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Abstract

The introduction of the revised primary school curriculum in 1999 reflects the child centred vision of education that was a striking feature of the last major review of the primary school curriculum in 1971. Active learning experiences for children are envisaged which will make learning interesting, enjoyable and fulfilling. The area of the curriculum that is examined in this thesis is mathematics. “Mathematics education is concerned with the acquisition, understanding and application of skills” (Government of Ireland 1999:2). Constructivist learning is presented as central to the mathematics curriculum. In facilitation of curriculum implementation this study introduces mathematical games as a learning strategy to enable children express mathematical thinking and understanding.

This thesis examines current practice in a junior primary school. It explores a constructivist approach to teaching and learning mathematics where children are engaged in activity-based mathematics. The strand unit ‘comparing and ordering numbers’ is prioritised for the study. It is conducted in a cross-section of four classes in the school. Data is gathered from interviews with teachers on the action-research team, classroom observations and video recordings of children in classrooms playing mathematics games.

An evaluation of the use of games in the mathematics class is presented. The report concludes that mathematical games, are intrinsically motivating, enable children to express mathematical thinking and understanding, and are an invaluable assessment tool for teachers that facilitates instructional planning.

Chapter 1: Introduction

1.0 Setting

The junior school in this study is situated in Co. Kildare. The school was built in 1981 to provide a junior primary education for the growing population of a new parish. There are one hundred and twenty-three junior schools in Ireland and only one other with a similar number of children in attendance. After completing second class the children transfer to a senior school located on the same campus to complete their primary education. The school population peaked in September 1992 when there were seven hundred and twenty-five children attending the school. Since then there has been a steady decline to three hundred and twenty pupils in attendance in April 2002. The children attending our school are aged between four and eight. Teaching staff includes an administrative principal, a deputy principal, an assistant principal and thirteen assistant teachers. The children are grouped in twelve classes. A resource teacher and a remedial teacher provide learning support for children with special needs. There is also provision for language support for non-national children.

There is a middle management structure in place consisting of a deputy principal, an assistant principal and six special duties teachers. Teachers were appointed to middle management positions on seniority. I am a teacher in this school. The style of management aspires to a collegial model where power and decision-making should be shared among members of the organisation. Bush (1995:59) considers this model as the most appropriate way to manage primary schools. I share the opinion of Hargreaves (1994:192) that collaborative working relationships between teachers and their colleagues tend to be spontaneous, voluntary, informal, and geared to development. The principal allows each teacher sufficient discretion in the classroom in the approach to their teaching

methodologies. She values collaboration and encourages the teachers of each class group to work closely together to implement the curriculum. She is always supportive of new ideas to improve the quality of education being provided for the young children attending the school. Working groups are established to review curricular areas. The decision-making processes within these working committees as described by Bush (1995:63) strive to be 'egalitarian with influence dependent more on specific expertise than on official position'. Teachers who have an authority of expertise are encouraged to share innovations with colleagues. Year group teachers meet regularly to plan collaboratively to ensure a consistent approach to teaching.

1.1 Background to the research

Arising from my interest and expertise in mathematics education I conducted an action research project in my classroom with children in first class last year in mathematics. This project began with the recognition of the fact that when children record correct answers in their copies or textbooks, these answers do not necessarily imply understanding. Asking children to explain how they reached their answers whether correct or incorrect can reveal their level of understanding. This becomes an arduous task with the number of children in the class.

To counteract this problem I arranged the children into groups of five initially and then groups of two. I decided to focus on place value for the duration of the project as some children had difficulty understanding this aspect of number. The children worked together in groups playing maths games using game dice and base ten materials to reinforce renaming tens to units. These activities developed into group problem solving tasks involving addition and subtraction of two digit numbers using the base ten materials. The

project lasted about six weeks and during this time no textbooks were used. The children seemed to be enjoying the activities and frequently asked ‘when are we playing the maths games’? Following this I reverted back to the textbooks and again assigned each child a partner who demonstrated the task with concrete material to the child who was recording.

I feel that this approach to teaching mathematics gives the children an opportunity to communicate and express mathematical ideas, processes and results in oral and written form in a structured environment. Constructivist learning is central to the revised mathematics curriculum. It places emphasis on understanding and building on students thinking. Children do not construct knowledge alone. They invent mathematical ideas together and learn to communicate these ideas. They test ideas and approaches based on their prior knowledge and experience. ‘When working in a constructivist way children usually operate in pairs or small groups to solve problems co-operatively’ Primary Curriculum (1999:3).

The understanding gained from this study has influenced the way I now structure the mathematics class. I have adopted an activity-based approach to teaching mathematics in my own classroom embodying the following values:

- implementation of a mathematics curriculum that promotes children’s understanding
- accommodation of individual differences among the learning styles of the pupils
- promoting the role of social interaction in developing mathematical understanding
- recognition of the interactive nature of teaching and learning which requires me to engage actively with children to elicit understanding in order to plan appropriate instruction

1.2 Curriculum Change

The introduction of the revised primary school curriculum in 1999 reflects the child centred vision of education that was a striking feature of the last major review of the primary school curriculum in 1971 entitled *Curaclam na Bunscoile*. Active learning experiences for children are envisaged which will make learning interesting, enjoyable and fulfilling. ‘An important aim of the mathematics programme is to enable the child to use mathematical language effectively and accurately. This includes ability to listen, question and discuss as well as read and record’ (Government of Ireland 1999:6).

1.3 Facilitator of Change

Reflecting on the success of the action research project that I conducted with the children in my class I considered the possibility of facilitating mathematics curriculum implementation by exploring the use of games to enable children to express mathematical thinking and understanding. This suggestion was presented initially to the principal who welcomed it. I then addressed my colleagues at a staff meeting, explained the background to the research, described my educational values and invited teachers participate in the study (appendix A). I invited teachers to participate in the study. The study was conducted in four classes: junior infants, senior infants, first class and second class.

The implementation of this curriculum involves a collaborative planning process. “Special talents of the staff in areas of the curriculum and expertise in implementing innovative programmes can be identified and merged to support the change process” (Department of Education and Science 1999:64). Wilkinson (1992:278) suggests that the utilisation of strengths of teachers acts as a source of fulfilment and motivation for junior members of staff. Cave and Wilkinson (1992:43) report that a group of head teachers and

personnel representing all sectors of education and health presented the view that all teachers are managers and have significant contributions to make to the health of the organisation particularly in times of large scale change. This implies a change of culture, which will depend on openness, trust, sharing and participation by all. However as Wilkinson (1992:280) indicates 'it may be difficult for staff who are relatively junior in the school to exercise authority over senior management or, on occasion, middle management'.

At the outset I outlined my role as facilitator. I was explicit that while I demonstrate expertise in the subject area, this expertise was to guide the change process but not form it. Planning curriculum change in a school is in essence a collaborative task. My expertise was used to enthuse and motivate and ultimately culminate in the co-creation of change. The initial task began with 'the end in mind'; to establish a shared understanding and vision of a mathematics education as is communicated in the revised primary curriculum. 'To begin with an end in mind means to start with a clear understanding of your destination' (Covey 89:98). Applied to practice this translates as the visualisation of the school as providing experiences that embody the aims of the primary mathematics curriculum:

- to develop a positive attitude towards mathematics and an appreciation of both its practical and its aesthetic aspects
- to develop problem-solving abilities and a facility for the application of mathematics to everyday life
- to enable the child to use mathematical language effectively and accurately
- to enable the child to acquire an understanding of mathematical concepts and processes to his or her appropriate level of development

- to enable the child to acquire proficiency in fundamental mathematical skills and in recalling basic facts

This visualisation was communicated to all teachers at in-service training days for mathematics. The training involved active participation in activities and games recommended for use by children in the classroom. This active participation aided the change process. Teachers recognised the value of using these strategies to enable children to develop mathematical skills. An initial concern was the availability of resources in our school necessary to conduct the study. As facilitator I suggested that I would design, develop or acquire any resources that would be required. Those taking part in the study welcomed this suggestion.

The aims of the primary mathematics curriculum were integral to identifying my educational values. This study endeavours to clarify the meanings of my values as they emerge in practice and become my living standards and to share my living standards with others by facilitating a process that engages teachers in professional dialogue with the intention of improving practice

1.4 Summary

I consider that facilitating curriculum change in mathematics encompasses the following key elements: engaging in professional dialogue to establish a shared understanding and vision of a mathematics education, recognising the centrality of children in the learning process, encouraging participation in curriculum change by providing support and advice and ultimately developing a framework for action that will guide the implementation process.

‘The implementation of the Primary School Curriculum provides schools with a unique opportunity to enhance the quality of educational provision’ (Government of Ireland 1999:62). As facilitator I communicated my educational values as I live them in practice which motivated colleagues to participate in the study. In an effort to enhance the quality of provision for mathematics education in my school, a collaborative working relationship between the teachers participating in the research evolved which was informal, enjoyable and productive.

Chapter 2: Literature review

2.0 Introduction

The purpose of this literature review is to establish a theoretical basis for the study and to identify what is already known about the topic of enquiry, which together aim to inform the research. Literature on curriculum, facilitation of curriculum change and mathematics education is reviewed.

2.1 Background to the Revised Primary School Curriculum

In 1991 the National Council for Curriculum and Assessment (NCCA) began the work of developing the revised curriculum. Specialist committees were put in place. ‘Through the work of the committees the curriculum incorporates current educational thinking and the most innovative and effective pedagogical practice’ (Department of Education and Science 1999:2). Inherent in the revised primary curriculum at a macro level is a focus on learning. ‘An important goal of the curriculum is to enable children to learn how to learn, and to develop an appreciation of the value and practice of lifelong learning’ (Government of Ireland 1999:7).

2.1.0 Curriculum Theory

Kelly (1989:2) presents the view of educationalists, who acknowledge that educational change must be deliberately managed. This will ensure that, educational change keeps pace with and match changes in society, standards and values that transcend time are maintained and there is a response to an increased understanding of education and curriculum planning. He recommends that a study of curriculum theory underpinning curriculum development is the most essential item in the armoury of the modern teacher.

