any of the cards, in order to encourage the shyer child.

The groups then used the concrete or pictorial material to deliberate and form a position, then report back their findings publicly with a different child appointed as reporter each time to ensure development. The teacher, as facilitator, moved from group to group prompting, offering scaffolds, inviting students to comment on their progress and to describe the steps taken thus far, to note any areas of difficulty that they encountered and to explain how they overcame these obstacles on a very basic level. Due to their young ages this procedure took a few lesson sessions to become practice. The researcher noted that in lesson 1 that “*It took a while for the children to get used to the fact that they were being encouraged to talk… they were happy to be “fed” the answer. I may have expected too much open discussion from this early stage and had to do almost too much ‘prompting’”* Appendix D (RRJ, P.4).

Mc Kernan (1991:175) puts forward that “*The movement from the whole class group to smaller cells allows for a group dynamic to ensue. Socratic groups are motivated to discussion because of the’ ‘rehearsal’ in the small group.”*

Figure 4.7 So-called Socratic Model of grouping

Opportunities for whole class interactions were incorporated into my adaptation of the learning intervention programme i.e. in listening to and taking part in simple demonstrations, discussions and debates. At all times the work and progress was carefully monitored by the teacher and recorded in the RRJ. The teacher's role included acting as a facilitator of learning to encourage students to really think and to reflect on what they have learned and to coach where necessary. The researcher recorded that an important adaptation of the LTEY to whole class instruction, was the introduction of pupil instruction on social skills necessary and a list of do's and don't s created to achieve the programmes aims mores fully. These are listed on page 5 of the RRJ along with the following comment: *"I needed to establish the mode of working that the children will need to get used to in order to give them the best possible chance to develop their thinking ability in the following lessons or it could be a waste of time"* Appendix D (RRJ, 5).

Questioning

Although the questioning style was carefully designed in the LTEY programme, additional questioning was required in the whole class situation to allow every child an opportunity to discuss. Careful attention was paid to the various levels of thinking in designing the syntax of additional questions, questions emphasising such cognitive objectives as describing, identifying, imagining, predicting, recalling, comparing and contrasting were included. Questions that led to the application and evaluation of the information in extra concrete child friendly activities were also included. According to Costa (1991:195) "*Application invites* *students to think creatively and hypothetically to use imagination, to expose or apply value systems and to make judgements."*

In a further effort to develop the thinking disposition of metacognition in addition to that set out in the LTEY programme, pupils were encouraged to ask their own questions throughout the session. From her own experience as a teacher, the researcher has found this activity to be an extremely beneficial learning activity as it appears to help pupils sharpen their thinking and understanding of the material at hand. The researcher also helped students to be alert to metacognitive occasions by reading from a chart displaying the metacognitive questions "What are you doing?, "Why are you doing it?" and "How does it help you?" Only certain children should be at a developmental level to be able to acquire this thinking disposition. Finally pupil's inclination towards metacognitive behaviour was promoted, by valuing and rewarding the behaviour when it was displayed.

Responding

Response behaviours according to Costa (1991:199-200) are "*the actions that teachers take after a student answers a question or follows directions"* which he reports strongly influence pupils achievement. Therefore a variety of response behaviours were incorporated into the interventionist programme in an effort to both improve the quality of teacher – student interactions and create a climate for cultivating thinking skills in the classroom. These response behaviours included using a few moments pause or silence after a question has been posed and after a question has been answered to allow students time to think of an answer and to digest or reflect upon what has been said. Other response behaviours included asking pupils to explain how and why they arrived at their answer. As Costa (1991:213) maintains "*Causing students to describe their thinking while they are thinking seems to beget more thinking*".

Modelling

Many educationalists believe that by teachers modelling good practice, creative, analytical and practical thinking and metacognitive strategies, they can further help develop thinking skills in their pupils. Costa and Marzano (1987:32) state that:

> *"Teachers too, may share their thinking by making their inner dialogue external. Verbalising questions they are asking themselves about ways to solve problems and … how to check their accuracy are ways teachers can model their metacognitive processes to students."*

Therefore in an effort to further develop pupils thinking skills, I as the teacher endeavoured to 'think aloud' during the intervention lessons, describing, giving reasons for actions taken, making errors but demonstrating how we can learn from our mistakes and also demonstrating such dispositions as open-mindedness and tolerance of others' opinions and ideas. However in the initial lessons the researcher expressed early difficulties: "*All the children agreed with the speaker all of the times even when she was wrong despite prompting from the researcher to perhaps disagree with others and adopt a different idea*". Appendix D (RRJ, 5)

The above are some of the ways that the teacher-role was changed and the existing LTEY programme was adapted as a learning intervention designed to maximise pupils thinking.

4.5. Timetable for Data Collection

The research study took place during the first and second terms (November – April) of the school year 2005 / 2006 as part of the scheduled school activities in the classroom. It was laid out as in Table 4.6. The Researcher's Reflective Journal was maintained throughout the lessons and during the testing sessions in the intervention school.

Table 4.6 Timetable for data collection

Date	Topic	Location	Teacher Guiding Task
September/October 2005	**Permission** was sought and acquired from Parents of participants, Non-intervention and Intervention schools Board of Managements to participate in this research study.	Intervention School Non-intervention School	Teacher A (Researcher)
November 2005	**Pre – Intervention Tests :**		
	Test One "The Spatial Awareness Test"	Intervention School Non-intervention School	Teacher A (Researcher) Teacher B(Non-intervention Schoolteacher)
	Test Two "The ConservationTest"	Intervention School Non-intervention School	Teacher A (Researcher) Teacher A (Researcher)
	Test Three "The Scientific Skill Test"	Intervention School Non-intervention School	Teacher A (Researcher) Teacher B(Non-intervention Schoolteacher)

Table 4.6 contd Timetable for data collection

April 2006	**Pupil Questionnaire**	Intervention School	Teacher A (Researcher)
	Teacher Questionnaire distributed	Intervention and Non-intervention School	
	Post – Intervention Tests :		
	Test One "The Spatial Awareness Test"	Intervention School	Teacher A (Researcher)
	Test One "The Spatial Awareness Test	Non-intervention School	Teacher B(Non-intervention Schoolteacher)
	Test Two "The ConservationTest"	Intervention School	Teacher A (Researcher)
	Test Two "The ConservationTest" "	Non-intervention School	Teacher A (Researcher)
	Test Three "The Scientific Skill Test"	Intervention School	Teacher A (Researcher)
	Test Three "The Scientific Skill Test"	Non-intervention School	Teacher B(Non-intervention Schoolteacher)

4.6 Data Analysis

The analysis of the quantitative data from the teacher and pupil questionnaires was restricted to the simple descriptive statistics of frequencies. Due to the nature of the questionnaire, this simple analysis is appropriate.

The data gathered from the pre-intervention and post-intervention tests was categorised and presented in accordance with whether the pupil was a member of the intervention or non-intervention school and displays gender and class details. The quantitative data from the pre and post intervention tests were compared and analysed:

- to assess the level of cognitive development, if any, between the intervention and non-intervention group pupils;
- to determine any differences with regard to gender;
- to determine any differences with regard to age of pupil or class grouping (Senior or Junior infants)
- to assess the science skills test to determine if there were any significant gains in the specific early science skills/schema focused on in the LTEY intervention programme and, if so, in which ones;
- to determine if there were any obvious gains in the transfer of thinking skills, from data from the Spatial awareness and the Conservation tests.

Each set of data was analysed by determining the Residual Gain Scores (RGS). The RGS analysis was used in order to gain greater insight into the degree of change that the non-intervention and intervention groups had. It was necessary to analyse the data in terms of scores they achieved in the pre- and post- tasks determining Piagetian levels. This was done by residual gain score analysis.

The method of testing the effect of the CASE programme on the students used was to measure the residual gains scores. This technique works by determining the linear relationship between the pre- test scores for each non-intervention person to his post –test scores.

The pre-test score for each intervention group student was then entered into the linear equation and the difference between the predicted and actual post-test score estimates the effect of the intervention in comparison with the non-intervention. This method of analysis is valuable in so far as each student’s gains are compared with non-intervention students of similar pre-test scores. A positive residual gain score implies that the programme has had a positive effect, whereas a negative score implies a negative effect.

4.7 Possible limitations of the Study

It is acknowledged that a fifteen week programme is unlikely to permanently affect pupils’ thinking skills particularly in the light of Sternberg and Wagner’s (1982:50-53) assertion that students need repeated cognitive skills instruction across all areas of the curriculum and over extended periods of time to transfer, generalise and apply cognitive skills. A longer period of research would have been desirable as change is a slow process and more significant improvements in the children’s understanding would have been observable after a longer research cycle. However if the results of this research demonstrate an immediate positive effect on ordinary children’s academic achievement and raised general levels of thinking, then it would be seen to be beneficial in the long term to acknowledge Sternberg and Wagner’s view and introduce this learning intervention programme for each class level in each school year in our recommended “Spiral Curriculum” (NCCA, 1999).

Regarding the issue of validity or the subjectivity of this research, measures were taken to offset the possibility of researcher bias. Information was collected from pupils, other teachers as well as from the researcher’s own reflective journal. This ensured that a rounded picture of the situation was formed. Although the researcher’s own critical reflection played a central part, it was balanced by data from multiple sources. Reliability refers to the extent to which another researcher in the same situation would have recorded the same data. By using questionnaires that allowed the respondents maximum freedom of response, researcher bias was minimised in collecting information. The use of standard marking systems for the majority of the tests also contributed to the reliability factor.

Upon reflection on the research procedure used, the researcher regrets not piloting the “scientific skills test” as it was not created by an experienced educational researcher as the other tests were. Results displayed a general difficulty with the phrasing of Question 1 in this test, which could have been avoided by piloting it with another class initially. As a direct result of this both the teacher and pupil questionnaires were piloted with pupils of a similar age in a similar school, to check the language level and language was appropriate.

4.8 Conclusion to Chapter 4

This chapter has outlined the research design used in this immediate research study. It detailed the intervention tests, journal, and questionnaires used for the purposes of data collection in this study and considered how this data would be analysed. Chapter 4 provided an overview of the learning intervention programme in use and the methods of evaluating the effects of the LTEY programme was discussed. The adaptation of this programme to the Irish Curriculum was looked at and a timetable for data collection was outlined. Chapter 4 concluded by noting the possible limitations specifically relevant to this research undertaking. The next chapter shows the results obtained and these will be discussed in detail.

Chapter 5: Results and Discussion

"Perhaps our mental and intuitive capacities are only a shadow of what might be. Perhaps it is possible to teach people to be more effective thinkers, to be more intelligent".

(Fisher: 1990:vii)

5.1 Introduction

This chapter will present the results of the analysis of responses obtained from the results of the pre- and post-intervention tests in both the non-intervention and intervention schools including the pupil and teacher questionnaires, and the RRJ. These will be examined and compared in order to determine the effects of the intervention programme LTEY. Finally the strengths and weaknesses of the LTEY programme will be identified in a critical reflection of the intervention programme.

5.2 Results of the Pre-intervention and Post-intervention Testing

The following section presents the overall performances of the non-intervention and intervention school pupils on the pre- and post-test instruments. Residual gain score (RGS) analysis has been used in the analysis of results.

a). Section 5.2.1 will present the results of the analysis of responses obtained from Test 1: "Spatial Awareness Test."

b). Section 5.2.2 will present the results of the analysis of responses obtained from Test 2: "Conservation Test."

c). Section 5.2.3 will present the results of the analysis of responses obtained from Test 3: "Scientific Skills Test."

Section 5.2.4 will discuss these test findings.

The comparison in performances of students in each group from pre-to-post testing detailing gender and class will be presented. The average age of the pupils was four years in junior infants (their first school year), with an average age of five years in senior infants. The pre-test results served as a baseline from which the effectiveness of the learning intervention could be compared. Each section is discussed on its own and the final section will discuss the effects of the intervention among pupils in participating and non-intervention schools at post-testing and indicate the effects as regards gender, class and transfer of thinking.

5.2.1 Results and analysis of Test 1 "Spatial Awareness Test"

The "spatial awareness test" (transfer test) as explained in Chapter 3 was used purposely to assess the pupils' cognitive level, their analytical, creative and practical thinking skills and to probe for transfer of thinking skills.