The revised primary curriculum, which is being currently introduced into primary schools in Ireland, is indicative of how the concept of curriculum as a field of study has expanded. The revised curriculum is based on a philosophy and psychology of teaching and learning that incorporates the most advanced educational theory and practice' (Department of Education and Science 1999:10). It reflects economic, social cultural and technological developments. The revised curriculum promotes assessment as an integral part of teaching. The management of curriculum change and professional development of teachers is supported.

Goodson (1994:19) claims that the written curriculum, which he defines as 'the visible and public testimony of selected rationales and legitimising rhetoric for schooling', most often sets important parameters for classroom practice. He recommends that a study of written curriculum that is allied to other kinds of educational study and grounded in social, economic and cultural contexts will increase an understanding of the influences and interests active in the pre-active level. He subsequently contends that this understanding will then further the knowledge of the values and purposes represented in schooling and the manner in which pre-active definition may contribute to the setting of parameters for the interactive realisation and negotiation in the classroom and school.

2.1.1 Defining Curriculum

Morrison and Ridley (1989:41) define curriculum as 'all those activities designed or encouraged within the school's organisational framework to promote the intellectual, personal, social and physical development of its pupils'. An alternative definition is offered by Becher (1989:52) who states that the term curriculum is open to a number of interpretations. In its narrowest it may refer to a list of subjects to be taught. He highlights a

wider interpretation as ‘the totality of the planned provision through which any educational organisation sets itself to achieve its educative purpose’.

Kelly (1989:14) proposes the use of a definition that embraces at least four major dimensions of educational planning and practice: the intention of the planners, the procedures adopted for the implementation of those intentions, the actual experience of the pupils resulting from the teachers’ direct attempts to carry out their or the planners intentions and the hidden learning that occurs.

2.1.2 Curriculum Practice

Davies and West-Burnham (1997:223) insist that a great fallacy of late twentieth century educational policy-making at macro and micro level is the belief that there is a necessary and contingent relationship between teaching and learning. The authors present the case that teaching can take place with no resulting learning. They contend that at a micro level, the school’s management structures and processes represent a ‘natural organisational imperative to seek to codify and to simplify’. (Davies and West-Burnham 1997:224) Inherent in the revised primary curriculum at a macro level is a move away from this belief towards a focus on learning. The principles underpinning the focus on learning are; new learning is shaped by the learner’s prior knowledge, much learning occurs through social interaction, learning is closely tied to particular situations and success learning involves various strategies.

2.1.3 Implementing Curriculum Change

Reid, Hopkins and Holly (1989:108) and Kelly (1989:15) present The ‘Tyler model of curriculum’ as a model of curriculum change often used in schools.

Objectives ———▶ Content ———▶ Organisation ———▶ Evaluation

Reid, Hopkins, and Holly criticise this model on the grounds that: it trivialises the nature of knowledge, it implies predictable outcomes which is a contradiction to the constructivist theory of learning implicit in the curriculum, learning cannot be carefully packaged and has little to offer to increase the quality of educational performance. Elliot (1991:17), reflecting on the work of Stenhouse (1975) presents this approach to curriculum change as the changing of content rather than the process of education. It represents the traditionalists' commitment to the view that education is about the reproduction of knowledge content.

Fullan (1992:112) outlines the following three factors that relate to the characteristics of change: need, clarity and complexity.

- Need: Teachers frequently do not see the need for the advocated change. There is also difficulty in prioritising needs among a set of desirable needs.
- Clarity: When there is agreement that some kind of change is needed, clarity is essential. An oversimplification of the interpretation of the change results in false clarity. The main feature of the change in the curriculum is in methodology and because there is no major change in content it may be dismissed on the premise that that 'we are doing this already'. This perception also makes explicit the emphasis on content to the neglect of the salient emphasis on process.
- Complexity: Change requires an array of activities, structures, diagnoses, teaching strategies and philosophical understanding if effective implementation is to be achieved.

Reid, Hopkins and Holly (1989:112) present a model of curriculum development based on the work of Gibbons (1977) (diagram 2.1) which, 'helps teachers and others become

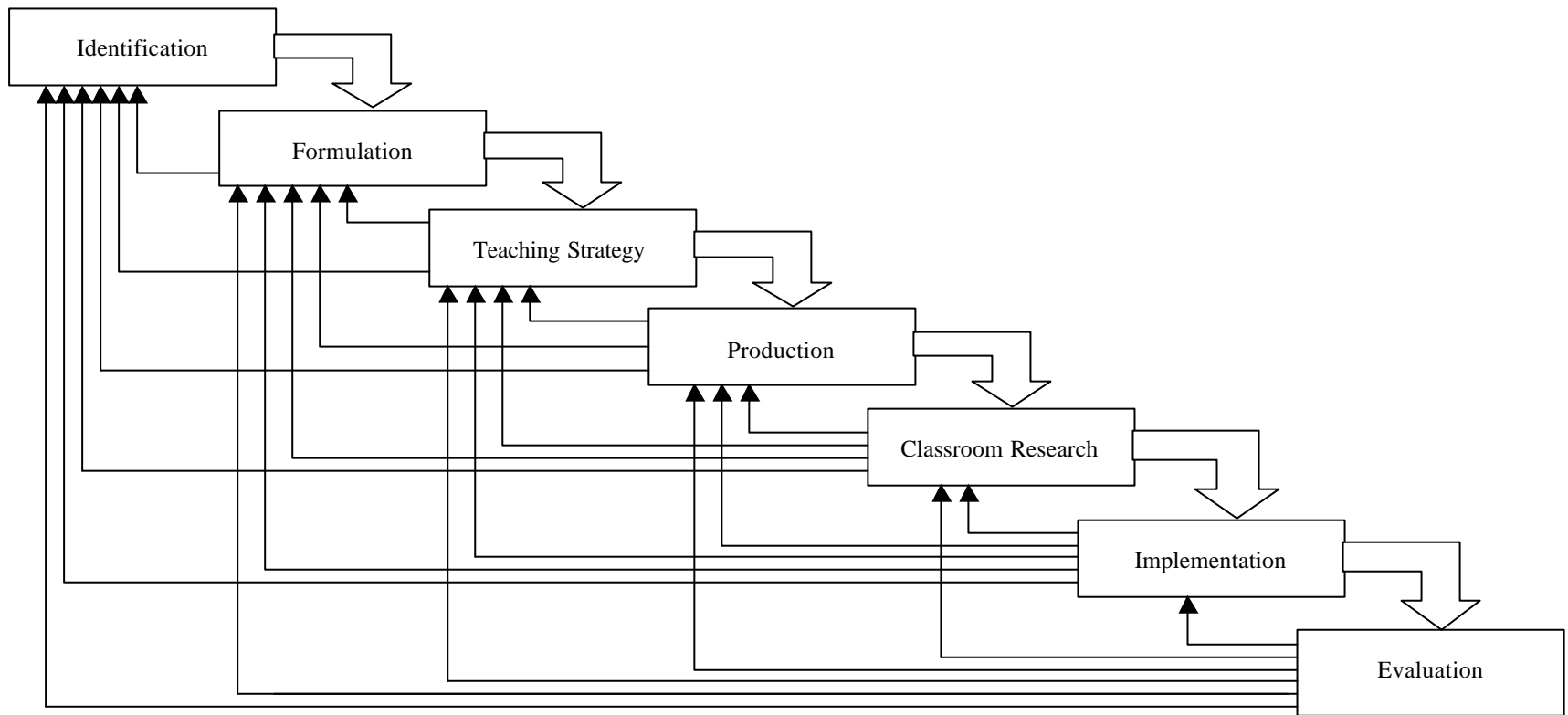


Diagram 2.1: Curriculum Development Cycle

Reid, Hopkins and Holly (89:112)

more systematic and reflective about the curriculum development task' 1989:112). The model consists of seven stages, each with a specific task. It involves a series of adaptable, overlapping and inter-related cycles of activities that enable a range of ideological perspectives on the curriculum to be accommodated.

Reid, Hopkins and Holly (1989:123) report that a component of change that is often tackled is a change in textbooks and yet it is on the necessary changes in teaching style, understanding and commitment, that the success or failure of implementation depends.

2. 2 Facilitating curriculum change

Teachers need to participate in the change process to ensure its success. This leads to a sense of ownership and empowerment. 'Worker empowerment means less resistance to change since people tend to support what they create. Thus, an increasing common tool for creating an involvement culture is the use of worker teams'. (Hackett and Martin 1993:10)

The facilitator is described by Hackett and Martin (1993:12) as, 'an individual who is responsible for structuring teams, groups or task forces, and their activities to provide for their success in attaining organisational goals and objectives'. In facilitating the change process through the use of teams, the role of the facilitator role is to 'tap into a group energy which respects trust, perception, mission building and innovation' (Mulcahy:01).

'Effective leaders are increasingly those people who are capable of facilitating change and improvement through team empowerment' (Hackett and Martin 1993:12). The authors advise that the involvement of teams empowered to enhance quality has spawned a relatively new set of skills among leaders. These skills are characterised as facilitation skills.

Facilitation skills are elaborated on by Davies and West-Burnham (1997:234) who suggest that ‘effective leadership and management in the new millennium involves; knowing yourself, knowing others and integrating that knowledge with communicative and business skills to achieve new and powerful outcomes’. The authors present personal skills, which they regard as necessary to create an effective performance culture:

- Outcome-orientated; this requires focusing on the activity that is being sought with continual redirection of personal goals towards achievement.
- Taking charge of the agenda by becoming proactive: interpreting the organisational situation and reorganising it to best suit the educative process.
- Creative thinking: promoting different solutions to the many challenges are required.
- Self-knowledge of own skills, abilities and leadership traits are a prerequisite to effectively facilitating others
- Knowing others and becoming accustomed to their needs and perspectives, awareness of undertones.
- Effective communication skills contribute to leadership effectiveness

West-Burnham (1990:96) contends, ‘organisations only have reality through the experiences of the individuals working in them and so managing change comes down to enhancing the ability of individuals to learn and communicate that learning within the context of the organisation as a whole’. The integration of personal management skills – time management, conflict management and stress management into the facilitation process are necessary to effectively manage change.

Ellison (1990:124) comments that while much attention is given to the topic of time management in business management training it is an issue that is often ignored in education. The reason for this emanates from the fact that classroom teachers are responsible for the children in their classes throughout the day with no time to engage in management tasks. Effective personal management of time involves building relationships, recognising new opportunities, determining purpose, values and priorities.