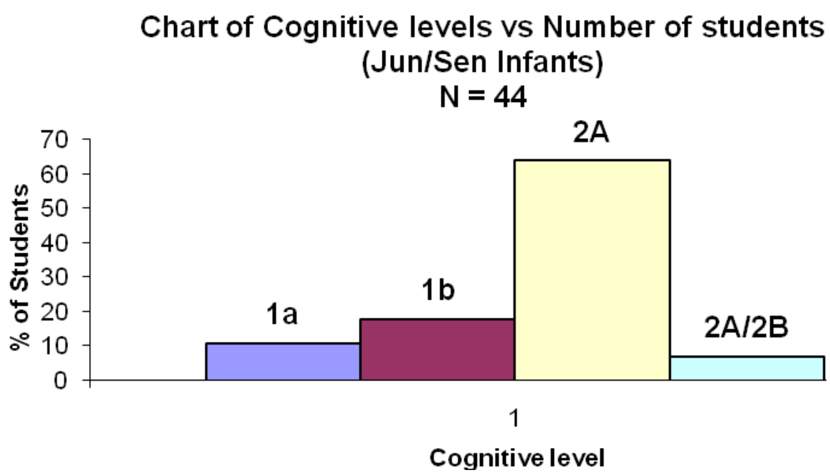

Figure 5.1 Graphical description of initial Piagetian Cognitive level of Junior and Senior Infants

The pre-test cognitive level of all the children involved in this study (both non-intervention and intervention school pupils) before any intervention programme was introduced is displayed in Figure 5.1 They are based on the Piagetian developmental levels seen in Table 5.1 and were determined from Test 1 “Spatial Awareness Test” included in Appendix A, as a pre-test. These pre-test cognitive levels serve as a baseline from which the effectiveness of the learning intervention can later be measured or compared. The results displayed in Figure 5.1 show us that the bulk of the 44 children were actually beyond the pre-operational stage and in the early concrete stage (28 pupils) with a small minority even in the mid-concrete stage (3 pupils) of cognitive growth. This was before the intervention programme was introduced.

Piaget’s theory indicates that pupils who have just started school should be thinking in a pre-operational way and intellectual growth should be taking place through the transition from ‘pre-operational’ thought to ‘early concrete’ operational thinking from around five years old. The ages of the participants in this study ranged from 4.0-6.5 years. Over 50% (23) of the total participants were five years of age, with almost half of this sample (20 pupils) in their second year of school. Then this level of cognitive growth appears to be in line with Piaget’s expectations as regards age and experience.

Table 5.1 Piagetian Developmental levels

Developmental Level	Descriptive
1a	Pre-Operational
1b	Pre-Operational
2A	Early Concrete
2A/2B	Mid-Concrete

The detailed differences between the initial pre-test cognitive levels in the non-intervention school and the intervention school are presented in Table 5.2 and 5.3. The profile of the pre-test cognitive level of the children in the non-intervention school and intervention school pupils were very similar with the majority at the early concrete stage. The non-intervention school did display a higher pre test level of pupils in the early concrete stage.

Table 5.2 Pre-test Cognitive Levels - Non-intervention School

N=24

Level	No. of students
1a	2
1b	4
2A	17
2A/2B	1

Table 5.3 Pre-test Cognitive Levels – Intervention School

N=20

Level	No. of students
1a	3
1b	4
2A	11
2A/2B	2

From each student's individual scores on both the pre test and the post test, the profile of the non-intervention group is shown in Figure 5.2. The findings displayed in Figure 5.2 demonstrate that there was a general increase in the cognitive development of the pupils in the non-intervention class in the fifteen week period from pre testing to post testing with no intervention. The number of children thinking in a pre-operational way has reduced (from 6 pupils to 2 pupils) with only one pupil in the earliest 1a stage, while there has been an increase in the transition from Piaget's 'pre-operational' thought to 'early concrete' operational thinking in a number of pupils (from 17 to 21 pupils) with no increases to the higher stage of ‘mid-concrete’ thought (remained at 1 pupil).

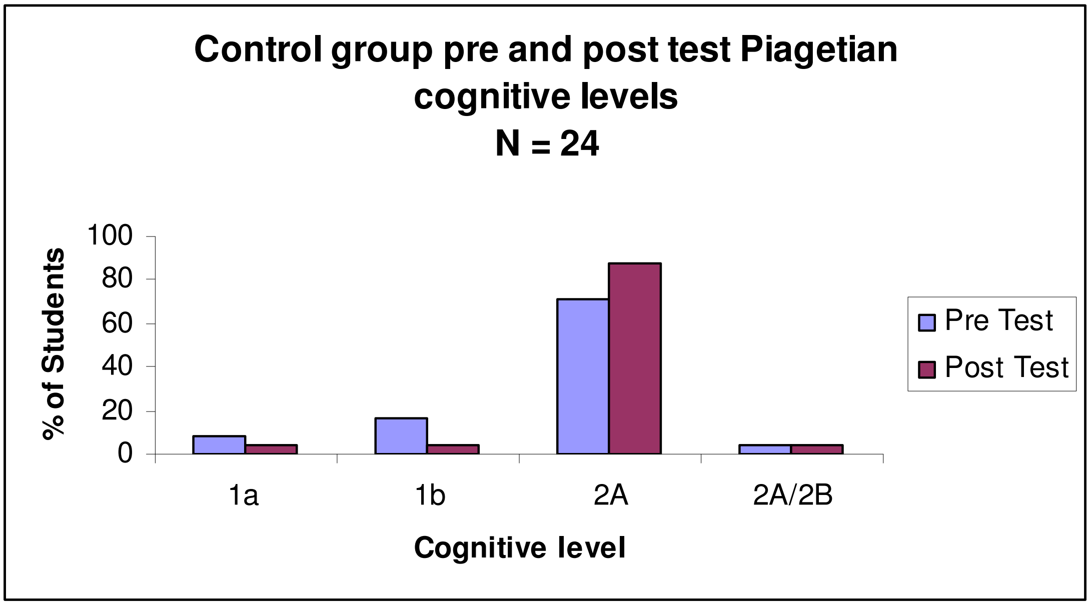

Figure 5.2 Pre and Post test Piagetian Levels for Non-intervention School Pupils in “Test 1” (Control = non-intervention group)

Figure 5.3 shows the profile of the intervention group, as determined from test 1, both before and after the intervention programme. The findings displayed in Figure 5.3 reveal that there was a strong increase in the cognitive development of the pupils in the intervention class in the fifteen week period from pre testing to post testing. The number of children, thinking in a pre-operational way has reduced (from 7 pupils to 2 pupils) with no children in the earliest 1a stage, while there has been an increase in the transition from Piaget’s ‘pre-operational’ thought to ‘early concrete’ operational thinking in a large number of pupils (from 13 to 18 pupils) with an vast increase to the higher stage of ‘mid-concrete’ thought (from 2 pupils to 8 pupils).

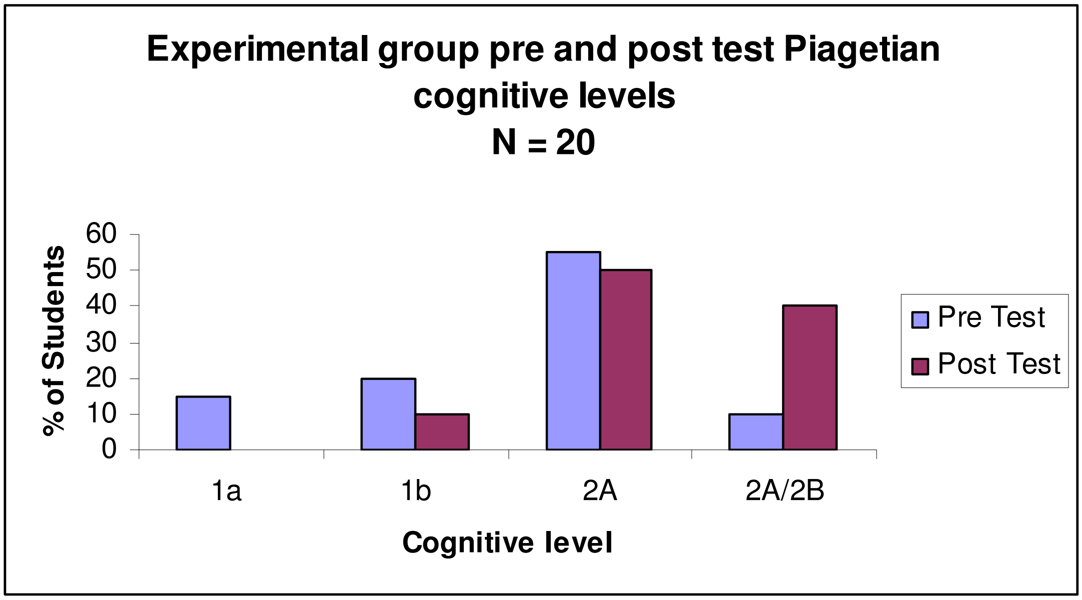

Figure 5.3 Pre and Post test Piagetian Levels for Intervention School Pupils in Test 1 (experimental group = non-intervention group)

Table 5.4 details the results from pre-to-post testing between the non-intervention school pupils and the intervention school pupils on Test 1. The data in Table 5.4 showed that on Test 1, the pupils in the intervention class made an average gain of 0.83 units compared to a gain of 0.24 units in the non-intervention class.

Table 5.4 Difference between Pre and Post scores for intervention and non-intervention groups in "Test 1" (The range of scores achieved are given in brackets)

School	Gender	N	Pre-test mean	Post-test mean	Difference	RGS*
Intervention	Male	10	3.18 (1.62-4.05)	3.67 (2.56-4.53)	.49	1.15
Intervention	Female	10	2.54 (1.62-3.24)	3.71 (2.56-4.53)	1.17	2.60
Non-intervention	Male	12	3.31 (2.92-4.29)	3.46 (2.92-4.29)	.15	0.00
Non-intervention	Female	12	2.68 (1.62-3.24)	3.02 (1.62-3.79)	.34	0.00
Intervention	All	20	2.86	3.69	**.83**	**1.86**
Non-intervention	All	24	2.99	3.24	**.24**	**0.00**

* RGS = actual post test score – predicted post test score

In order to gain greater insight into the degree of change that the control and experimental groups had it was necessary to analyse the data in terms of scores they achieved in the pre- and post- tasks determining Piagetian levels. This was done through residual gain score (RGS) analysis. This technique works by using the pre- test score for each control person as a covariate to his post- test scores, and a regression line is computed for the pre- and post- test scatter. The pre- test score for each experimental group student was then entered into the regression equation, and the difference between the predicted and actual post- test score estimates the effect of the intervention in comparison with the control. This method of analysis is valuable in as far as each student's gains are compared with control students of similar pre- test scores. A positive residual gain score implies that the programme has had a positive effect, whereas a negative score implies a negative effect.

Table 5.5 shows the RGS for each student in the intervention and non-intervention groups. The mean RGS value for the intervention group was 1.86 compared to a RGS mean value for the non-intervention group of 0.00. This shows a gain in spatial awareness skills in the intervention group over the non-intervention group.

The data in Table 5.4 also shows the gain in female scores was 1.17 for the intervention group and 0.34 for the non-intervention group. The difference for the boys was not as marked- being 0.15 for the non-intervention group and 0.49 for the intervention group. The RGS values show the improvement in the girls was 2.60 and the boys was 1.15.

Non-intervention Group				Intervention Group			
Pre-test	**Post-test**	**Predicted Post Test**	**RGS***	**Pre-test**	**Post-test**	**Predicted Post Test**	**RGS***
4	4	4.81	**-0.81**	4	8	4.81	**3.20**
5	7	5.67	**1.33**	5	7	5.67	**1.33**
1	1	2.22	**-1.22**	1	4	2.22	**1.78**
5	7	5.67	**1.33**	5	8	5.67	**2.33**
1	2	2.22	**-0.22**	1	3	2.22	**0.78**
4	4	4.81	**-0.81**	4	8	4.81	**3.20**
3	5	3.94	**1.06**	4	4	4.81	**-0.81**
5	5	5.67	**-0.67**	3	6	3.94	**2.06**
4	5	4.81	**0.20**	2	3	3.08	**-0.08**
4	4	4.81	**-0.81**	8	10	8.25	**1.75**
5	7	5.67	**1.33**	5	7	5.67	**1.33**
7	7	7.39	**-0.39**	4	8	4.81	**3.20**
6	6	6.53	**-0.53**	5	6	5.67	**0.33**
4	4	4.81	**-0.81**	8	10	8.25	**1.75**
6	6	6.53	**-0.53**	5	9	5.67	**3.33**
3	4	3.94	**0.06**	1	6	2.22	**3.78**
6	6	6.53	**-0.53**	2	7	3.08	**3.92**
4	5	4.81	**0.20**	3	5	3.94	**1.06**
9	9	9.11	**-0.11**	7	9	7.39	**1.61**
6	7	6.53	**0.47**	5	7	5.67	**1.33**
4	4	4.81	**-0.81**			**Mean RGS=**	**1.86**
3	5	3.94	**1.06**				
2	4	3.08	**0.92**				
5	6	5.67	**0.33**				
		Mean RGS=	**0.00**				

*Correlation of pre- and post- test scores for non-intervention group is:

$y = 0.8615x + 1.3615$ $R^2 = 0.7891$

This equation was used to predict the post test scores. The difference between the predicted post test score and the actual post test score gives the RGS.

Table 5.5 Table of RGS data for Test 1 for the intervention and non-intervention groups.

The data in Table 5.6 shows the results of the spatial awareness test with respect of what class pupils are in.