Empathic listening is a prerequisite of managing conflict. 'Empathic listening gets inside another person's frame of reference. You look out through it, you see the world the way they see the world, you understand their paradigm, you understand how they feel' (Covey 1989:240). According to Riches (1998:170) 'participants in communications can easily have different values which may reflect deep emotions, beliefs and prejudices, and refuse to recognise and understand other people's viewpoint'. When opposing views, needs and revised curriculum was appropriate to the planning for the implementation of the curriculum at this stage.

2.3.0 The mathematics curriculum

An important aim of the curriculum is to provide opportunities for the child to explore the nature of mathematics and to acquire the knowledge, concepts and skills required for everyday living and for use in other subject areas. With due regard of the intrinsic abilities and varying circumstances it is envisaged that concerns are understood then the work on collaborative problem solving can begin.

A psychological approach to stress management focuses on the interaction of the person and the environment. Edworthy (2000:5) presents this concept of stress as 'something that occurs within the individual when they are faced with demands that tax or exceed their

resources'. Implementing change in schools may be a source of stress if the gap between what is being demanded of teachers and what teachers are capable of delivering is not bridged. Stress can be reduced or eliminated by the following; forming a direct relationship with the pace and scale of change and the capacity to absorb it, a willingness to be open to different views and provision of time for planning and discussion.

A review of literature on mathematics education reflecting the aims of the the mathematics curriculum will enable the child to acquire the following skills:

1. Apply mathematical concepts and processes, plan and implement solutions to problems, in a variety of contexts.
2. Communicate and express mathematical ideas, processes and results in oral and written form.
3. Make mathematical connections within mathematics itself, throughout other subjects, and in applications of mathematics in practical everyday contexts.
4. Reason, investigate and hypothesise with patterns and relationships in mathematics
5. Implement suitable standard and non-standard procedures with a variety of tools and manipulatives
6. Recall and understand mathematical terminology, facts, definitions, and formulae

(Government of Ireland 1999:12)

A constructivist approach to learning mathematics is central to the revised mathematics curriculum.

'A constructivist approach to mathematics learning involves the child as an active participant in the learning process. Existing ideas are used to make sense of new experiences and situations. Information acquired is interpreted by the learners themselves, who construct meaning by making links between new and existing knowledge' (Government of Ireland 1999:5).

The importance of providing the child with structured opportunities to engage in exploratory activity in the context of mathematics is emphasised. The crucial role of the

teacher is identified in guiding the child to construct meaning, to develop mathematical strategies for solving problems, and to develop self-motivation in mathematical activities. Enabling the child to use mathematical language effectively and accurately is documented. Discussion with the teacher and peers is acknowledged as playing a significant role in the development of mathematical concepts. It is recommended that concepts should be adequately developed through oral reporting and discussion before finding expression in written recording. The extensive experience of manipulating and using objects is an essential component that is highlighted in the development of both mathematical concepts and constructive thought throughout the strands of the curriculum.

2.3.1 Children and learning

Sperry (1997:14) advises that the writings of three famous cognitive psychologists give teachers information on developmentally appropriate education. She comments that Piaget, Bruner and Vygotsky have influenced education throughout the twentieth century and have made significant contributions to the way teachers of mathematics approach the process of teaching and learning.

Clemson and Clemson (1994:6) state that the work of Piaget has had a powerful impact on mathematics education. Piaget suggests that children think differently from adults and that their thinking passes through five main stages, which are equated to chronological bands. Sperry (1997:14) believes, 'the strengths of the Piagetian approach include a focus on the child's thinking, or the process, not just the answer; self initiated

active involvement in a rich environment; avoiding pushing the child to be adult like, and viewing the role of the teacher as a guide or a resource person’.

Clemson and Clemson (1994:7) also propose the work of Jerome Bruner as an important influence on how children’s learning is viewed. Bruner (1966) as cited in Clemson and Clemson (1994) defines three modes of thinking: enactive, iconic and symbolic. Enactive representation means learning through action, iconic representation depends upon the use of images to detect patterns and symbolic representation refers to the utilisation of symbols through which hypotheses can be explored and manipulated. The authors suggest that it is likely that the enactive mode is the pre-eminent mode for young children and advise that the imperative for teachers in arranging learning situations for young children is to make them ‘active and practical’.

Cobb et al. (1997:10 -11) comment on the work of work of the Russian psychologist Lev Semenovich Vygotsky (1896-1934) translated in the 1970’s. The major theme of Vygotsky’s theoretical framework is that social interaction plays a fundamental role in the development of cognition. A child learns as he interacts with peers who have established higher capabilities and with adults. ‘In Vygotsky’s view it is the adult’s responsibility to help the child perform actions that are beyond his or her individual competence. ‘As the child interacts with the adult, he or she gradually takes over and internalises these intermental or socially distributed actions’ Cobb et al. (1997:11). Sperry (1997:15) refers to this as ‘their zone of proximal development’. Co-operative learning groups are recommended, where children hear other people’s thoughts and assimilate their own ideas into their own private speech. The combined theories of these educationalists form the basis

for constructivism, a theory that views the child as creating knowledge by acting on experience gained from the world and then finding meaning in it.

2.3.2 Constructivist learning

Gagnon and Collay (1995:1) contend that constructivism represents a paradigm shift from education based on a behaviourist epistemology that focuses on intelligence, domains of objectives, levels of knowledge and reinforcement to education based on a constructivist epistemology that assumes learners construct their own knowledge on the basis of interaction with their environment. The authors present four epistemological assumptions that they regard as critical to constructivist learning.

Gagnon and Collay (1995:1-2) state

1. Knowledge is physically constructed by learners who are involved in active learning.
2. Knowledge is symbolically constructed by learners who are making their own representations of action.
3. Knowledge is socially constructed by learners who convey meaning to others.
4. Knowledge is theoretically constructed by learners who try to explain things they don't completely understand.

Constructivist leaning is implicit in curriculum reform in other countries. Mathematics curriculum reform in the United Kingdom and in the United States of America reflects a focus on the learning of mathematics with understanding. Anghileri (2000:2) indicates that reform of the mathematics curriculum in the United Kingdom has led to shift from teaching standard procedures for calculating, to enabling children to observe patterns and

relationships, and make connections so that they develop insight and a feel for numbers. She emphasises that understanding relationships between numbers and developing methods of computation has become the focus for learning. This process involves children in constructing their own methods.

‘Children are no longer considered as ‘passive’ receivers of information, but are actively ‘involved’ in constructing their own knowledge through discussing their own strategies and making sense of those used by others. Explaining what they are doing and justifying their decisions helps children to develop skills in reasoning and clarity in communication that will have benefits across all aspects of learning’

Anghileri (2000:7).

The National Council of Teachers Of Mathematics (2000:20) reflects a vision for mathematics education in the United States of America, which is based on students learning mathematics with understanding. The authors contend, ‘students understanding of mathematical ideas can be built throughout their school years if they actively engage in tasks and experiences designed to deepen and connect their knowledge’.

Haylock and Cockburn (1997:3) report that learning without making connections is what they regard as learning by rote. The authors view growth in understanding in mathematics as the building of cognitive connections between the four types of experiences concrete materials, symbols, language and pictures. Any one of the arrows in diagram 2.2 represents a possible connection between experiences that might form part of the understanding of a mathematical concept.

symbols



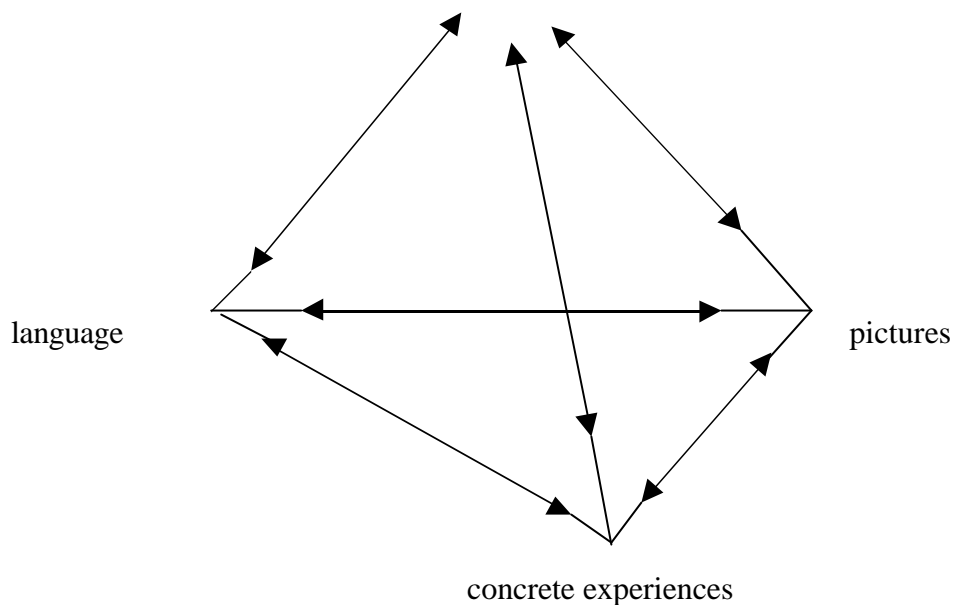


Diagram 2.2 Some significant connections in understanding mathematics
Haylock and Cockburn (1997:3)

Askew (1998:3) states his belief about learning mathematics as ‘essentially a social process and comes about through the sharing of ideas’. He recommends more attention needs to be given to pupils’ processes in carrying out arithmetic. Helping children become confident in number he believes children need to have broad and balanced experiences. ‘Broad in the sense of encountering mathematical ideas through a variety of practical resources and contexts. Balanced in the sense of any particular way of working not being dominant’ Askew (1998:7).

Ackermann (1995:342) elaborates the role of the teacher in promoting understanding by considering the dynamic relationship between the knowledge of the children and the knowledge of the teacher. Without engaging in what he called ‘indirect teaching’, the role of the teacher would be limited to regarding children from the point of view of conventional adult knowledge emphasising the teacher as a first order observer. ‘As a

teacher learns to appreciate her student's views for their own sake, and to understand the deeply organic nature of cognitive development, she can no longer impose outside standards to cover wrong answers' Ackermann (1995).

The importance of the social construction of learning and the role of the teacher is emphasised by Steffe (1996:82), 'without establishing rich consensual domains of interactive mathematical communication with children, we adults cannot possibly understand children's mathematics as a dynamic and living subject nor could we understand how to bring it forth'. He further states that what the teacher interprets from children's actions and operations is complex because 'the adult must create mathematical concepts and operations that she may not attribute to her own mathematical reality'. To overcome this he believes, the teacher is required to assume the role of a second-order observer which involves being aware of her own activity in interaction, and of the influence this might have on learning. Steffe (1996:96) recommends experiential situations that are of interest to children and have the possibility of engaging children in mathematical activity with a playful orientation.

2.3.3 Critical dimensions of classrooms that promote understanding

Carpenter and Lehrer (1999:19) advise that in order to prepare mathematically literate citizens for the twenty-first century classrooms need to be restructured so mathematics can be learned with understanding. The authors consider the availability of an emerging research base that describes how students themselves construct meaning for mathematical concepts and processes and how classrooms support that kind of learning.

The authors propose five forms of mental activity from which mathematical understanding emerges.

- Constructing relationships
- Extending and applying mathematical knowledge
- Reflecting about experiences
- Articulating what one knows
- Making mathematical knowledge ones own

In proposing these five forms of mental activity the authors point that they are not suggesting that all students learn in exactly the same way or that understanding always looks the same in all individuals. What is proposed is that the development of understanding involves these forms of mental activity in some way. Carpenter and Lehrer (1999:24) advise that in order for learning with understanding to occur on a widespread basis, it is essential that opportunities be provided that enable the children to engage in these activities. The authors outline three dimensions of instruction that need to be considered in order to organise a classroom that promotes understanding: tasks, tools and normative practices.

For understanding to develop on a widespread basis tasks must be engaged in for the purpose of fostering understanding, not simply for the purpose of completing the task.

Tools are described as paper and pencil, manipulative materials, calculators, computers and symbols. The connection between symbols and symbolic procedures and the underlying mathematical concepts they represent are not always apparent. Connections with representational forms that have intuitive meaning for students can greatly help students

give meaning to symbolic procedures. Normative practices form the basis for the way tasks and tools are used for learning. In classrooms that promote understanding, the norms indicate that tasks are viewed as problems to be solved, not exercises to be completed using specific procedures. Students expect that the teacher and their peers will want explanations as to why their conjectures and conclusions make sense and why a procedure they have used is valid for the given problem. In this way, mathematics becomes a language for thought rather than merely a collection of ways to get answers. Co-operative group work is suggested to encourage reflection and articulation on tasks. When students are solving a problem together, they must articulate their assumptions, conjectures and plans to one another.

Carpenter and Lehrer (1999:24-25) insist that teachers need to understand the mathematics and understand students' thinking. Without this requisite understanding they believe teachers will be relegated to the routine presentation of ideas neither written nor adapted for their own students. This entails understanding how mathematics is reflected in the goals of instruction and in different instructional practices. Knowledge of mathematics must be linked to knowledge of students' thinking so that teachers can recognise landmarks of understanding in individuals. The authors advise that teacher carefully select tasks and tools to provide a window on student's thinking, in order for the teacher to provide more appropriate instruction for specific students and also so that better models for understanding students thinking in general can be constructed.

Fennema et al. (1999:189) also outline the teachers' responsibilities for developing classrooms that promote understanding as; the establishment of classroom norms that encourage learning with understanding, the selection of tasks that lead to understanding,

the purposeful incorporation of equity concerns and the assessment of each students' understanding.

Askew (1998:159) suggests that many children's experience of learning mathematics is a set of rules and procedures. Methods are set out by the teacher or a textbook. The children are expected to learn uncritically from these methods. Alternatively children may be given a problem to solve and left on their own to discover a method of solution. The former is referred to as a transmission model, the latter a discovery model. Askew believes that these models have real limitations in their most extreme. An over emphasis on transmission can lead to children not thinking about mathematics and relying too much on the teacher telling them what to do. Too much emphasis on children discovering methods can lead children to using inefficient and inappropriate techniques.

Semadeni (1996:218) highlights the limitations of iconic and symbolic representations of arithmetical concepts in early grades of primary school. The author is of the opinion that these representations have a serious shortcoming when shown in a textbook, 'they are usually static, appearing ready printed, and hence difficult for the child to comprehend' Semadeni (1996:221). He believes this to be a major obstacle to the children's understanding.

'In many schools, iconic and symbolic representations are used too early, without adequate introduction and motivation. One of the reasons is that only two types of representation can be shown in textbooks. Textbooks are the easiest way of organising classroom instruction. Organizing manipulation of concrete objects requires much more effort on the part of the teacher – it is technically more complicated, requires flexibility, individualisation, coping with clumsiness of certain children and so on' Semadeni (96:221).

This view is also supported by Gifford (1997:76) who states 'in class management terms, it seems easier to give children written tasks and to structure their recording'.

Standifler's (1993:99) suggests that traditionally, mathematics has been a 'silent subject' with children quietly listening to a teacher or completing written worksheet assignments. She suggests that to foster arithmetic understanding and thinking, children need to be active. They need to be engaged in real and purposeful activities, to exchange ideas and strategies and to defend their procedures and answers.

Kamii (2000) favours the use of maths games as an appropriate strategy that enables teachers to develop classrooms that provide children with opportunities to communicate mathematical understanding in contrast to the conventional use of textbooks and worksheets.

2.3.4 Principles of teaching with games

Kamii (2000:ch 12) recognises as essential, the teachers need to capitalise on children's intrinsic motivation to learn. 'Children choose to engage in them and try to become increasingly better at them. Some children even ask if they can take playing cards to the lunchroom, but they never ask if they can take a worksheet to the lunchroom' Kamii (2000:200). Kamii considers the desirability of games over worksheets. Motivation is intrinsic in games partly because they are a natural activity in childhood and when children engage in an activity for the pleasure of the activity they are likely to repeat it. Feedback is immediate in games because children supervise each other. By contrast it is impossible to give immediate feedback to worksheets. In a game the players decide whether an answer is correct, when worksheets are used truth is perceived as being decided by the teacher. Games can be played at many levels in a variety of ways. Worksheets encourage children to write answers mechanically. Writing answers can interfere with the possibility of remembering sums. Children are much more likely to remember sums when they are free to

think. Children are more likely to build up a network of numerical relationships. When children complete worksheets they approach each problem mechanically as a separate and independent problem. There is an element of choice in selection of a game. In selecting a game that appeals to children, they are likely to work harder. Children seldom choose the worksheet they get. Playing games reinforces the social interaction of cognitive development. Children interact, compare answers and procedures, make decisions together and learn to resolve conflict together. These activities are precluded when sitting alone filling out worksheets.

Anghileri (2000:13) suggests also that, a most effective way to encourage mental work and classroom discussion is through the use of games and puzzles. 'As a classroom resource, games can present teachers with opportunities for listening to children - 'eavesdropping on playing games is an excellent way to assess their mental skills - and also 'to identify misconceptions'. In support of providing to children who are beginning to develop number concepts, opportunities that make numbers an integral part of their classroom experiences, Burns (1992:161) notes that 'they also benefit from talking about their ideas and hearing how other children think'.

2.4 Summary

Curriculum change poses a challenge to teachers. Stenhouse (1975) as presented by Elliott (1991:16) recognises the centrality of teachers as researchers in curriculum development. Stenhouse claims that there can be no curriculum development without teacher development. Proactive participation in the process will lead to a sense of ownership and empowerment. A starting point for this participation is a belief that

curriculum change will enhance children's education. This belief is dependent on understanding the principles underlying the change and reconciling them with existing attitudes and values. Reviewing literature on facilitation, curriculum development and examining current practice of children learning mathematics in other countries, established a theoretical basis for the study and identified what is already known about the topic of enquiry and highlighted the importance of this study: 'exploring the use of games to enable children to express mathematical thinking and understanding'.

Chapter 3: Methodology

3.0 Introduction

This chapter will analyse the relationship between paradigm and method in research design. It will present a philosophical framework that distinguishes two dominant research paradigms. It will examine ontological and epistemological assumptions inherent in the two research paradigms within this philosophical framework. In light of the contrasting ontological and epistemological assumptions it will reflect on the implications for research methods in this study, which explores the use of games to enable children to express mathematical thinking and understanding.

3.1.0 Philosophical framework of research

Lincoln and Guba (1985:15) claim, 'inquiry whether in the physical or social sciences has passed through a number of 'paradigm eras', periods in which certain sets of basic beliefs guided inquiry in quite different ways'. Maykut and Morehouse (1994:4), define a paradigm as a 'set of overarching and interconnected assumptions about the nature of reality'. The authors suggest, 'a paradigm provides the largest framework within which the research takes place'. The two dominant paradigms are described as positivist and post-positivist or naturalistic paradigm.

Lincoln and Guba (1985:33) propose challenges and critiques of positivism and legitimise the naturalistic paradigm to be known as post-positivism and state that 'post-positivism is an entirely new paradigm not reconcilable with the old'. In an effort to understand the differences between these two paradigms I will explore questions of ontological and epistemological assumptions within the two paradigms. According to Maykut and Morehouse (1994:12), the answers to these questions make up the postulates that under gird different approaches to inquiry.

3.1.1 Questions of ontological and epistemological assumptions (adapted from Lincoln and Guba 1985:37)

The nature of ontology: How does the world work?

Within the positivist paradigm there is only one reality. This can be segmented and analysed in parts independently in order to understand the whole. Inquiry can converge onto a predictable and controllable reality. The naturalistic assumption is that there are multiple realities that can only be studied holistically. Prediction and control are unlikely outcomes, some understanding may be achieved.

Maykut and Morehouse (1994:11) reveal the way we understand the nature of reality directly affects our epistemological assumptions.

What is the relationship between the knower and the known?

The positivist paradigm views the knower as external to what is known. The knower can stand outside what is to be known. Knowledge is objective and tangible. The naturalistic assumption interprets the knower and the known as inseparable and interdependent.

What role do values play in understanding the world?

Values can be suspended in order to understand within the positivist paradigm.

Values mediate and shape understanding within the naturalistic paradigm.

Related to these questions of ontological and epistemological assumptions are the questions of causal linkages and generalizability.