Table 5.6 Difference between Junior and Senior infant classes Pre and Post scores in "Test 1" (The range of scores achieved are given in brackets)

School	Class	N	Pre-test mean	Post-test mean	Difference	RGS
Intervention	Junior Inf.	11	2.77 (1.62-4.05)	3.52 (2.56-4.05)	**0.75**	**1.59**
Intervention	Senior Inf.	9	2.98 (1.62-4.05)	3.89 (3.24-4.29)	**0.91**	**2.20**
Non-intervention	Junior Inf.	13	2.90 (1.62-3.79)	3.15 (1.62-3.79)	**0.25**	**0.00**
Non-intervention	Senior Inf.	11	3.10 (2.15-4.29)	3.35 (2.92-4.29)	**0.25**	**0.00**

Junior infants in the non-intervention group has a slightly higher mean in the pre-test in comparison to junior infants in the intervention group; however they showed a gain of 0.25 as compared to a gain of 0.75 in the intervention group. Likewise the senior infants intervention group showed a gain of 0.91 in comparison to that of the non-intervention group of 0.25. The RGS values for both intervention groups were significantly higher than the non-intervention groups and the improvement for the senior infants groups was much higher at 2.20 than the junior infants at 1.59.

5.2.2 Results and analysis of Test 2: "Conservation Test".

The "conservation" (transfer test) was created to assess the pupils' analytical, creative and practical thinking skills and to probe for transfer of thinking skills. Note that only 7 students were selected to participate in this test in each group due to the time required to test each child one by one.

Table 5.7 shows the comparison of results from pre-to-post testing between the non-intervention school pupils and the intervention school pupils in Test 2.

Table 5.7 Difference between Pre and Post scores for intervention and non-intervention groups in "Test 2"

School	Gender	N	Pre-test mean	Post-test mean	Difference	RGS
Intervention	Male	3	3.67	5.33	1.66	1.37
Intervention	Female	4	1.75	4.50	2.75	1.41
Non-intervention	Male	3	2.33	2.67	0.34	0.00
Non-intervention	Female	4	1.00	2.25	1.25	0.00
Intervention	All	7	2.71	4.92	**2.20**	**2.57**
Non-intervention	All	7	1.66	2.46	**0.80**	**0.00**

In this test, the data displayed in Table 5.7 showed that the pupils in the intervention class made an average gain of 2.20 units compared to 0.80 gain in the non-intervention class. RGS value for the intervention group was 2.57 compared to a RGS value for the non-intervention group of 0.00. This shows a large gain in conservation skills in the intervention group over the non-intervention group. Table 5.8 shows the RGS for each student in the intervention and non-intervention groups.

Non-intervention group				Intervention Group			
Pre-test	**Post-test**	**Predicted Post Test**	**RGS***	**Pre-test**	**Post-test**	**Predicted Post Test**	**RGS***
1	2	1.93	**0.07**	0	2	1.07	**0.93**
0	1	1.07	**-0.07**	0	5	1.07	**3.93**
2	3	2.80	**0.20**	2	5	2.80	**2.20**
0	0	1.07	**-1.07**	2	3	2.80	**0.20**
2	3	2.80	**0.20**	3	3	3.66	**-0.66**
1	3	1.93	**1.07**	4	8	4.52	**3.48**
5	5	5.38	**-0.38**	7	8	7.11	**0.89**
		Mean RGS=	**0.00**			Mean RGS=	**1.57**

Note: each line refers to an individual student

*Correlation of pre- and post- test scores for non-intervention group is:

$y = 0.8629 x + 1.0726$ $R^2 = 0.8394$

This equation was used to predict the post test scores. The difference between the predicted post test score and the actual post test score gives the RGS.

Table 5.8 RGS data for Test 2 for the intervention and non-intervention groups.

The data in Table 5.7 pertaining to performance as regards gender on this conservation test reflected the differences in gain between the intervention class and non-intervention class. The male group in both the intervention and non-intervention groups scored higher in the pre-test than their female counterparts. Interestingly, the female increase after the intervention is greater than that shown by the male grouping in the intervention group. Likewise the female increase in the non-intervention school is greater than the male group. The RGS values show the improvement in the girls was 1.41 and the boys was 1.37.

Table 5.9 shows results in tests based on their class groupings. It reflects the differences in gain between the intervention class and non-intervention class and junior infants and senior infants.

Table 5.9 Difference between Junior and Senior infant classes Pre and Post scores in "Test 2"

School	Class	N	Pre-test mean	Post-test mean	Difference	RGS
Intervention	Junior Inf.	4	1.00	3.75	2.75	1.93
Intervention	Senior Inf.	3	1.56	6.33	4.77	1.59
Non-intervention	Junior Inf.	4	.75	1.5	.75	0.00
Non-intervention	Senior Inf.	3	2.67	3.67	1.00	0.00

In the pre-tests, junior infants results in both the intervention and non-intervention groups were similar but the senior infant grouping scored a higher value. However while the senior infant groups both increase in the post test, the magnitude of the increase is greater for the intervention group. The RGS values for both intervention groups were significantly higher than the non-intervention groups and the improvement for the junior infants group was much higher at 1.93 than the senior infants at 1.59.

5.2.3 Results and analysis of Test 3: "Scientific Skills Test"

The "Scientific Skills Test", as explained in Chapter 3, was created to assess the pupils "scientific thinking" (direct test) and perhaps highlight the most improved schema in the intervention class. Table 5.10 shows the pre- and post-test means and residual gain scores (RGS) for the intervention and non-intervention groups in total and split gender-wise.

Table 5.10 Difference between pre- and post-test scores for intervention and non-intervention groups in "Test 3" (The range of scores achieved are given in brackets)

School	Gender	N	Pre-test mean (%)	Post-test mean (%)	Difference in %	RGS (%)
Intervention	Male	10	64(38-87)	78(52-96)	14	8.18
Intervention	Female	10	60 (40-74)	86(60-96)	26	26.57
Non-intervention	Male	12	76(24-90)	75(30-90)	-1	0.14
Non-intervention	Female	12	61(23-96)	61(29-90)	0	0.10
Intervention	All	20	62	82	**20**	**18.93**
Non-intervention	All	24	68.5	68	**-0 .5**	**0.04**

The pre–test results showed that each grouping achieved a very similar score, with the exception of the non-intervention male group. There was no obvious or clear reason for this difference. However, this group dropped 1% overall in the post test while both intervention groups increased. In Test 3, the outcome data showed that the pupils in the intervention class made an average gain of 20% compared to a loss of 0.5% in the non-intervention class. RGS values for the intervention group was 18.93% compared to a RGS value for the non-intervention group of 0.04%. This shows a large gain in scientific skills in the intervention group over the non-intervention group. Table 5.11 shows the RGS for each student in the intervention and non-intervention groups.

The data in Table 5.10 taking into account gender on this science based test reflected the differences in gain between the intervention class and non-intervention class as being 26% for girls and 14% for boys. The RGS values show the improvement in the girls was 26.57% and the boys was 8.18%.

Table 5.11 RGS data for Test 3 for the intervention and non-intervention groups.

Non-intervention group				Intervention Group			
Pre-test	**Post-test**	**Predicted Post Test**	**RGS**	**Pre-test**	**Post-test**	**Predicted Post Test**	**RGS**
63%	66%	64.06%	**1.94%**	68%	90%	67.43%	**22.57%**
65%	65%	65.41%	**-0.41%**	43%	92%	50.58%	**41.42%**
65%	65%	65.41%	**-0.41%**	46%	82%	52.60%	**29.40%**
40%	50%	48.56%	**1.44%**	40%	80%	48.56%	**31.44%**
36%	40%	45.86%	**-5.86%**	73%	60%	70.80%	**-10.80%**
23%	29%	37.10%	**-8.10%**	61%	82%	62.71%	**19.29%**
40%	48%	48.56%	**-0.56%**	38%	78%	47.21%	**30.79%**
67%	35%	66.76%	**-31.76%**	55%	96%	58.67%	**37.33%**
24%	71%	37.78%	**33.22%**	51%	52%	55.97%	**-3.97%**
62%	30%	63.39%	**-33.39%**	70%	68%	68.78%	**-0.78%**
81%	65%	76.19%	**-11.19%**	54%	69%	58.00%	**11.00%**
78%	78%	74.17%	**3.83%**	46%	94%	52.60%	**41.40%**
86%	80%	79.56%	**0.44%**	58%	82%	60.69%	**21.31%**
90%	90%	82.26%	**7.74%**	63%	88%	64.06%	**23.94%**
74%	77%	71.48%	**5.52%**	74%	90%	71.48%	**18.52%**
86%	86%	79.56%	**6.44%**	73%	96%	70.80%	**25.20%**
80%	80%	75.52%	**4.48%**	67%	90%	66.76%	**23.24%**
74%	76%	71.48%	**4.52%**	87%	74%	80.24%	**-6.24%**
86%	77%	79.56%	**-2.56%**	82%	88%	76.87%	**11.13%**
90%	88%	82.26%	**5.74%**	80%	88%	75.52%	**12.48%**
73%	75%	70.80%	**4.20%**			**Mean RGS=**	**18.93%**
87%	89%	80.24%	**8.76%**				
82%	80%	76.87%	**3.13%**				
96%	90%	86.30%	**3.70%**				
		Mean RGS=	**0.04%**				

The data in Table 5.12 shows the Test 3 results based on their class group. The gain between the intervention class and non-intervention class is junior infants 23% and senior infants 18%.

Table 5.12 Difference between Junior and Senior infant classes Pre and Post scores in "Test 3" (The range of scores achieved are given in brackets)

School	Class	N	Pre-test mean (%)	Post-test mean (%)	Difference in %	RGS (%)
Intervention	Junior Inf.	11	54(38-73)	77(52-96)	**23**	**22.45**
Intervention	Senior Inf.	9	70(46-87)	88(74-96)	**18**	**14.77**
Non-intervention	Junior Inf.	13	56(23-86)	56(29-80)	**0**	**0.10**
Non-intervention	Senior Inf.	11	83(73-96)	83(75-90)	**0**	**0.08**

In both the intervention and non-intervention groups, the mean score for senior infants was greater than that for junior infants. The RGS values for both intervention groups were considerably higher than the non-intervention groups and the improvement for the junior infant groups was much higher at 22.45% than the senior infants at 14.77%.

A set of 'schema' were used on which to build the classroom activities as discussed in Chapter 3. Table 5.13 gives an indication of the extent to which the intervention class exhibited increased understanding in the science schema of classification, seriation and causality used in the LTEY programme compared with the non-intervention class who had no intervention.

Table 5.13 Pre and Post test means for science skills/schema for intervention and non-intervention schools.

School	N	Pre-test *classification* mean	Post-test *classification* mean	Pre-test *seriation* mean	Post-test *seriation* mean	Pre-test *causality* mean	Post-test *causality* mean
Intervention	20	53%	78%	59%	85%	69%	81%
Non-intervention	24	61%	63%	74%	77%	65%	68%

The specific three scientific skills/schema developed in the intervention activities were assessed in this test to determine the direct learning effects resulting from the activities. In the test, questions 1, 2 and 3 were classification based questions, questions 4, 5, 6 were seriation questions while questions 7 and 8 were causality based questions. The data given in Table 5.13 demonstrates that the non-intervention class had an average gain of 3% from pre to post test. The intervention group shows a gain of 26% in the schema of seriation, a 25% gain in the schema of classification and a 12% gain in the schema of causality.

5.2.4 Discussion of test findings

From analysis of the results of the tests on the pupils, the key findings are:

- overall the intervention group made significantly greater gains in cognitive development over the period of the intervention than the matched non-intervention school in both direct (science based) and transfer (conservation and spatial awareness) tests, as shown by significant RGS values in the intervention group for each test.

- The specific cognitive gains in the transition from Piaget's 'pre-operational' thought to 'concrete' operational thinking although significant in the non-intervention class were considerably higher in the intervention class where intervention had occurred. The amount of cognitive development that occurred in the non-intervention class without any intervention taking place would have been the natural increase of thinking capacity advised by Piaget with age and experience or even due to 'familiarity' as the same test was repeated. However the intervention class's accelerated cognitive development to higher levels (8 pupils in the 'mid'-concrete stage in the intervention group compared to 1 pupil in the non-intervention group) was directly attributable to their experience with the intervention programme.
- When gender was considered boys in the intervention group had greater gains than boys in the non-intervention group; however while these boys made gains, they were not as great as those made by girls. The differences in gain between the intervention class and the non-intervention class were higher for the girls than the boys in the scientific skills test (26% for girls and 13% for boys) in the spatial awareness test (0.83 for girls and 0.34 for boys) and in the conservation test (1.50 for girls and 1.32 for boys). The RGS values confirm that the improvement in girls was much higher in all three of the tests than the boys, with the scientific test showing the most dramatic difference (2.65% for girls and 8.18% for boys). The RGS scores for the spatial awareness test (2.60 for girls and 1.15 for boys) and the conservation test (1.41 for girls and 1.37 for boys) had similar results. This notion fits neatly with Piaget's beliefs that the concrete operational stage comes at a younger age for girls than it does boys in line with girls generally earlier maturity at this age.