Are causal linkages possible?

Within the positivists framework events are sequenced and can be explained as the result of a cause. Within the naturalistic framework it is impossible to distinguish cause from effect as all entities are in a state of mutual shaping.

What is the possibility of generalisation?

Within the positivist paradigm explanations from one time and place can be generalised free from time and context. The naturalistic paradigm aims to develop a working hypotheses that describe an individual case that is time and context bound.

Maykut and Morehouse (1994:12) regard quantitative research as resulting from the postulates of the positivist paradigm and qualitative research resulting from the postulates of the naturalistic paradigm. The ontological and epistemological assumptions inherent in the each tradition have enormous implications for the way research will be conducted.

Cohen, et al. (2000:5) state, 'educational research has at the same time absorbed two competing views of the social sciences- the established, traditional view and a more recent interpretive view'. The traditional or quantitative view claims social sciences and natural sciences are in essence the same and as such are 'therefore concerned with discovering natural and universal laws regulating and determining individual and social behaviour'. The interpretive or qualitative view emphasises the difference between people and each other and also the difference between people and inanimate natural phenomena, 'while still sharing the rigour of the natural sciences and the same concern of traditional social science to describe and explain human behaviour'.

Guba and Lincoln (1998:201) insist that the methodological question of 'how can the inquirer go about finding out whatever he or she believes can be known' is constrained by answers given to ontological and epistemological questions. 'The methodological question cannot be reduced to a question of methods; methods must be fitted to a predetermined methodology'. I will now answer these questions to clarify what paradigm informs and guides the research.

3.1.2 Questions of ontological and epistemological assumptions and the nature of my research

What is the nature of reality?

The classroom does not represent a homogenous group of children. It comprises of multiple realities in the form of individual, unique children with different intellects. Each child presents with a different physiological and cognitive style unique to him or her, which will influence learning. Learning is also influenced by environmental factors such as; socio-economic background, family expectation and attendance at school. The school itself represents multiple realities, among which are its teaching methods, pupil teacher ratio, cultural and ethnic factors, relationships between teachers and pupils, pupils and their peers and teachers and parents. Inquiry in this context must recognise the interconnected variables that affect learning.

What is the relationship between the knower and the known?

Children are active agents in their own learning. Learning reflects the child's experience of and interaction with his or her environment. The child is an active agent in constructing his or her own knowledge. Sugrue (1997:3) states, 'teaching and learning are intimately connected and it is difficult to come to terms with one without the other'. Implicit in this relationship is an acknowledgement that teachers as researchers interact with children in order to develop an understanding of their learning. Understanding individuals' behaviour is dependent on 'the researcher sharing their frame of reference: understanding of individuals interpretations of the world around them from the inside, not on the outside'. Cohen et al (2000:21)

What role do values play in understanding the world?

Inquiry is influenced by the values inherent in the context of the research question. In order to foster arithmetic understanding and thinking, children need to be active. The revised curriculum presents constructivist learning as central to the mathematics

curriculum. It places emphasis on understanding and building on students thinking. Children do not construct knowledge alone. They invent mathematical ideas together and learn to communicate these ideas. They test ideas and approaches based on their prior knowledge and experience.

The following are my values which form an integral part of the research:

- implementation of a mathematics curriculum that promotes children's understanding
- accommodating individual differences among the learning styles of the pupils
- promoting the role of social interaction in developing mathematical understanding
- recognition of the interactive nature of teaching and learning which requires teachers to engage actively with children to elicit understanding in order to plan appropriate instruction

These values permeate the conduct of the inquiry. Whitehead (1998:2) defines values as 'those qualities which give meaning and purpose to our personal and professional lives'.

Are causal linkages possible?

Given the multiple realities that exist in any classroom it is impossible to distinguish causes from effects. 'If reality is multiple and constructed, it follows that the causal links will be mutual and that in terms of what an event of action means, the event is not unidirectional but multidirectional' Maykut and Morehouse (1994:11). Hitchcock and Hughes (1995:25) present the view that the processes of education, teaching and learning are so complex and multifaceted that to focus upon cause and effect, products, outcomes or correlations in research on schools is of limited value.

What is the possibility of generalisation?

In light of answers to the previous questions theories of generalisation are context bound. 'Each school is a unique organisation, with a distinctive character, tradition and culture, and a particular set of values and priorities. It is influenced by its size, location, and by particular internal and external environmental circumstances and dynamics' (Department of Education 1999:63).

These ontological and epistemological assumptions legitimise the qualitative methodology chosen that will guide the inquiry. Denzin and Lincoln (1994:2) offer a generic definition of qualitative research as 'multimethod in focus, involving an interpretive, naturalistic approach to its subject matter'.

3.2.0 Designing qualitative research

I will now focus on the characteristics of qualitative research. A qualitative research study is designed to develop a deeper understanding of some 'phenomenon of interest'. Maykut and Morehouse (1994:43) It takes place in the natural setting where 'realities are wholes that cannot be understood in isolation research from their contexts'. (Lincoln and Guba 1985:39) Qualitative data collection requires methods that are natural to social situation of the inquiry. A variety of data collection methods can be used. 'Each method attempts to capture people's words and actions, the data of qualitative research' Maykut and Morehouse (1994:68). These methods include field-notes, participant observation, interviews, questionnaires, documents and diaries. Audio-visual data collection may also be used which according to Cohen et al. (2000:313) 'has the capacity for completeness of analysis and comprehensiveness of material'.

Data collection and data analysis occur simultaneously. Cohen et al (00:147) define data analysis as, 'making sense of the data in terms of the participants' definitions of the

situation, noting patterns, themes, categories and regularities'. Morse and Field (1996:121) outline four cognitive processes integral to all qualitative analysis: comprehending, synthesising, theorising and recontextualising. The researcher collects and analyses the data systematically. Approaches to qualitative data analysis include content analysis, thematic analysis, discourse analysis and visual analysis.

3.2.1 Curriculum implementation using a qualitative research methodology

The NCCA recommended a planned introduction and implementation of the revised primary curriculum with due regard for the size, type and location of each school. Mathematics in-service has been delivered to all teachers in this current academic year 2001-2002. The mathematics curriculum will be implemented in 2002-2003.

At a micro level, the structure and organisation of the present curriculum, its delivery and assessment in the school reflect the emphasis on teaching as an activity rather than learning as a process. The school plan is a statement of broad objectives and content. There is no reference to methodology. The research that I am conducting seeks to develop a focus on the process of student learning in mathematics. The inquiry aims to place children at the centre of the learning process. 'Teachers don't merely deliver curriculum. They develop, define and reinterpret it too. It is what teachers think, what teachers believe and what teachers do at the level of the classroom that ultimately shapes the kind of learning that young people get' (Hargreaves:1994:ix). The systematic and reflective nature associated with curriculum implementation pointed towards action research.

Action research Zuber-Skerritt (1996:83) suggests that 'the aims of any action research project or program are to bring about practical improvement, innovation, change

or development of social practice and the practitioners better understanding of their practice’.

3.3.0 Defining Action Research

Action research is a study of a social situation that focuses on practical problems of professional concern. It is a reflective and evaluative cyclical process of enquiry whereby a problem is clearly defined, a plan of action is proposed, the action is implemented and evaluated to monitor and establish the effectiveness of the action taken. A systematic reflection on this process provides insights into the nature of one’s descriptions and explanations to improve practice, resulting in a claiming of educational development which is communicated for validation.

‘Action research integrates teaching and teacher development, curriculum development and evaluation, research and philosophical reflection, into a unified conception of a reflective practice’ (Elliott 1994:54). The epistemological basis of action research is embedded in critical theory. Cohen et al (2000:28) state the purpose of critical theory is, ‘not merely to understand situations and phenomena but to change them’. Action research promotes professional dialogue and discussion among colleagues. It has the potential therefore to “create a forum for group self-regulation which transforms communities of self-interests into learning communities” (Carr and Kemmis 1993:239).

3.3.1 Action Research Design

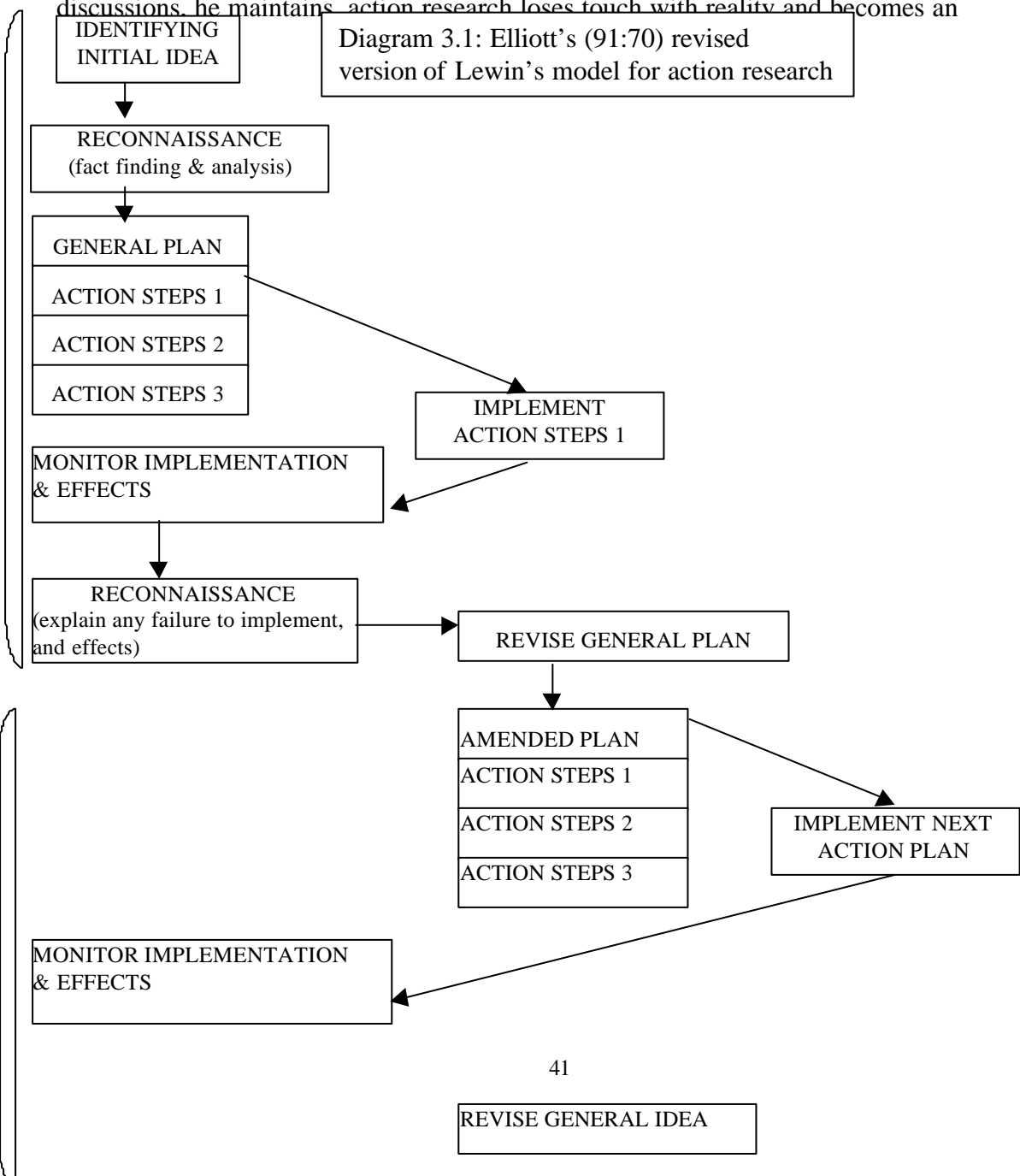
Action research is a cyclical process of: identifying a problem, planning an intervention, evaluating the outcome and critically reflecting on the previous three steps to

CYCLE 1

plan the next cycle. I chose Elliott's elaborated version of Lewin's model of action research (diagram 3.1). Elliott revised version of Lewin's model for action-research is selected as it accommodates a series of action steps in each cycle. The flexibility of this model acknowledges the complexity of the context in which teachers work.

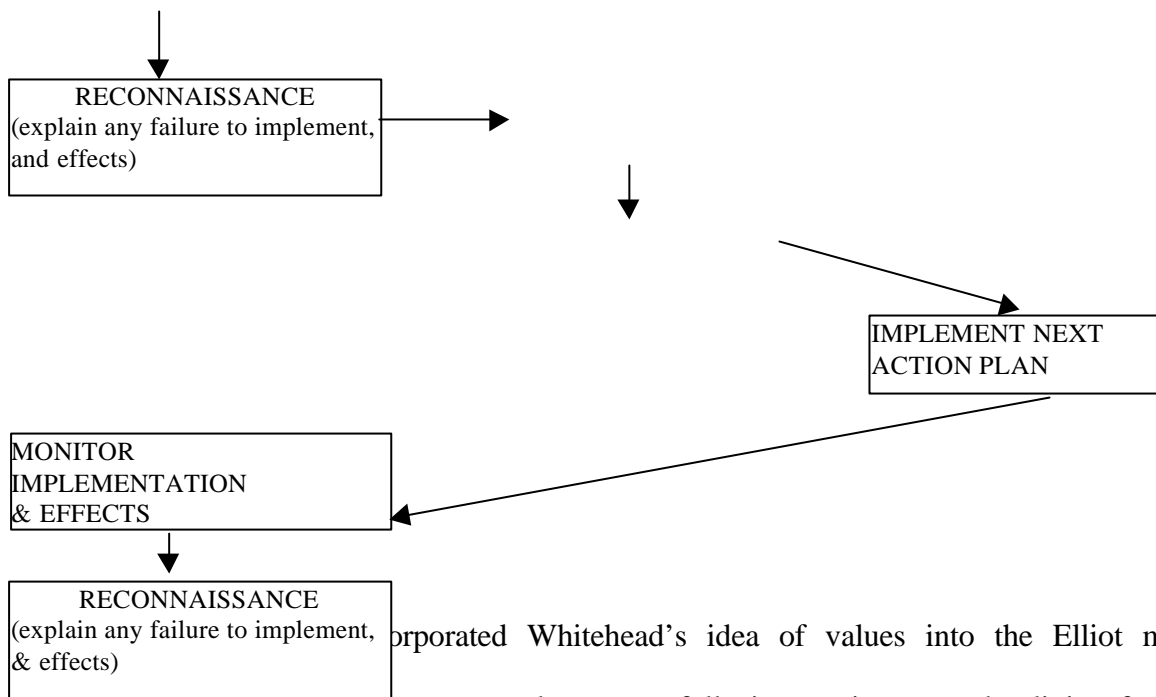
McNiff (1988:37) presents the view of Whitehead who is 'keen to keep the teacher-practitioner at the centre of the inquiry'. 'Unless we keep the living 'I' in our educational

discussions, he maintains, action research loses touch with reality and becomes an



CYCLE 2

CYCLE 3



incorporated Whitehead's idea of values into the Elliot model whereby the desire to live out my values more fully in practice created a living form of action research.

- How do I live my educational values in practice?
- Clarifying the meanings of my values as they emerge in practice, transform my values into living criteria or standards.
- Can I share my values/criteria with other teachers in my school to develop a shared understanding, which may transform their practice?

Elliot (1991:69) portrays Lewin's model as a spiral of cycles involving a basic cycle of activities from which the researchers then spiral into developing a second cycle of activities. 'New action-reflection cycles develop out of previous ones, so it is possible to imagine a series of cycles, in order to show the process of developing practice' McNiff (1995:11). Elliot recognises Lewin's model as an excellent starting point for action-researchers. However he is critical of fixing the general plan in advance and also

recommends that reconnaissance should involve analysis as well as fact-finding. I followed the revised model allowing me the opportunity to clarify the general idea as part of reconnaissance in each of the action cycles.

3.3.2 Methods for data collection

Lincoln and Guba (1985:40) state that the interpretative researcher uses qualitative methods of data collection over quantitative methods in an inquiry, as they are more adaptable to dealing with multiple realities. These methods are 'more sensitive to and adaptable to the many mutually shaping influences and value patterns that may be encountered'. Multiple methods of data collection were conducted to present a chain of evidence to support the research question: Do games enable children to express mathematical thinking and understanding? According to Cohen et al. (2000:238) in conducting action research the participants can be both methodologically eclectic and can use a variety of instruments for data collection.

Data collection included teachers field notes, documents analysis, tape recordings of group interviews with teachers, classroom observations by teachers, progressive observation as an assessment tool, and videotape.

Prosser and Schwartz (1998:116) image based researchers state, through the use of photographs they can communicate the feeling or suggest the emotion imparted by activities, environments, and interactions. 'We can provide a degree of tangible detail, a sense of being there and a way of knowing that may not readily translate into other symbolic modes of communication'. Photographs were used to provide the reader with an opportunity to capture a visual image of the actions of the children engaged with the games

to complement the written report. Labinowicz (1985:35) suggests that the most complete documentation of interviews with children is offered by videotape. Audible and visible behaviours can be replayed for analysis.

Recognising the collaborative characteristic of curriculum development interviews with teachers were conducted as a group with the purpose, as defined by Maykut and Morehouse (1994:103) 'to understand what people experience and perceive about the focus of inquiry, through a process that is open and emergent'.

3.3.3 Methods for Data Analysis

Winter (1982) as cited in Cohen et al. (2000:241) draws attention to the lack of clear established procedures for data analysis in action research. 'The action research/case study tradition does have a methodology for the creation of data, but not (as yet) for the interpretation of data'. Maykut and Morehouse (1994:121) report that qualitative data analysis is fundamentally a nonmathematical analytical procedure that involves examining the meaning of peoples' words and actions. Research findings are inductively derived from this data. Data analysis began during the data collection process. The data was examined using 'tactics for generating meaning' as outlined by Miles and Huberman (1994:245)

Strategy for generating meaning involved elements of the following activities:

noting patterns and themes, seeing plausibility, clustering, making contrasts and comparisons and making conceptual/theoretical coherence.

3.3.4 Issue of rigour and validity

Winter's (1996:13-14) six key principles of action research are integrated into my methodology to ensure scientific rigour and will be the criteria by which I will judge the study for rigour.

Reflexive critique: This study insists upon modest claims on the basis of judgements of personal experiences. Accounts are written up from interviews, observations and statements gathered from participants. The reflexive basis of these accounts is made explicit so that claims may be transformed into questions.

Dialectical critique: The revised curriculum has influenced my thinking about my educational values and the desire to engage with the new curriculum. An analysis of how the action research process accommodated this activity, its influence on, my own learning, children's learning and teachers' learning is presented through a dialectical critique.

Collaboration: Each participant's view is taken as a contribution to understanding the situation.

Risking disturbance: As a researcher I have engaged in a process where the purpose is change. This process is investigated and reported. My report must show evidence that change has taken place.

Theory and practice internalised: Theory and practice are mutually dependent phases of a change process, which represents the strongest case for practitioner action research as an activity which represents a rigorous and worthwhile form of practical professionalism and a rigorous and valid form of social enquiry. The theory of the enquiry based in practice is itself transformed by the transformation of practice.

Documentation of the multiple methods of data collection and data analysis throughout the study was maintained to add to the trustworthiness of the research. Whitehead (1989:5)

states, 'questions of validity are fundamental in all research which is concerned with the generation and testing of theory'. Triangulation of data sources was used to collect observations and accounts from a variety of angles. Among the data sources were; visual and audio data, teacher observation of children and interview-based assessments of children's understanding.

McNiff (1988:131) stating that a common challenge to action research is that it is subjective and therefore unreliable, outlines three steps towards establishing the validity of a claim to knowledge: self validation, peer validation and learner validation. Self - validation concerns the interpretation of one's own practice and decision to improve it because of a desire to live out educational values more fully, a cycle of action and deliberate critical reflection, which together constitute a claim to educational development. During the action research process I participated peer validation group meetings at Dublin City University (DCU) with my supervisor and three masters students who were also conducting action-research as a means of validating my claim to educational development that 'mathematical games enable children to express mathematical thinking'. The validation meetings helped me to critically assess my claim to knowledge and clarified what evidence I needed to present to support my claim to knowledge.

Learner validation presented through the use of video recordings of children engaged with maths games provided essential evidence that I have influenced their learning.