- When the school class pupils attended, either senior or junior infants, was considered separately the older senior infants class, where the average age is 5 years old, had greater gains in the transfer of thinking tests than the younger junior infant class, where the average age is 4 years old. However the junior infants had greater gains than the senior infants in the direct test where the pupils were specifically tested on the three schemas they had practised in the intervention programme. The differences in gain between the intervention classes and the non-intervention classes were higher in both of the transfer intervention tests i.e. in the spatial awareness test (0.5 for junior infants and 0.66 for senior infants) and in the conservation test (2.00 for junior infants and 3.77 for senior infants). In the direct test, the increase in scores for the scientific skills test (23% for junior infants and 18% for senior infants) reversed this notion. These results could indicate the older children are at a more advanced stage of thinking that they could transfer their acquired thinking skills to other applications. Alternative explanations could be that the younger class pupils in their first year of school were perhaps more open to instruction than their older counterparts or it could simply be that the junior infants had not been exposed to science before.
- The gains made by the intervention pupils on the science skills Test 3 (20%) was important because it confirmed that the LTEY programme enhanced early science skill development in the intervention class. The RGS value of 18.93% also confirms this enhancement. The non-intervention class who were not exposed to the learning intervention did not make any gains at all. There was no real difference between the non-interventions pre and post test results in the science skill test despite the boys and senior infant non-intervention groups

obtaining higher pre test scores than their intervention counterparts in the same pre test. In the schema of seriation the intervention school showed the largest improvement of 26%, with a 25% gain in the schema of classification and a 12% increase in the schema of causality. This compares to an average of 2% gain in individual schema in the non-intervention school. This confirms that a cognitive acceleration programme through science helps in the development of science skills as there was minimal increase in the scores from the non-intervention school and indicates that there is a requirement for thinking schema to be taught.

- The RGS gains made by the intervention pupils on the cognitive tests, both the spatial awareness (1.86) and conservation (1.57) tests, were particularly significant in the researchers view because there were no activities in the LTEY intervention programme relating to the spatial awareness or conservation schema / 'way of thinking'. These gains in a schema that was not part of the intervention programme indicates that there has been transfer beyond the schema addressed. This suggests that these fifteen LTEY activities provided broad-based cognitive stimulation and they genuinely improve children's general ability to think.

5.3 Evaluation: Pupil Questionnaire

Forty four pupils completed the questionnaire, twenty from the intervention group and twenty four from the non-intervention group. The non-intervention sample size was reduced by 4 pupils due to illness on the day it was administered, however this only served to even out the numbers as regards comparison with the intervention school. The same questionnaire was administered to each school at the end of the series of lessons, however certain questions like Q.9 would have more meaning to the intervention school having undergone the intervention lessons. A copy of the pupil questionnaire can be found in Appendix C while the list of questions can be seen in Table 5.14. Results of the questionnaire are displayed in Figure 5.4 and Table 5.15.

Table 5.14 List of questions in the pupil questionnaire (original version in Appendix B)

Q1.	Did you like this lesson?...Yes/No
Q.2	Do you like science **more than** any other schoolwork? … Yes/No
Q.3	Do you like working out what to do yourself?…THINKING! ... Yes/No
Q.4	Do you like teacher telling you what to do? ... Yes/No
Q.5	Do you like working by yourself? ... Yes/No
Q.6	Do you like working with friends? ... Yes/No
Q.7	In this lesson which part did you **like the best?** – talking /thinking /working with friends /writing.
Q.8	In this lesson which part did you **NOT like doing?** – talking /thinking /working with friends /writing.
Q.9	Do you think that Thinking in Science is very difficult?...Yes/No
Q.10	Do you think that science is boring?...Yes/No
Q.11	Do you think that we do too much science at school?...Yes/No
Q.12	Do you think that we do too much writing in science?...Yes/No
Q.13	Draw a picture, if you can for Sam the Science Man of your favourite science Lesson?...

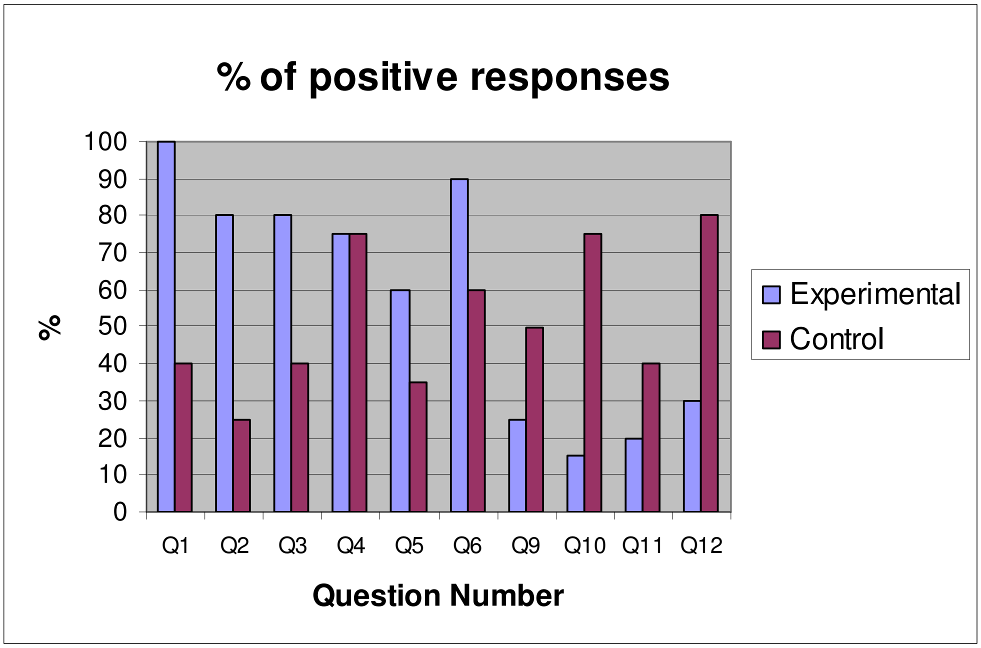

Figure 5.4 Percent of positive responses for questions 1– 6, 9-12

Table 5.15 The % responses for each category in questions 7 – 8
(N=20 Intervention Group and N=20 Non-intervention Group)

	Intervention School				Non-intervention School			
	Talking	**Thinking**	**Friends**	**Writing**	**Talking**	**Thinking**	**Friends**	**Writing**
Q7	25	30	35	10	10	15	5	70
Q8	10	25	5	60	15	60	0	25

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5.3.1 Attitudes to science as a lesson

The purpose of this questionnaire was to determine whether the children enjoyed the science lessons of the intervention programme. Questions 1, 2, 9, 10, 11, 12 particularly indicated if this science skill intervention programme was beneficial in contributing to children enjoying early science skills lessons and the pupil's responses to these questions are displayed in Figure 5.4. The non-intervention group's answers served as a comparison. When questioned about their attitude to the science lesson in general, bearing in mind that both groups had completely different experiences of science teaching methodology, the intervention class expressed a resounding 'yes' in favour of enjoying the LTEY science as a lesson. The majority of the non-intervention class expressed a dislike for the didactic style science lesson with 75% of the class preferring other subjects to science. 'Thinking' in science is regarded as easy by 75% of the intervention class and only 50% of the non-intervention class. There is a significant disparity between both classes as regards their attitude on whether science is boring with the majority of the non-intervention class believing it is and the extreme opposite for the intervention class. This reflects the interest and motivation that the topics and methodology of the LTEY science programme inspire in the pupils. Both classes agree that there is not too much science being taught at school which is probably due to its recent introduction as a new curriculum subject. However the different style of teaching early science skills, as adopted in the LTEY programme, is recognised as the majority of pupils of the non-intervention school expressed their opinion that they do too much writing in science in contrast to the opposite opinion expressed by the intervention class.

The favourite lessons chosen by the vast majority of the intervention pupils (question 13) were lesson 7 "Mixed – up Stories" (seriation and classification) about fairytales and lesson 11 "My Family - Who are We?" (seriation) involving ordering the ages of families from the youngest to the oldest. This indicates that children enjoy and get involved in lessons more where the topic is familiar to them like their family and fairytales. These particular lessons used in the LTEY programme were great fun as they demanded a lot of imagination and debate which also contributed to pupil's involvement.

These results indicate that the intervention children enjoyed the science lessons of the intervention programme in comparison to the non-intervention pupils who had a more negative opinion of their didactic style science lessons.

5.3.2 Attitudes to the teaching methodology

A secondary purpose of this questionnaire was to assess whether this type of teaching methodology appeals to the pupils which in turn could indicate this as a better method of teaching science to pupils. Questions 3, 4, 5, 6, 7, 8, 12 were relevant to assessing the teaching methodology employed and the pupils responses are displayed in Table 5.15 and Figure 5.4. 75% of the non-intervention and intervention classes liked the teacher telling them what to do in the science lesson and working with friends. The young age of the children is a contributing factor to their lack of independence from the teacher. There is a significant differentiation between the class's attitude to 'working out what to do yourself in a science lesson…thinking!'. This appealed to the majority of the intervention class pupils perhaps due to their familiarity and enjoyment with this process in the LTEY lessons, while the bulk of the non-intervention class disliked this idea, due perhaps to their inexperience with it. The process of 'thinking' appeared again more popular with the intervention class than the non-intervention with 'writing' proving least popular as a method of participation in a science class. These results indicate that the general impact of teaching early science skills through the LTEY methodology for accelerating thinking with lots of discussion, opportunities for thinking and little writing had a positive impact on the pupils involved, therefore implying that this methodology would help pupils participate more fully.

The inappropriateness of this written questionnaire for some of the very young children was conveyed in the way that a few of the younger pupils just filled in all similar faces before the questions were asked. The researcher was also aware that the pupil questionnaire was open to teacher bias as the teacher could persuade answers by repeating or emphasising certain words e.g. “thinking” as the children were looking for guidance. However this was not carried by the researcher.

5.4 Evaluation: Teacher Questionnaire

5.4.1. Teachers’ understanding of what constitutes “pupils thinking processes” in the classroom

Question 1 of the teacher’s questionnaire was designed to give an insight into the experienced teachers understanding of what defines pupils “thinking”. Teachers ranked their first three choices and these are shown in Figure 5.5. Combined choices are used in analysis. Clearly the pupil’s ability to “question why?” is rated by most teachers, 71% of those polled as a 1st or 2nd choice, as an important element of what constitutes “pupils thinking processes” in the classroom, with 28% selecting it as the most important feature. The pupil’s ability to ‘predict what will happen next’ obtained the majority of teachers 1st choice votes while ‘ability to interpret results’ closely followed behind with 57% of teachers selecting them, although not as their first choice as the principal feature in their understanding of what represents “Pupils Thinking Processes” in the classroom. Pupils’ ‘reflecting on their own work’ was deemed by 42% as a significant element of pupils thinking processes, however not as teachers first choice. 28% of the teachers polled selected a pupil's ability to "listen attentively" in either their 1st or 2nd choice of what is involved in pupils thinking in the classroom.

Piaget rated the skills of classification and sequencing/seriation as principal schema / ways of thinking by pupils in the classroom. However only 28% of teachers choose the pupils ability to 'recognise sequences' as being important (all 2nd choices) and only 14% (1st choice) selected 'classification' as being central to their understanding of what constitutes pupils thinking in the classroom. The low rating of importance awarded by teachers to two principal 'ways of thinking' that Piaget deemed extremely important, indicates the low level of teachers understanding of what exactly defines pupils "thinking".

The pupils capacity to 'read a sentence correctly', 'recite a poem,' and 'copy work off the blackboard', as expected, didn't score at all as features of pupils thinking skills according to the teachers polled in the classroom, as these are largely acknowledged as activities where not a lot of personal 'thinking' is required. This question did indeed serve its purpose which was to give an insight to the researcher into the experienced teachers understanding of what defines pupils "thinking" in the classroom. All teachers did actually have a general understanding of what was involved in this skill. These findings suggest that teachers with their good basic understanding of pupils thinking skills could provide a good delivery of any programme introduced to develop pupils thinking skills. It should also have helped focus the teachers understanding of 'thinking' as regards subsequent questions.

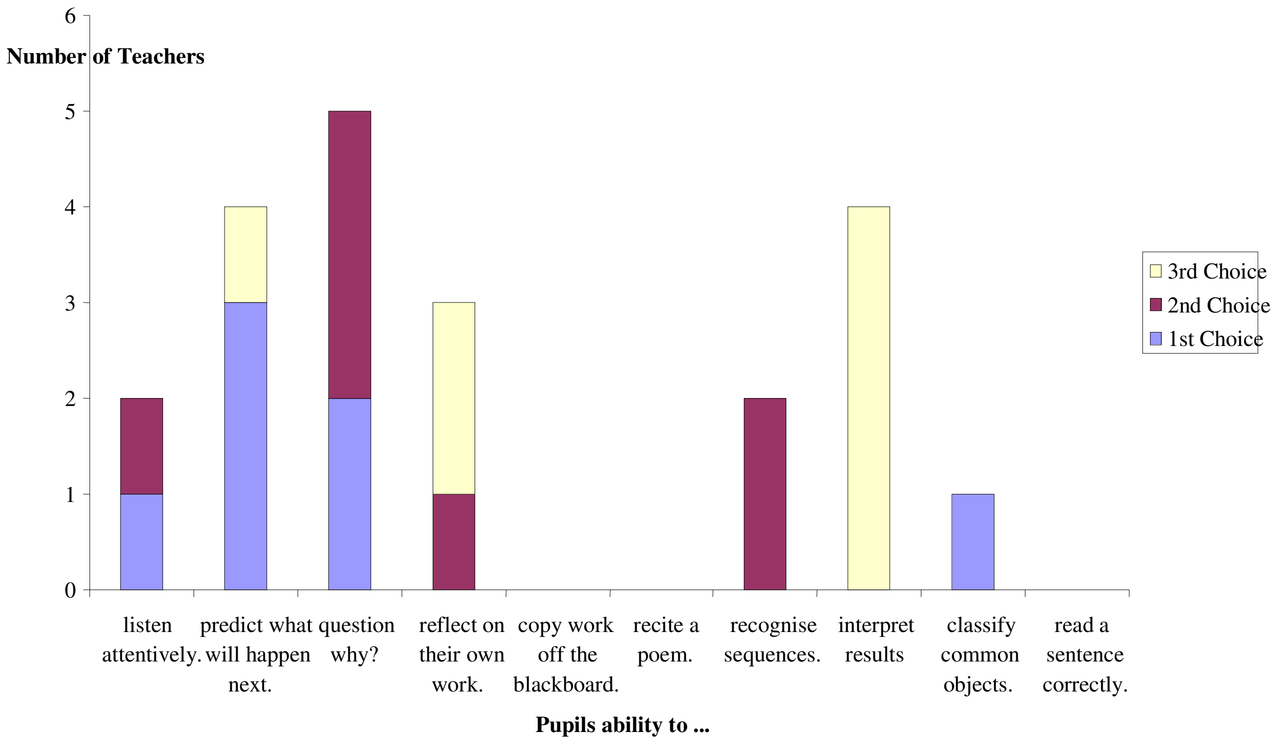

Figure 5.5 Teachers views on what constitutes pupils thinking skills

5.4.2 Teacher's views of pupils thinking, past and present

Question 2 in the teacher's questionnaire aimed to establish if developing thinking skills is a recent issue in primary education or if it has always been there in the past. Figure 5.6 shows the general results of this question. When asked their opinion on whether or not they thought children were better thinkers in the past than at present, five teachers or 71% responded in the affirmative while 2 teachers or 29% replied in the negative.

Pupils were better thinkers in the past than at present!

Explanations of why they believed that children were better thinkers in the past than at present were varied. One teacher believed that children's reduced thinking was due to "*different interests: more handed to them without the children having to think for themselves. Just a reflection of society*" (Respondent 6). Another teacher felt that in the past "*children had to think on their feet more as teachers used to throw out questions on mental arithmetic regularly. Also there was less reliance on commercially prepared workbooks*" (Respondent 1). Other reasons were on a similar vein that teachers believed that in the past "*children had less done for them and given to them therefore had to think more for themselves and be more resourceful. Children appear more reliant and dependant on adults recently*" (Respondent 4). A contributory factor to better thinking abilities in the past than at present according to one teacher is because:

> "*In classrooms of the past maths was totalled in pupils heads whereas now there is widespread use of calculators, while 'spell-check' is used when typing stories instead of pupils thinking for themselves resulting in children lazy to use their thinking skills. Nowadays children are 'spoon fed' everything i.e. every task is set/planned out for them. Teachers at present are up against time constraints of an extensive curriculum to be covered and generally don't give tasks that require pupils 'figuring out' time, which wasn't an issue in the past when the curriculum was smaller"* (Respondent 7).

While another teacher believed that the reduced thinking abilities of recent times is largely because:

> "*Children have so much given to them now that they do not need to think. There are more TV and computer games where children do not have to really think and less time for informal self discovery make-believe play which uses imagination"*. (Respondent 2)

Pupils are better thinkers at present than in the past!

Explanations of why they believe that children were not any better thinkers in the past than at present were varied. One teacher argued that:

> "*In the past, pupils were taught mainly by the learning by rote method with the teacher doing the majority of talking, compared to today, where children are encouraged to think in every activity with 80% pupil discussion and lots of group work.*" (Respondent 5)

This teacher believed that the teaching methodology at present in primary schools was more conducive to developing thinking skills than the approach applied in the past. This opinion was reiterated by another teacher: *"Because the revised curriculum provides lots of opportunities for children to participate in active discovery learning and this in turn stimulates predicting and questioning skills*" (Respondent 3). A noteworthy point from these comments was that the two respondents that answered 'no' to the question, were recently qualified teachers trained in the revised 1999 curriculum and are probably aware of the importance of and have been applying methodologies in their general teaching to enhance pupils thinking abilities.

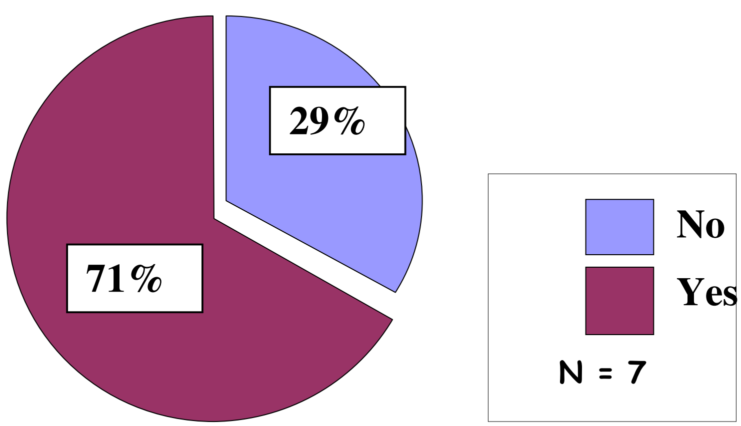

Figure 5.6 Children were better thinkers in the past than at present-teachers opinions

This interesting finding helps establish that developing thinking skills is a recent issue as it hadn't been an obvious concern in the past for teachers and therefore helps to further ascertain from an experienced teacher's point of view that it would be beneficial to introduce a 'Thinking Skill Programme' in the present day primary school.

5.4.3 Teacher's Perceptions of subjects that require pupils to use their thinking skills most.

Figure 5.7 presents the findings of question 3 of the teacher's questionnaire designed to discover which subjects make the most demands on pupils thinking skills or which curricular area the child with enhanced thinking skills would benefit the most. The subject of maths appears to be the curricular area which most teachers believe children are required to use their 'thinking skills' the most, with science following a close second in importance. It is interesting to note that while English received some support, there was no indication of thinking skills enhancing Irish, History, Music or Geography.

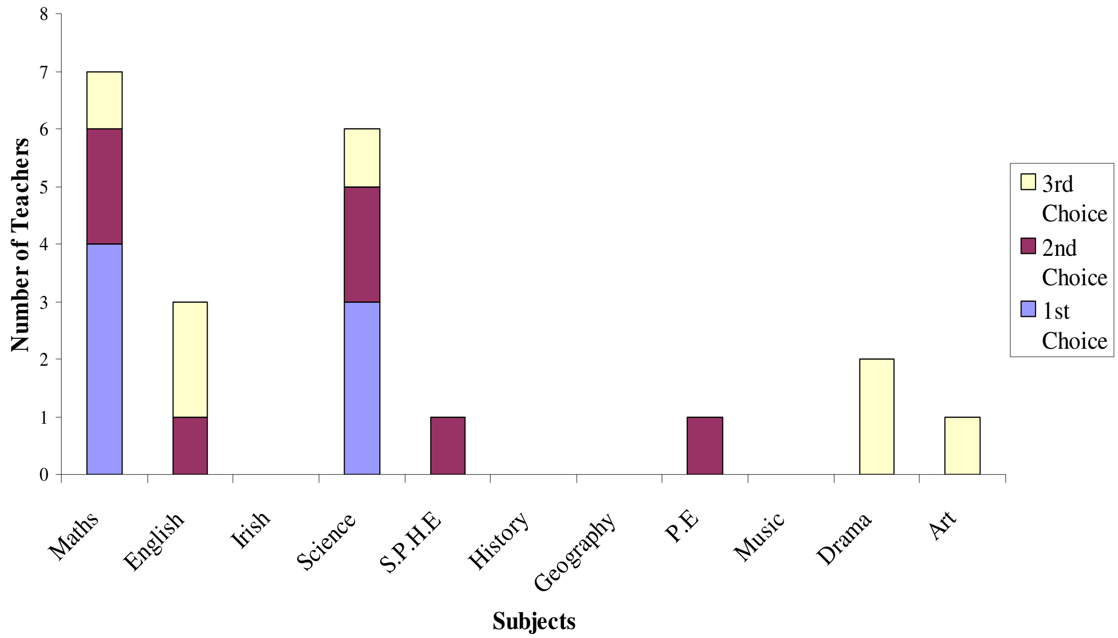

Fig 5.7 The curricular areas in which teachers believe children need to use their "thinking skills" most

5.4.4 Teachers views of the importance of developing pupils thinking in the classroom

Table 5.16 shows the findings of question 4 that intend to provide an insight into the level of importance experienced teachers assign to developing pupils thinking skills in the classroom. It is apparent that teachers consider the development of these skills to be very important to essential, which is a positive finding as regards the possible introduction of cognitive acceleration programme into the primary school.

Table 5.16 Levels of importance, of developing pupils thinking in the classroom as expressed by teachers

Of no importance	*Not so important*	*Generally desirable*	*Very important*	*Essential*
0%	**0%**	**0%**	**43%**	**57%**

5.4.5 Teachers' opinions and suggestions on the procedure of developing pupils thinking skills in the classroom

Teachers' opinions and suggestions on the actual 'procedure' of developing pupils thinking skills in the classroom, as obtained from the findings of question 5, are discussed in this section. Question 5 had five different parts to it and therefore the results are discussed similarly in five separate sections.

A) Teachers recommendations

Teachers were asked how they would promote the development of children's thinking within their classroom. Many of the teacher recommendations encompass the teaching style recommended in the implementation of the intervention programme to enhance pupils thinking skills in use in this study. This is demonstrated by a suggestion from one of the respondents: "*Rather than the teacher solving too many of the problems that arise throughout the school day-let the children arrive at the answers-be it the wrong ones" (*Respondent 3). This highlights the recommended Piagetian view and one of the intervention programmes' five pillars of cognitive acceleration, "Cognitive challenge" where "the whole point of the exercise is not the solution, but the struggle" (Robertson: 2006:8,9). Additional teacher suggestions along a similar line include: *"Instead of teacher led discussions I would set up work stations (discovery method) whereby children would think, reason and attempt to come to their own conclusions"* (Respondent 5). While another teacher recommended that to promote the development of thinking in their classroom, they would "*Encourage children to be more independent work things out for themselves"* (Respondent 2).

One teacher observed that "*I think thinking skills are developed not through a structured programme but rather through the atmosphere, ambiance and attitudes in the classroom modelled by the teacher and crosses all areas of the curriculum. Children are encouraged to be self reliant, think on their feet, question, reflect and analyse whatever subject they are doing"* (Respondent 7). This comment encourages the Vygotsky recommended teaching style of 'scaffolding' although doesn't recommend developing thinking within a single subject but rather across the curriculum.

The use of discussion, group work and prediction exercises as cognitively stimulating activities are an integral part of the style of teaching advocated by the LTEY intervention programme. Interestingly many of the teachers recommendations echoed this; "*Group activities, pair activities, using activities and eliciting predictions from pupils as to results etc. Comparing and contrasting results and methods used in intervention activities etc"* (Respondent 1). While another teacher suggested to "*Pose lots of questions to encourage deeper thinking rather than acceptance. Provide pupils with lots of opportunities to predict, experiment and interpret results. Encourage class discussions, debates"* (Respondent4) and "*Discussion of problems; teaching thinking strategies; providing a variety of learning experiences" (*Respondent 6).

These teacher-suggestions on how they would promote the development of children's thinking within the classroom were very informative and they are invaluable in guiding learning as they are the recommendations of the ordinary experienced teacher on the ground. Furthermore, the researcher feels supported in her introduction of this particular programme in the classroom by the fact that the teachers suggested similar ideas to promote children's thinking in the classroom as the researcher's ideas and those advocated in the LTEY Intervention programme.

B) Do teachers feel that they are doing enough?

When asked if, as teachers, they feel that they are doing enough to promote children's thinking in the classroom, 71% believed that they weren't doing enough while 29% believed that they were. Interestingly, the 29% group were the newly qualified teachers. As referred to before, these results could reflect the minority of recently qualified teachers immersed in the revised 1999 curriculum who are aware of the importance of and have been applying methodologies in their general teaching to enhance pupils thinking abilities.

C) Do teachers believe there is a need to introduce a structured programme?

When asked if, as teachers, they believe that there is a need to introduce a structured programme to accelerate the development of children's thinking processes, the same 71% of the teachers polled as above felt that there is a definite need to introduce a programme while the 29%, the newly qualified teachers, didn't feel that it was a necessity. This is a positive finding concerning the possible introduction of cognitive acceleration programme into the primary school.

D) At what class level should a structured programme be introduced?