3.3.5 Ethical Considerations

I made participating colleagues aware that as a researcher I would be non-judgmental about their practice. Anonymity of the all participants was protected. Teachers are referred

to by the class that they teach, the children's names have been changed. Permission was sought from parents and guardians of the children in these classes for tape-recording and video recording to take place (appendix A).

3.12 Summary

Guba and Lincoln's (1998:218) recommend that no inquirer 'ought to go about the business of inquiry without being clear about just what paradigm informs and guides his or her approach'. I share the opinion of Pateman (1996:322) who insists that, 'research based on quantitative paradigms has produced little in the way of advice for teachers as to how to conduct their classrooms in the struggle to teach mathematics'. The qualitative paradigm acknowledges that classrooms are complex places. A qualitative research approach allows the researcher to ask 'how do children learn mathematics under the influences of the social interactions they engage in daily, instead of what mathematics do children know or should know'. Pateman (1996:322)

In light of review of literature on facilitating curriculum development, children and learning I will now report on the action research process applied to the curriculum development model described earlier that allowed me to explore the following question: how do I improve the process of mathematics education in my school.

Chapter 4 Action Research Process

4.1.0 Cycle 1: Identifying the initial idea: A systematic and reflective approach to curriculum implementation

According to Elliott (1991:72) the general idea is essentially a statement, which links an idea to an action. He relates two important criteria for selecting the general idea: it impinges on one's field of action and it is something one would like to change or improve on.

The revised mathematics curriculum is scheduled for implementation in September 2002. Arising from my interest in mathematics education I was concerned that a systematic and reflective approach be undertaken to implement the mathematics curriculum. The use of maths games is a recommended approach. My concern at this stage was to explore the use of games as an approach to enable children to express their mathematical thinking and understanding.

4.1.1 Reconnaissance: Analysis of the underlying principles of the revised curriculum

I began the reconnaissance phase of action-research in March 2002 after mathematics in-service training was delivered. Data collection methods used at this initial phase of reconnaissance were: the researchers diary, curriculum documents, interviews with participating colleagues. Elliott (1991:73) outlines two parts to the reconnaissance phase of action-research: describing the facts of the situation and analysing the facts of the situation

Description of the facts of the situation

The underlying principles of the revised mathematics curriculum based on a philosophy and psychology of teaching and learning were presented at mathematics

curriculum in-service on March 7th and 8th. The skills spanning the content of the curriculum that is envisaged the children will develop were mentioned. The child-centred nature of the mathematics curriculum was emphasized and in particular the role of play in learning. The rationale for using games and activities was clearly communicated. Teachers engaged in some mathematical games and activities.

A meeting was held with the teachers participating in the study to reflect on their thoughts of the recent in-service training. As this was my first meeting with my co-researchers I decided not to audio-tape on this occasion, notes were taken at the meeting (appendix C). My co-researchers acknowledged that there is no major change in content in the revised curriculum. The activities and games were especially enjoyed and it was conceded that 'we should be doing a lot more' by the teacher of second class. When questioned why she thought this she answered, 'I can see the value in the games. I enjoyed playing them myself, there is a fun element. Children really enjoy games, they are very motivated. They can talk, while they are talking they are learning and while they are learning they are talking. But getting organised is the problem. There is certainly cheap equipment available'.

The teacher of first class mentioned that she started to use some base ten material during her maths activities and even though she didn't have enough she noticed how patient the children were in waiting for their turn. The teacher of junior infants was concerned about documenting the children's progress as they engage with practical activities. She remarked, 'a textbook provides a record of children's work'. I sought their opinions on why activities and games aren't used in maths classes. Storage, finding time getting or making the resources, quantity, furniture and grouping of the children were mentioned.

Analysis of the facts of the situation

The data gathered here was partitioned into positive and negative comments about the use of games (table 4.1)

Positive	Negative
Enjoyment	Storage
Child-centred	Quantity
Motivation	Furniture
Value	Grouping children
Inexpensive equipment	Record keeping
Opportunity for discussion	Class size
	Time

table 4.1: Teachers comments on the use of games

The positive comments revealed an understanding of the benefits of games and activities. The negative comments were concerned with organisation of resources, pupils and record keeping.

I related the success of the action research project last year when I introduced co-operative activities into my mathematics class. I explained that the understanding gained from this study provoked me to facilitate the exploration of mathematical games to enable children express thinking and understanding. I identified my values to the research team: implementation of a mathematics curriculum that promotes children's understanding, accommodating individual differences among the learning styles of the children, promoting the role of social interaction in developing mathematical understanding and recognising the

interactive nature of teaching and learning which requires active engagement with children to elicit understanding in order to plan appropriate instruction.

Above all I communicated that I was concerned that a systematic approach be taken to curriculum implementation that engages teachers in professional dialogue about their practice. According to Fullan (1992:117), ‘some teachers, depending on their personality and influenced by their previous experiences and stage of career are more self-actualised and have a greater sense of efficacy, which leads them to take action and persist in the effort required to bring about successful implementation’.

4.1.2 General plan: Explore games to enable children express mathematical thinking and understanding

A strand of the curriculum was prioritised for the focus of the study. This emerged following a review of the introductory chapter of the curriculum. ‘One of the causes of failure in mathematics is poor comprehension of the words and phrases used. Some of the language will be encountered only in the mathematics lesson, and children will need many opportunities to use it before it becomes part of their vocabulary’ (Government of Ireland 1999:6). An audit of the number strand unit at an in-school planning day for mathematics implementation revealed, the strand ‘comparing and ordering’ is crucial to understanding all aspects of number. (Appendix D) It was agreed that the language of comparing equivalent and non-equivalent sets within the strand unit number presented difficulty to a lot of children in each class in the school in particular when this language was encountered in problem solving exercises. The general plan was to explore games involving the language of comparing and ordering numbers to enable children to express their mathematical thinking and understanding using this language and thereby contribute to the

children's development of number relationships. Thompson (1997:130) argues 'the ability to determine which of two collections is the larger is central to number sense'.

The research question was: do mathematical games enable children to express mathematical thinking and understanding? I proposed tracking the development of skills spanning the content of the curriculum as a means of evaluation.

4.1.3 Action steps

- Design skills development checklist
- Research suitable games
- Develop resources for the game
- Demonstrate the games and explain skills development checklist
- Use the games in the classroom
- Monitor the effectiveness of the games using the skills development checklist

The skills for each class group were outlined as detailed in the revised curriculum with boxes to be marked when the development of a skill was observed for each of the three children (appendix E). Suitable games were selected from Kamii (2000: 144-194) and Wrigley (1999:17-45). Some games were modified and referenced accordingly. A list of the games for each class was compiled with increasing level of difficulty from class to class. Resources, organisation and rules for playing each game were outlined (appendix F). Some of the resources were already available in the school: dienes blocks, unifix cubes and counters. Where there were insufficient amount of resources, the teachers borrowed resources from other classes. I purchased playing cards, dice and two sided counters. Reflecting on the use of regular playing cards in the infant classes though recommended in

the two texts mentioned above, I considered that some children might have difficulty recognising the number value of each card, as they were only beginning to develop number concepts. To overcome this difficulty I designed and produced a set of customised playing cards for the infant classes with the intention of reinforcing number concepts, colour and shape (appendix G). Each set was numbered on the back for organisational purposes. The cards were laminated to make them durable. Numeral cards, game boards and grids were also designed and produced.



Photograph 4.1: Customised playing cards used in the game ‘play by the rules’

I briefly reviewed the skills development checklist and recommended to document any observation of the notable development of any skill. Clarification of some skills were sought. I demonstrated the games at our meeting. Teachers used the games in their classrooms. Selection of games and classroom organisation for the playing of the games was at the discretion of each teacher.

4.1.4 Monitor implementation and effects

A meeting was held with my co-researchers at this first monitoring phase to provide an opportunity; to discuss their experience of the using games, to establish if there was a shared understanding of the skills that the curriculum aims to develop and to also establish if the development of these skills are easily identified among the children while playing the games.

Each teacher outlined their approach to using the games. It varied from a single group playing a game to the whole class. The teacher of second class commented, 'I have given them to the whole class because I feel they are of benefit to the whole class'. The teacher of junior infants observed that playing the game with the whole class revealed difficulties. 'I think doing it as a class, it becomes obvious very quickly who is grasping the concept, and you notice other children that you might have thought were capable but have difficulty'. She further stated, 'I just feel all the children need this'. She also highlighted the social construction of the learning. 'When they are playing maths games as a group, they are correcting each other and learning from each other, especially the traditionally 'weak' child who has been getting the wrong connections, second time around s/he is much sharper'. The teacher of first class also agreed that even when traditionally 'brighter' children play the game very quickly, other children merely observing helps their learning. There was general agreement that the children really enjoyed playing. In some classes children played the games during indoor break time in the classroom.

Observing the development of skills proved quite problematic. Difficulties that emerged included: understanding of the terminology of the skills, the number of skills listed and monitoring the skills. The teacher of second class said, 'sometimes I'm there saying what does that mean, guessing, I'm not sure if I'm right. You couldn't possibly monitor and

record while they are playing and afterwards it is difficult to think back'. She was of the opinion that non-familiarity with the skills resulted in difficulty in recognising their development in the classroom, 'its part of the new curriculum, we haven't really got our heads around the terminology'.

The teacher of junior infants didn't think that the skills applied immediately to the games the children were playing in her class, so the development of the skills were not that instantly obvious to her. The teacher of second class queried if recall of facts when children say 'I have more than you, you have less than me'. I suggested that I understood this to be an example of using mathematical language to communicate and express. The teacher of second class conceded 'well it is probably something that we don't traditionally do in maths'. She outlined an observation of two children playing the game double compare. Each player is required to turn over two cards, add both cards, the child with the greater total wins all four cards. The first child turned over 4 and 2, second child turned over 7 and without turning next card announced that he was the winner. I suggested that recognising the relationship between $4+2$ and 7 involved the skills of reasoning, integrating and connecting. The teacher of junior infants mentioned that during one of the games where children were required to turn up the next card and place it on the table if it came before or after a card already on the table, the children began to search through their bundle to find a suitable card. I stated that I viewed this activity as an indication of the children's ability to problem solve.