Table 5.17 presents teachers recommendations as regards the specific classes most suitable for the introduction of a cognitive acceleration programme in the primary school. The newly qualified teachers felt that although it was not a necessity to introduce such a programme into the classroom, that the first four years of primary school would be more suitable. The findings indicate teacher's realisation of the importance of the early year's classroom in which to develop thinking skills, although a whole school approach appears to be the chief recommendation.

Table 5.17 Teachers suggestions for suitable class level for developing thinking programme to be introduced

Junior/Senior Infants	*1st/2nd Class*	*3rd/4th Class*	*5th/6th Class*	*All Classes*
1	1	0	0	5

E) Have the teachers polled any experience with a structured programme for this?

All the teachers polled responded that they had never encountered a structured programme for developing thinking in children in their teaching career. This may be because most of these programmes are English based and only recently developed and so have not yet found their way into the Irish system. Furthermore, Irish primary teachers are only just getting to grips and familiarising themselves fully with the aims and objectives of the 1999 Irish curriculum at the moment, including those referred to earlier of developing thinking skills. However since this research study has been carried out, the researcher has noticed new teachers resource books, focusing specifically on integrating this topic of developing thinking for different age levels in the primary school, appearing in

Irish educational bookshops, so perhaps this question will be answered differently in a few years time by these same teachers.

5.5 Evaluation: Researcher's Reflective Journal (RRJ)

This section will present a summary of the data recorded in the RRJ, (Appendix D). The RRJ contains recordings of the researcher's observations, reflections and incidental anecdotes of pupils' activity, noted during testing and the intervention programme. The RRJ was useful for recording events objectively, particularly after difficult or extra good lessons, allowing a more critical analysis of the lesson.

The researcher found that undertaking the teaching style advised in the LTEY programme was a transformative process in her teaching methodology and this was reflected in the findings of the RRJ.

> "*Teaching this programme is still a shock to my system, not so much that the pupils are beginning to develop their ability to think, but that I have to think, to redevelop my teaching skills. I have had to almost put my hand over my mouth to stop myself from talking and listen!* Appendix D (RRJ,7)

However the researcher records that by lesson 10 "*I am becoming much better at listening to the pupils' ideas and working from them now without enforcing my own"* Appendix D (RRJ, 18). By lesson 14 the researcher expressed that at this stage she had "*my new role as the mediator instead of the instructor clearly established where pupils only require a little guidance"* Appendix D (RRJ, 23). There was an apparent movement towards improving the researchers own teaching style to teach for the acceleration of thinking. The researcher also discovered *"that it is the questions that you ask and the way that you ask them that will decide the degree to which you develop pupils thinking abilities"* Appendix D (RRJ,8). The researcher acknowledged that teaching for the LTEY programme demanded a very different style of teaching for a teacher whose teaching aims are usually primarily "content" acquisition rather than primarily "skill" development.

The older more vocal pupils began to display an increased "working memory" by lesson 4 of the intervention programme, defined by the LTEY programme (2006:3) as "*the part of our mental system that processes information as it comes in, making sense of it before it is used or stored"* processing more than three or four independent pieces of information. They could discuss how some objects pictured could involve more than one 'sense'. *"I put the ambulance at the ear because we can hear it*" responded one child, and when prompted by the teacher if he can place the ambulance anywhere else, replied *"We can see it, so I can put it beside the eye too"* Appendix D (RRJ, 10).

Most children, almost 75% of the class, by lesson five were actively and energetically discussing the stimulating challenges put forward and from teacher observation, their information processing capabilities appeared to be growing as they struggled with and puzzled over the task set and then provide reasons for their ideas, instead of letting someone else think for them as at the start of the intervention programme. The researcher has noted that a few pupils in particular have had their confidence boosted by other children listening to and agreeing with their ideas.

The researcher was surprised how difficult it was for the pupils to put a set of objects in order of size in the initial 'seriation' activities but according to the LTEY programme theory (2006:3)

> *"This is because, for a pre-operational child with a very limited working memory capacity, it is difficult to attend to more than two objects at a time. Such children tend to form many series of two or three objects but find it difficult to see the series as a whole."*

The older, more experienced pupils seemed to be more successful at this, which suggests that they are in a higher cognitive level than the Piaget period of "pre-operational" and are possibly in "concrete operational". The RRJ refers to "*every child participating at their own cognitive level*" Appendix D (RRJ, 21) during the lessons reinforcing Piaget's opinion that children's thinking develops through distinct stages. From teacher observation in lesson 8 "*the older more experienced senior infant child's thinking skills are being enhanced at a faster level than the younger junior infant who is still grappling with the basics"* Appendix D (RRJ, 16) thus indicating the impact of 'age' on the effects of the cognitive acceleration programme.

When asked at the end of lesson 6 regarding how they classified, " *What helped you to work out the pictures?*" one child responded, demonstrating his level of metacognition, that " *We would ask questions to tell us things to help us find out what was on the card*" Appendix D (RRJ, 13).

The researcher felt that by the end of the intervention lessons there had been a great improvement in about half of the class's conscious awareness of their own thinking. The LTEY programme theory (2006:8) states that "*if young children learn to capture their thoughts as they occur, this helps them to be aware that they have ideas."* Each lesson concluded with a progressively better evaluating / metacognition discussion.

The RRJ observes that the children enjoyed filling in the worksheets that reminded them of what they had just learned and helped consolidate their knowledge. The researcher felt that the worksheet "*helps with pupils metacognition as they subconsciously reflect afterwards on their thoughts during the lesson*" Appendix D (RRJ, 16).

A gender effect was noted in the RRJ, when the subject matter of the lesson appealed to them like the toys in lesson 9, 'How do my Toys move?' "*the boys paid more attention and had lots of well thought out suggestions to this lesson than any other"* according to the researcher's observations, Appendix D (RRJ, 17).

The cognitive challenge put to the children in lesson 10, *"How would you bring me water in this slatted spoon?"* produced a lot of discussion, debate and rethinking of their original ideas, when disagreed with by their peers and demonstrated at the sink (pupils <u>disagreeing</u> is a good development in this thinking process as it challenges ideas). A few of their ideas were to *"Put a cloth over it, Hammer down the steel, Put a sheet of paper under it, Glue the holes, Tape up the holes, Place your hands under it, Bits of cement, Put a book under it, Put a plate under it,*" Appendix D (RRJ, 19). An excellent evaluation / <u>metacogntion</u> section followed this, where, as a result of the concrete nature of this lesson, pupils could easily answer questions like "*What did you have to think about?"*. To which question, one child responded "*stopping the water getting through the three long holes"* proving that she recognised the fact that the size and the number of holes had consequences "causality" which was the main schema to be developed in this challenging activity.

By lesson 12, without being asked, most groups had already completed their task and classified the family into two or three groups. This convinced the researcher that out of the entire three schemas, classification is the one the pupils have least problem with, probably due to the fact that it has been the most practised schema in this programme.

The researcher observed a vast improvement in the whole classes thinking ability during lesson 14, of the intervention, "*nobody was relying on someone else to answer for them or waiting for the teacher to give them the answer*, *all were busily searching for clues that would help them to make decisions on which card matched which person"* Appendix D (RRJ, 22).

The RRJ acknowledges that "*the enjoyment is apparent*" during lesson 14 of the intervention programme and noted the improvement in pupil's social and scientific skills as *"the children are very interactive with each other discussing and disagreeing with their class-mates why a picture should go there and moving around the cards* Appendix D (RRJ, 23).

The Irish Primary School Curriculum for infant classes stresses *"the centrality of language in early childhood learning,"* (NCCA:1999b: 30) which, as observed in the RRJ, was clearly developed by the introduction of this programme. Even by lesson 6 the children were much better at expressing themselves vocally and justifying their ideas came more naturally, with very reasonable explanations as to why the object should be somewhere, with even the shyer children contributing and having the confidence to argue their points of view. The following example of dialogue recorded in the RRJ Appendix D (RRJ, 13) conveys the development from single word answers in the initial lessons:

Pupil A:*"I put the crab there in the sand near the water, because he lives there and needs to drink water."*

Teacher prompt: "*How did the cat get there?*

Pupil A: "*I think mammy brought the cat"*

Pupil B: *"It might run into the sea and drown"*

Pupil C: *"Cats don't go to the beach."*

Pupil C's comment was challenged and it portrayed that individual child's cognitive growth that he was confident in his idea and had the ability to defend and explain it.

By the final lesson most pupils, according to the RRJ, Appendix D (RRJ, 23) were thinking for themselves and validated /explained their answers without being asked. *"Emma would like cartoons because she is my age"* and "*Ben is too young to watch TV."* to which another child challenged "*Babies watch anything"* is an example of some of their improved dialogue.

Following the fifteen intervention lessons, the researcher felt that only one child had remained totally unchanged during this programme of lessons, and that the programme had a positive impact, in encouraging pupils to recognise and develop the way in which they think.

When performing the post-tests, the researcher noticed a number of developments in the intervention pupils' thinking ability in comparison to conducting the pre-tests. In the scientific post-test "*a large amount of pupils showed a new ability to attacking these questions, they clearly showed signs of thinking before finally looking for help"* Appendix D (RRJ, 24). The RRJ reports that in the spatial post-test, a lot of the younger, more childish junior infant pupils, despite doing really well answering out and showing enhanced thinking ability in the intervention lessons, went straight back to “quick first guess” answers in this written test. The researcher felt that perhaps their young age is a restriction to ‘transfer/bridging’. *“The pupil’s recently developed thinking ability with concrete objects and are not very good at bridging from concrete to pictorial representation, which is required in written tests”* Appendix D (RRJ, 25). The older and less childish senior infant pupils, appeared to have excelled in this area and seemed to be using their new thinking skills in the written test. This further indicates the effect of the age of the child on their development level of thinking.

The RRJ records a significant difference between the non-intervention and the intervention class responses to the post conservation test. More of the intervention pupils, chiefly the older children, did appear to think more about the post-test task before they answered it and attempt to work it out successfully, than during the pre-intervention test. However, the majority of the children in the non-intervention class “*are still not pausing to actually think of their answer or the reason how they arrived at this answer but saying the first thing that came into their head”* Appendix D (RRJ, 26) in the corresponding post-test. This highlights the vast improvements in how the class with the intervention programme has developed its ability to think more deeply and justify their reasons, in comparison with its equivalent class without the intervention.

The intervention programme has clearly also been beneficial in the development of pupils mode of working /organisational skills, like listening to others without butting in, explaining their reasons behind their point of view clearly, sharing and working together in groups. The researcher notes that *“this has made a substantial difference to the whole world of learning in my early years classroom*”Appendix D (RRJ, 25).

5.6 Critical Reflection of the Interventionist Programme

Strengths

1. The programme was successful in engaging these early years' pupils' interest and motivation, particularly through the use of pair and group problem solving activities. In general the younger children find it hard to work in a group bigger than a pair. The pupils enjoyed the fifteen activities that form the core of the programme.

Figure 5.8 Pictorial cards from the LTEY programme (lesson 6)

The colourful child friendly pictorial cards provided as shown in Figure 5.8, inspired a lot of pupil interest as did the appealing familiar topics chosen like "My Family, My Toys". The RRJ reports lesson 7, Mixed-up Stories as being the favourite lesson topic of the programme so far, probably because fairy stories are particularly special to that age group. The pupils themselves in their questionnaire also selected this as one of their favourite lessons. Very positive feedback was consistently obtained from all participants regarding the resource materials. The RRJ acknowledges that "*the enjoyment is apparent*" during lesson 14 of the intervention programme. The research findings also appear to suggest that, the content of the programme of learning intervention was deemed developmentally appropriate at early childhood level.

2. The use of pair and group work also encouraged the development of a variety of social, personal and communicative skills. "*Some pupils reluctant to speak out in whole class discussions were more vocal in offering their opinions in smaller groups"* Appendix D (RRJ, 22). Many children of this age find the communicative challenge of explaining their thinking difficult and there was a clear improvement in most pupils' communication through developing speaking, listening and reasoning ability after the fifteen lessons. The RRJ observed that by lesson 4 the pupils' developing fluency of language is helping them justify their opinions without having to be prompted. When asked to match the object with the 'sense' they would use to identify them, one previously shy participant remarked without further prompting that *"I can taste the ice-cream because I can lick it with my tongue"* Appendix D (RRJ, 9), displaying enhancement to oral sentence structure as well as more independent thinking. By lesson 14 the researcher notes the progression that *"The children are very interactive with each other discussing and disagreeing with their team-mates why a picture should go there and moving around the cards"* Appendix D (RRJ, 23).

The social challenges of sharing, taking turns and working with others were clearly improved. The researcher noted in lesson one that "*most of the children weren't able to share with more than one child due to their age"* Appendix D (RRJ, 4). However by lesson 14 the researcher reported often hearing phrases from the pupils like "*This is teamwork, we have to take turns"* which confirms the additional social skills acquired in this programme, Appendix D (RRJ,23). The intervention programme clearly has been beneficial in the development of pupils organisational skills, the RRJ lists the improvements as, listening to others without butting in, explaining their reasons behind their point of view clearly, sharing and working together in groups. The researcher notes that *"This has made a substantial difference to the whole world of learning in my early years classroom*"Appendix D (RRJ, 25).

Meanwhile pupils' creative development was helped through the use of stories to expand imagination and ideas. The pupils had the most interesting reasons for justifying why a particular picture should go next (lesson material exhibited in Figure 5.9) always related to their own life experience e.g. *"Mummies have to have a child, so the child is first"* and discussing what clue*s* tells them someone is older e.g. height "*She is taller so she is older,"* which although can be true when you are a child, isn't always the case in adulthood, Appendix D (RRJ, 20).

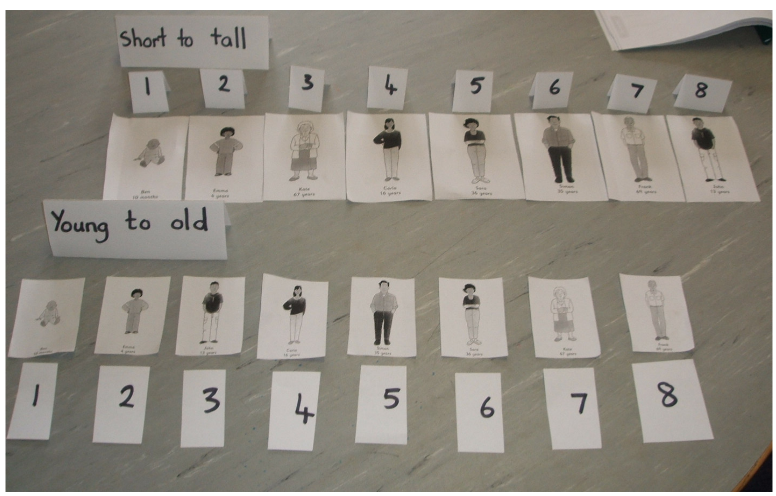

Figure 5.9 Material used in lesson 11 to develop seriation

3. The programme also appeared to positively affect pupils' learning and understanding based on pupils' responses to questions, discussions, follow up worksheets and pre-intervention and post-intervention testing. Initially pupils tended to give only one word responses to attempts at discussion. However after I refocused my role as group facilitator and provided prompts, scaffolds and praise for attempts, pupils began to participate actively in discussions to give their own opinions and predictions, backed up with reasons and to respond to one another's opinions explaining why they agreed or disagreed with what had been said. While classifying in lesson 9 the researcher expected the object groupings to be based on visual similarities like all the red things together but surprisingly, a lot of the children had began to think a little about the action and what kinds of movement are produced as a result*, "We put the cars together as they all roll on wheels"* said one group, Appendix D (RRJ, 17).

4. The gains in the cognitive tests by those children involved in the intervention over those children who didn't take part, in a schema that was not part of the intervention programme indicates that there has been transfer beyond the schema addressed.

5. Teacher observations in the RRJ showed that this programme had a strong emphasis on developing the pupils' thinking disposition of being metacognitive, however only some stronger children, usually older acquired this ability. When asked to explain her thinking when she was classifying coloured petals in lesson 1, a senior infant girl remarked that *"I was thinking that it's like tidying my toys away into their right boxes"* Appendix D (RRJ, 5). By Lesson 8 about one third of the intervention class were actively engaging in this reflective process, when asked *What have we been thinking about?* one child replied "*We put the pictures in the right order and that made a story"* Appendix D (RRJ, 15).

Weaknesses

1. The RRJ does refer to the time constraint of some of the LTEY lesson plans being too long and detailed which impinged on time allocation in other curricular areas.

2. Despite the intervention programme helping accelerate the thinking abilities of most of the intervention children involved, some children remained unchanged by the process. During problem solving these pupils tended to go with their first idea and not to consider other alternatives. They rushed through activities completing them in a few minutes without really thinking thoroughly about each part of the exercise and their answers tended to be short, often repeated from another child. The intervention programme style did not help this minority of the intervention programme develop their thinking skills.

5.7 Conclusion to Chapter 5

This chapter presented the results of the analysis of responses obtained from both the pupil and teacher questionnaires and the RRJ. The categorised results of the analysis of the pre and post intervention tests in both the non-intervention and intervention schools were analysed and compared. Graphic and descriptive formats were used in the presentation of these results.

The findings of the RRJ indicated a steady improvement in the majority of the intervention pupil's personal and social development through developing collaborative group work skills in the LTEY programme. A significant enhancement of their communication, language and literacy skills through developing speaking, listening and reasoning ability was also noted. The intervention pupils' creative development was advanced through developing imagination, linking to stories, discussion and developing ideas, while their knowledge of early science habitats, senses and mathematical ability was improved. The RRJ observed the struggles to adapt to the new role of the teacher as ‘mediator’ and the realisation of the advantages of the LTEY teaching methodology in the primary classroom. Pupils began to display an increased level of cognitive ability as the lessons progressed with each *child participating at their own cognitive level* supporting Piaget’s belief that children’s thinking develops through distinct stages. An improvement in about half of the class’s conscious awareness of their own thinking ‘metacognition’ was recorded by the end of the intervention programme. The RRJ observed the LTEY programme as having the greater effect on accelerating the thinking ability of the older children particularly with their ability to transfer to other schema. The enjoyment factor was recorded throughout the RRJ.

The findings of the pupil questionnaire signify that the intervention children enjoyed the science lessons of the intervention and the LTEY teaching style for accelerating thinking with lots of discussion, group work, cognitive challenge, opportunities for thinking and little writing had a positive impact on the pupils involved. Therefore this suggests that the methodology employed by the LTEY programme would indeed help pupils develop a love for the subject of science.

The information obtained from the teacher’s questionnaire indicated that teachers would benefit from an increased awareness as to what constitutes thinking skills or Piaget’s ‘ways of thinking’. The majority of teachers believe that children have not as good thinking skills as they did in the past due to a number of reasons. Teachers perceive maths and science as the subjects which make the most demands on pupils thinking skills and the curricular areas through which the child with enhanced thinking skills would benefit the most. All of the teachers polled responded that they had never encountered a structured programme for developing thinking in children in their teaching career. However they consider the development of thinking skills in primary school to be essential, the bulk of the teachers polled believed that they weren't doing enough to promote this skill development in their classrooms and recommended the introduction of a cognitive acceleration programme in either the early year's classroom or adopt a whole school approach to it. There was a correspondence between the experienced teachers recommendations on how to promote children's thinking in the classroom and the procedures already advocated in the LTEY Intervention programme. The researcher feels that this similarity supports the LTEY programme as a suitable choice of a cognitive acceleration programme in the Irish primary classroom.

The data emerging from the test instruments indicate that the intervention improved both thinking and early science skills among the pupils in the intervention school, over those of the non-intervention school, following their usual approach to learning early science skills. The intervention group overall made significantly greater gains in cognitive development than the non-interventions in both direct (science based) and transfer (conservation and spatial awareness) tests. The transition from Piaget's 'pre-operational' thought to 'concrete' operational thinking was accelerated with the intervention class more than the non-intervention class and pushed some pupils into the higher 'mid-concrete' stage. When genders were considered separately intervention boys' had greater gains than non-interventions; however these gains were not as great as those made by girls in general. Regarding the effect of ‘age’, the older senior infants class had greater gains in the transfer of thinking tests than the younger junior infant class; however the junior infants had greater gains than the senior infants in the direct science test. The data presented suggests strongly that the LTEY programme enhanced early science skill development while the schema of ‘seriation’ emerged as the greater improved science skill in the intervention although only by a slight margin. Gains made by the intervention pupils on the cognitive tests provided evidence of transfer of thinking skills indicating that LTEY activities provided broad-based cognitive stimulation and they suggest improved children’s general ability to think.

Chapter 6. Conclusions and Recommendations

"Children can be taught to value their capacity for thinking, they can be taught the principles of reasoning, how to use reason as a tool for learning, how to learn from others and how to play their part in the shared enterprise of inquiry."

(Fisher: 1990: vi)

Chapter 6 will discuss the main findings obtained from this research study. The relationship between the findings of this study with the literature and the findings of previous research based on programmes developing thinking with 4 and 5 year olds through early science skills will be discussed. Limitations of the methods used in this research study and suggestions for further research will be outlined. The implications of this present study on early childhood science and developing thinking skills will also be discussed for the researcher, for the school community and for the educational community as a whole. Finally recommendations will be suggested and general conclusions of this research study gathered and summarised.

6.1 Links between these research findings and the research literature

Previous chapters have demonstrated obvious links on an incidental basis between the methodology used in this study and the literature reviewed. These links include the adoption of a Piagetian-style of testing, actual Piagetian based tests, an intervention programme with its theoretical foundations from Piaget and Vygotsky and the provision of hands-on-activities for the early childhood participants. This section of Chapter 6 will link the findings of this research study to key literature that is significant and has application to the present study.

Bliss (1995; 155) highlighted Vygotsky's beliefs that instructors should use structured questioning techniques in order to assist children in the development of concepts. The structured questioning techniques employed in the researcher's adaptation of the LTEY programme appeared to be successful in motivating certain pupils to reach the level of metacognition where they became aware of their own thinking. Vygotsky and Piaget both advocated the principle of metacognition, that cognitive development is helped if children are consciously aware of their own thinking and are helped to develop the ability to evaluate their own thinking. The LTEY programme used this in each lesson as one of their five pillars of cognitive growth and in the spatial awareness test children's cognitive level did rise perhaps due to the metacognitive questioning technique. Adey *et al.* (2001:2) stated that children's thinking processes develop at different rates which he based on the theories of Piaget. Piaget is renowned for his opinion that children's thinking develops through distinct stages. The findings of this study generally agree that thinking capacity does increase with age and experience. When the researcher conducted the spatial awareness pre-test with the intervention pupils she observed that:

> *"the dramatic level of cognitive difference between pupils was apparent… This indicates immediately that some children will be more ready for this programme than others and that there will be different levels of thinking ability and growth"* Appendix D (RRJ, 2)

When the class group was considered, either senior or junior infants, the older senior infants class (where the average age is 5 years old) had greater gains in the transfer of thinking tests than the younger junior infant class (where the average age is 4 years old). However the junior infants had greater gains than the senior infants in the direct test where the pupils were specifically tested on the three schemas they had practised in the intervention programme. This perhaps suggests that the younger class pupils are more open to specific skill instruction than their older counterparts who are at a more advanced stage of thinking and could transfer their acquired thinking skills to other applications. The RRJ also noted that by lesson 8 "*the older more experienced senior Infant child's thinking skills are being enhanced at a faster level than the younger Junior Infant who is still grappling with the basics*" Appendix D (RRJ, 16)

The majority of children in this research study had just started school and were thinking in a pre-operational way according to Piaget. LTEY programme is designed specifically to stimulate intellectual growth through the transition from Piaget's 'pre-operational' thought to early 'concrete' operational thinking. Piaget encourages us to increase this experience to maximise the development of children's thinking into the early stage of concrete operations, from around five years old. The activities in this programme were created based on the Piagetian theories specifically to do thus. The results of the spatial awareness pre-intervention test with both non-intervention and intervention pupils, informed us that the bulk of the 44 children were actually beyond the pre-operational stage and in the early concrete stage (28 pupils), with a small minority even in the mid-concrete stage (3 pupils) of cognitive growth. This was before intervention had taken place. However the difference between Piaget's original studies, the 4/5 year old based LTEY programme and this immediate research study is that this study was based in an Irish multi-class context (junior and senior infants), which included slightly older children (6.5 years old) than recommended. The ages of the participants ranged from 4.0-6.5 years. Over 50% (23) of the total participants were five years of age. All participants were attending the first or second year of their formal primary education with almost half of this sample (20 pupils) in their second year of school. Analysis of post intervention responses to the spatial awareness test did provide strong indications that thinking capacity does increase with age and experience as Piaget advised. The specific cognitive gains in the transition from Piaget's 'pre-operational' thought to 'concrete' operational thinking, although occasionally apparent in the non-intervention class were significantly higher in the intervention class where intervention had occurred. There was evidence to support the conclusion that the intervention class's accelerated cognitive development to higher levels (8 intervention pupils in the 'mid'-concrete stage compared to the non-intervention schools 1 pupil) was directly attributable to their experience with the Piagetian based intervention programme. According to Piaget each child *must* pass through the stages of cognitive development in the same order. A child cannot move intellectually from the pre-operational stage to the stage of formal operations without passing through the stage of concrete operations, the distinct structured increases of pupil's cognitive growth in this study appeared to agree with this theory.

Vygotsky's argument that "although children might develop some concepts on their own through everyday experience, they would not develop purely abstract modes of thought without instruction." (Das Gupta and Richardson: 1995:13, 14) suggests the question **'**does thinking need to be taught?' The gains made in this study by the intervention pupils on the science awareness test, (20% – RGS gain of 18.93%) compared to the lack of gains experienced by the non-intervention class who were not exposed to the learning intervention, suggests that a cognitive acceleration programme helps in the development of thinking skills and indicates that there may be a requirement for thinking schema to be taught. Fisher (1990: vi) points out that there is often an assumption that thinking skills and dispositions will develop automatically through instruction in the various curricular areas. However findings in this study points out that thinking skills and dispositions need to be clearly, systemically and explicitly developed within the context of the curricular content areas initially before transfer of thinking skills can automatically take place.

Nisbet (1993:286) highlights the advantage of the infusion of thinking into the curriculum without having to add an additional subject to an already overloaded syllabus as in this science based approach. It also offers a greater likelihood of transfer of thinking skills to other areas of the curriculum as it is skills developed in context. The gains made by the intervention pupils on both the spatial awareness (RGS 1.86) and conservation (RGS 1.57) tests were particularly significant because there were no activities in the LTEY intervention programme relating to the spatial awareness or conservation 'way of thinking'. This figure provides evidence of transfer of thinking skills.

Piaget and Vygotksy in literature referred to in Chapter 2 highlighted the importance of the interaction of maturation and environmental conditions in the development of children's thinking skills. Wakefield (1996:292) highlights the role of the environment in helping to distinguish novice from expert thinkers, reemphasising the learning that comes from experience. Fisher, Dewey and many others stress that the development of thinking skills requires the ethos of a 'community of enquiry' in the classroom. The researcher made a concentrated effort to create the environment of a "thinking classroom" in the intervention class for the period of the study as outlined in the LTEY adaptations in Chapter 3, the intervention pupils who had the additional changed environment of a "thinking classroom" for the period of the study showed a bigger gain in cognitive development than the non-intervention school.

Fisher (1998:25) advises that the 'community of enquiry' in the classroom is where the teacher takes on a non-didactic role, as facilitator. Many recent studies as documented in Chapter 2 have shown that teachers can affect the way in which their pupils' thinking develops. Wood *et al* (1976:89-100) used the term 'scaffolding' to describe the adult support through which the child can increase current thinking ability to higher levels of competency. Vygotsky placed significant emphasis on the role of the more skilled instructor arranging or 'scaffolding' experiences that would assist the development of the child's thinking, particularly in the early child by using activity-based, discovery learning techniques. Vygotsky believed that the child's zone of proximal development (ZPD) was attainable only with the help and support of an adult or more skilled person. Therefore the adapted LTEY programme advocated the important role of the teacher in structuring the classroom, questioning, responding and modelling and assisting the participants of the intervention group along their ZPD in developing thinking in early science skills. The findings of the pupil questionnaire conveyed the pupil's pleasure at this teacher style.

The LTEY uses the Vygotskian pillar of social construction to develop thinking, that much learning takes place between children in a well-managed (by an adult) group. The learning intervention in this immediate research study involved much interaction between the instructor and the participants in the intervention group. There was much group work and discussion and debate were actively encouraged as part of the programme. The post-intervention analysis of the RRJ established that these social interactions may have provoked ‘disequilibrium’ and led to the accommodation or development of new thinking abilities in the area of early science skills. The RRJ also suggested that the intervention children showed increased personal, social and emotional development through developing collaborative group work skills.

The notion of cognitive challenge comes from Piaget in the development of thinking in the early child “*where the children must experience difficulty for the activities to fully achieve their aim*” (Robertson: 2006:4). The LTEY programme used this as a method of questioning children to help lead them into productive ‘cognitive challenge’ and to produce disequilibrium. The RRJ reports an incident in lesson 3, Appendix D (RRJ, 8) when asked by the researcher *“What clues are you using*?” to support their argument, the vibrant imagination of some children comes alive, hand in hand with their developing thinking ability *“The shark could eat the elephant!”* but when asked how would the shark meet the elephant, the answer provided was *“when the elephant goes to drink water”* thinking is challenged further by the teacher prompting *“How deep would the elephant have to go into the sea to meet the shark?”* According to the LTEY programme *“a correct answer is not as important as the discussion created”* (p.20) as a result of other children disagreeing and pointing out the impracticalities (and teacher prompting) the pupil arrives at the realisation themselves that it wouldn’t work, while experiencing some cognitive challenge in this search for a solution. The researcher also expressed a positive reaction to and recommends the use of cognitive challenge and social construction in teaching all curricular areas.

6.2 The implications of the findings of this study

The obvious implication of the findings of this study is that children's thinking ability is sufficiently flexible to be amenable to change by a well-designed intervention programme. The LTEY has proven itself to be a very successful cognitive acceleration programme for this intervention. The particular age range of the children has proven, from the findings in this study, to be an excellent 'window' for cognitive growth; therefore the apparent suggestion would be to focus on this age group to develop thinking skills and build upon it throughout the primary school.

> *The new primary science curriculum is based on a spiral approach. All knowledge and understanding of each strand-unit is developed and extended at each class level*. (NCCA: 1999d: 17)

The effect of gender differences in cognitive achievement of boys and girls highlighted by the findings in this study has significance for the researcher, the school and wider educational community. The higher gains attained by the young girls in this study (the boys did have higher initial results in some areas) is following a trend in this country that generally shows girls achieving higher marks in the Leaving Certificate and college examinations. This research highlights the need to rectify this imbalance as young as the infant classroom. These findings should also remind the infant teacher to be aware of this gender difference in their classroom and perhaps take note of the RRJs findings that when the subject matter of a lesson appealed to them,*"the boys paid more attention and had lots of well thought out suggestions to this lesson than any other"* Appendix D (RRJ, 17)

A major personal goal for the researcher was for her to acquire the necessary teaching skills in order to teach for the stimulation of thinking. A direct result of this objective for the researcher was that it was a transformative process in her teaching style as she adopted the teaching style advised in the LTEY programme reflected in the findings of the RRJ. The implications for teachers and teacher development of this study consequently are significant. Mc Kernan (1991) argues that practitioner research leads to growth in understanding, greater teacher autonomy and thus increased professionalism, and helps establish schools as centres of inquiry. This vision of schools as being at the heart of teacher development is mirrored in "Charting our Education Future: White paper on Education" (Department of Education: 1995:128). It underlines the need for in-career professional development for teachers, to equip them with the capacity to respond to changes in curriculum, management and methodologies.

> *"The strong message emerging consistently from all quarters is that the approach to professional and personal development should be decentralised, school-focused and conducive to high levels of teacher participation in all aspects of the process."*

Supporting teachers in carrying out cognitive acceleration programmes like the LTEY programme could be one method of facilitating professional development on site in schools. In this study the researcher was empowered through undertaking the cognitive acceleration programme, to improve her teaching without attending courses or receiving guidance from off-site 'experts'. This type of personal evaluation (RRJ) and development is very important to ensure that practising teachers are continually trying to improve their teaching skills and maintain their interest in their work.

One of the findings of this study that there is transfer of thinking skills into schemata (ways of thinking) not included in the LTEY intervention programme taught has a significant implication on strengthening the recommendation that a cognitive acceleration programme like LTEY should be introduced to the early years classroom. Both the findings of this particular research and those reported in Chapter 3 by the CASE project, signify that gains in cognitive development lead to gains in academic achievement. *"Children, who think better, learn better"* (Adey *et al:* 2001a:9). They are better able to obtain meaning from the mainstream curriculum in all subject areas. An influential approach to raising academic standards in schools is therefore to spend time developing general thinking ability as this according to the CASE project research continues to influence all learning situations for many years afterwards.

An interesting observation from this study is that there is the strong possibility of a teacher effect, beyond that of the intervention itself. Any teacher introduced to the specific teaching methodology in use in the LTEY programme should find their style of teaching changed from the didactic to having the role of a mentor stimulating and guiding research, a methodology conducive to teaching for the acceleration of thinking across the curricular areas as did the researcher.

6.3 Recommendations

The implications of the study are now used as the basis for recommendations for individual teachers and schools, for national policy and for educational researchers. The recommendations cover issues relating to cognitive acceleration programmes, developing thinking skills through science in young children, teacher development, school policy and research issues.

- Given the success of the intervention in this study and its emphasis on the social construction of knowledge and tackling problems together, it makes sense to encourage principals to implement a whole school approach to cognitive intervention. A science based programme like LTEY has shown additional benefits.

- It is recommended that when gathering data for this age group, more of the data be obtained from structured drawing activities. Drawing does not require proficiency in reading and writing and provides a very rich source of data regarding children's ideas and it allows access to aspects of the topic which were difficult to probe in questionnaires, written tests and one to one interviews.
- The researcher in this study found that undertaking this research and following the teaching style advised in the LTEY programme assisted her professional development and personal growth. Encouraging teachers in carrying out cognitive acceleration programmes like the LTEY programme could be one method of facilitating professional development on site in schools.

In conclusion, the finding of this research study suggests that the LTEY programme accelerates cognitive development in the early year's child through science skills/schema. The research signifies that there may be a definite transfer into schemata /'ways of thinking' not included in the programme. The specific cognitive gains in the transition from Piaget's 'pre-operational' thought to 'concrete' operational thinking although significant in the non-intervention class were considerably higher and showed strong increases into the 'mid-concrete' level, in the intervention class where intervention had occurred. The findings also suggested that the LTEY programme enhanced early science development particularly in the schema of seriation and supported the proposition that there is a requirement for thinking schema to be taught in a structured programme. There were signs of a gender effect in the research findings, where despite the intervention boys' having greater gains than non-intervention pupils, the overall gains that the boys made were not as great as those made by girls of both classes. The girls generally had higher gains than the boys. Senior infants showed higher gains in the cognitive (transfer) tests than the junior infants who excelled in the direct test indicating that the younger class pupils in their first year of school were perhaps more open to instruction than their older counterparts or it could simply be that the junior infants had not been exposed to science before. The older senior infants, being at a more advanced stage of thinking, could transfer their acquired thinking skills to other applications, as assessed in the transfer tests, more successfully than the junior infants The RRJ also supported these findings that the older children had a better ability to transfer their new thinking skills than the younger children.

Pupils social and communication skills have been enhanced through the LTEY cognitive acceleration programme, the new role of the teacher as 'mediator' has been highlighted as a popular method of science instruction and the introduction of a cognitive acceleration programme has been recommended by experienced teachers in either the early year's classroom or as a whole school approach. There are important implications for teacher preparation, school planning and education. Teachers need to be made aware of the value of developing thinking skills in their pupils and the potential long term benefits of beginning this development in the early year's classrooms and possible transfer of skills to other curricular areas.

Shayer (2006) attributes the success of such a cognitive acceleration programme as this with young children to

> "*mediation – that is, the way in which the children working together as a 'collective' collaborating in each others learning can then mediate each other's development by showing and explaining successful solutions in ways that are close to their understanding. Just as simply 'telling' the children is not an option.*"

In the context of this study, research findings have answered the research question that a cognitive intervention programme through science can have a significant immediate and positive effect on the rate of the early year's pupil's cognitive development. If the issue of introducing cognitive acceleration programmes, particularly programmes through science, to the mainstream classes was addressed by educational and school authorities, and given proper time, attention and resources, given the indications about the effects of the interventions, it is probable that it would lead to significant effects in both the development of thinking skills and early science skills.

6.4 Limitations

While the intervention proved to be successful in enhancing students' thinking skills, it is recognised that there are potential limiting factors to the study. Firstly the intervention was implemented over a fifteen week period. There is a need to adopt the intervention over a longer period (at least a year) to track the effects of the study with intervention and non-intervention schools to determine the effectiveness of the programme in the long term.

It would be interesting to adopt a continuous assessment approach and to develop a variety of test instruments (including oral, video and pictorial assessments) to evaluate the effects of the intervention. The researcher feels that at this young age most children need the concrete representation of actual solid materials to help them think and aren't very good at bridging from concrete to pictorial representation, which is required in written tests, although the worksheets follow-up-activity in this study aimed to practise this.

6.5 Further Research

Many lessons have been learned as a result of undertaking this science research study. John Locke's (Matthews: 1994: P.X111) expression is very appropriate in this occasion:

> *"Some furrows have been made and some seeds have been planted. Hopefully, other people will water the garden, straighten the furrows, plant other seeds and remove some of the weeds."*

In other words, it is hoped that this research undertaking will serve as a catalyst for further research work to be undertaken in both accelerating cognitive development in the early years and early science education.

After reviewing a wide variety of programmes to teach thinking skills in primary schools, I observed that a further, interesting area of research, would be to observe the long-term benefits of introducing a similar age appropriate science based intervention programme into each primary class level with the one class from junior infants to sixth class and using the same design as the present methodology, test each year to assess both changes in students' thinking skills and science while assessing a potential transfer of skills demonstrated in increased academic achievement. We have agreed from the results acquired in this study that a cognitive intervention programme through science can have a significant immediate effect on the rate of early years children's cognitive development, further study investigating the longevity of this effect to pupils' academic development, which in turn will influence their social development and eventually their employment prospects, could be very interesting. In conclusion, the above interpretation of the findings of this study bears in mind Harlen's (1993:25) account of how children learn.

> "…*Any model of how children learn is no more than a hypothesis. There is no certain knowledge of how children's ideas are formed or how change in them can be brought about. All that anyone can do is to study the evidence in children's behaviour, put forward explanations for it and see which of these hypotheses seem to be contradicted the least.*"

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