At this stage of the group discussion I realised that a clear explanation of some of the skills was necessary in order to observe their development in the classroom. I used exemplars from the games to explain the skills. As the discussion progressed my co-

researchers themselves provided examples. Applying and problem solving in the game 'one more' requires the child to recognise the number on the die, use a strategy to add 1 more - counting on or counting all, recognise that they have found the answer.

There was agreement while it is easy to observe the development of the skill of communicating and expressing, there was consensus that some children find it very difficult to express their mathematical thinking. A discussion followed on the appropriate use of the language of comparing in particular 'greater' or 'bigger'. An example of the ambiguous use of big and small was mentioned. 'I can draw a big 5 or a small 5. My initial response that perhaps there should be a school policy on that issue. The teacher of second class offered an alternative. 'I think what is needed is a few different ways of saying certain things and draw attention to that. Children are going to come across different terminology, go to different classes, different schools, you want their learning to transfer'. This thinking reflects a philosophy of the revised curriculum. 'The acquisition of this ability to transfer learning is a central feature of the curriculum' (Government of Ireland 1999:16).

The teacher of junior infants considered the language of 'before' and 'after' in one game quite difficult for the children in her class. I was curious to know if the game exposed the difficulties children experience in communicating and expressing. She said 'it does, but as well it will help them to make sense of it' which agreed with the viewpoint of The National Council of Teachers of Mathematics (2000:129) who state, 'when students struggle to communicate ideas clearly, they develop a better understanding of their own thinking'. The teacher of second class suggested that using playing cards connects verbal, pictorial and symbolic means of representing numbers. She recognised that playing cards involved categorising sensory patterns and also the game 'guess my number' entails the

skill of reasoning: by giving a clue 'it's more than a guessed number' the child has to reason that this eliminates a lot of numbers.

In light of the clarification of some of these skills, and reflecting on the use of games in their development, I asked if the use of games was more appropriate than the use of a textbook and whole class instruction. This discussion ensued:

Teacher of First Class: A lot of time goes in at the start, teaching the game, even the card game, a lot of children had never held cards before, that tradition seems to be gone, its more computers now.

Teacher of Junior Infants: Even giving out the cards was a skill they had had to learn, one to one correspondence.

Teacher of Second Class: A few children didn't know how to shuffle a deck of cards.

Teacher of Senior Infants: Only twelve children had ever held a pack of cards.

Teacher of Junior Infants: Even with the dice games you could see some children recognising instantly the value of the dots, others had to count.

Teacher of Senior Infants: I was really surprised that in senior infants so many children had to count the dots.

Teacher of Junior Infants: I wasn't that surprised with those that had to count but great to see those who didn't need to count.

Teacher of Junior Infants: I was really shocked with children needing to count the five dots after all the work on the recognition and formation of five.

Teacher of Second Class: In the game 'make the biggest number', almost all the children knew to put the large digit in the hundred's place. I asked the children to say I have more, I have less than you or I have the least. One child found the language of less and least very

difficult and it was something I needed to teach her. This concurs with Thompson's (1997:130) view that young children have more difficulty with the word less.

Noting the themes emerging from the discussion, I concluded that the use of the games highlighted certain weaknesses among some children that may not have come to light using a textbook alone. The teachers acknowledged that while the games provided opportunity to develop certain skills, it was difficult to observe the development of the whole range of skills detailed on the checklist and engage in classroom management issues simultaneously.

4.1.5 Reconnaissance

I had not anticipated that observation of the mathematical skills would have been so problematic. This was due to the teachers' lack of clear understanding of these skills and also because of classroom management issues. I applied my knowledge of the skills to learning contexts that the teachers related from their classrooms to develop a shared understanding of the mathematical skills children were developing when playing the game. This discussion clarified my own understanding and my colleagues understanding of these skills. This activity also raised our awareness of the interdependent relationship of the skills as children learn with understanding. Learning mathematics with understanding requires the development of many of these skills simultaneously.

4.2.0 Cycle 2: Revise the general plan: Improve evaluation of the development of mathematical skills

To alleviate the difficulty in observing development of skills and dealing with classroom management issues, I suggested that each teacher visit another classroom to observe the children playing the games. The purpose of the observations was also to

triangulate the data being collected. Triangulation defined by Elliott (1991:82), 'is not so much a technique for monitoring, as a more general method for bringing different kinds of evidence into some relationship with each other so that they can be compared and contrasted'. He outlines the basic principle underlying the idea of triangulation as that of 'collecting observations/ accounts of a situation (or some aspects of it) from a variety of angles or perspectives'.

4.2.1 Action steps

- Observation visits
- Continue to use the games in the classrooms
- Monitor effectiveness of the games in light of any insights gained from observation visits

I arranged to supervise each observer's class during classroom visits. I suggested to each observer to note, any critical incidents that indicated the games were enabling the children to develop mathematical skills. Observations lasted approximately twenty minutes.

4.2.2 Monitor implementation and effects

A second group meeting presented an opportunity to each teacher to report on classroom visits. I began the meeting by asking if the visits revealed any development of mathematical skills. As the teachers reported on their visit in the junior classes it became apparent that the use of games enabled the development of some mathematical skills (table 4.2)

The teacher of senior infants visited the junior infant class. She provided a written summary of her observations (appendix I). She remarked that 'every child in the class could

say ‘there are more green counters than yellow counters, there are less yellow counters than green counters’, every child fully understood it, whereas with a maths book they might tick a box with that, but they might be copying.

Table 4.2 Overview of the skills associated with the activities of the children that were observed during visits in the junior classes

Class	Game	Activity carried out by the children	Skill
Junior Infants	Spill the beans	lined up counters 1-1 Expressed: there are more green counters than yellow counters, there are less yellow counters than green counters	Applying and problem solving Reasoning Implementing Communicating and expressing Understanding and recalling

Senior Infants	Ladybirds	placed ten ladybirds randomly; on a leaf, under a leaf and on the ground; discussed and explained activity recorded results using numbers and symbols to write a number sentence recognised the relationship between the verbal, concrete and symbolic modes of representing numbers	Applying and problem solving Communicating and expressing Reasoning Implementing Integrating and connecting Understanding and recalling
First Class	Make the biggest number	expressed :I have the most, I have the least selected dienes material to represent the 'least' and the 'most' connected the symbolic and concrete mode of representing numbers	Communicating and expressing Implementing Integrating and connecting Understanding and recalling

The teacher of junior infants visited the senior infant class. She observed a game that involved recording numbers and adding them together. She considered that this was very purposeful work with each child in turn interpreting for the group and instructing what to record. The children were able to tell why and how they recorded their data.

The teacher of second class visited first class children. She observed a child, experiencing difficulty selecting appropriate base ten materials to represent a number during her first turn in the game 'make the biggest number'. She remarked that further practice playing this game resulted in her selecting the material correctly. The teacher of first class stated that she encourages those with the 'least' and the 'most' to display their number 'just to get more children involved in using the base ten material'.

The use of the games as an assessment tool was further discussed as each teacher reflected on their own practice. The teacher of first class noticed two children experienced difficulty with the game and realised that ‘they needed somebody with them to lead them’. Pairing children selectively is recommended by Labinowicz (1985:85) ‘When children of unequal counting abilities are teamed, the less advanced child may benefit from the other child’s modeling of a more efficient method. At the same time, by displaying and verbalising his method, the more advanced child may become more conscious of his own thinking’.

The teacher of second class identified the role of the teacher on occasions like this. ‘I find that they benefit an awful lot more if you are at the table, directing them and asking the right kind of questions’. This view echoed the opinion of (Bright 1996:18) who contends, ‘since young children may have some difficulty in knowing how to describe their thinking, it is important for teachers to have good questioning skills when probing children’s thinking’. The teacher of junior infants used the game to gauge the children’s readiness for the concepts being presented and adapted it accordingly. ‘When you gave the game, you saw immediately, that this is too much to give, you went back two or three steps. Everyday you put another step onto it’.

While acknowledging the benefit of using the games, there was concern that acquiring the correct resources is problematic. ‘We don’t have the time to stick those counters together for example, get the boxes, sort them out and have the equipment right’ (Teacher of Junior Infants). Hargreaves (1994:15) comments that the shortage of time repeatedly appears as one of the chief implementation problems of educational change. He states ‘scarcity of time makes it difficult to plan more thoroughly, to commit oneself to the effort

of innovation, to get together with colleagues, or sit back and reflect on one's purposes and progress'. Suggestions as to how to alleviate this problem of 'time' were sought with no resulting consensus. Anecdotally one of the teachers mentioned that we should spend our next in-service day making maths games.

4.2.3 Reconnaissance

The teachers learning in this cycle included recognising the development of some mathematical skills among the children, the use of the games as an assessment tool to plan appropriate instruction and a concern about developing resources for full implementation of this approach across all strands of the curriculum due to constraints of time.

The use of the games as an assessment tool drew my attention to the role of the teacher when children are playing games. I had focused on teachers observing the development of skills. The learning that emerged was that I had identified the interactive nature of teaching and learning as one of my values and now needed to embody this value in practice in the research. According to Clements (97:198) 'we need to study how children think about the particular topics we teach, and we need to work to understand our students' thinking at a level deeper than everyday communication'.

I requested access to each of the classes to video-tape the children engaged with the games as a means of gathering comprehensive evidence of how the games were enabling children to express mathematical thinking and understanding. I requested permission also to interact with the children to elicit understanding and thereby embodying the value of the interactive nature of teaching and learning.

The teacher of senior infants mentioned during an informal conversation the previous day, introducing the use of games to other teachers in the school. I interpreted this,

as an indication that, this aspect of the mathematics curriculum implementation process was beginning to move beyond experimenting with a strategy in some classes to implementation throughout the school. The means by which this could be done was discussed at the meeting and consensus emerged that the video should be shown at the next in-school planning day for maths. If after seeing the video, teachers wanted to see the games in progress my co-researchers indicated that they were willing to accommodate the visits.

4.3.0 Cycle 3: Evaluate the effects of the use of games on student learning

There were now two purposes to videotaping the children, firstly as an evaluation tool to provide evidence that games enable expression of mathematical thinking and understanding and secondly to introduce the practice of children playing games to teachers outside the research team. To further evaluate the effects of the use of games on student learning, I proposed that teachers write their reflections on the use of the games in their classrooms as they participated in the study and discuss these reflections at a final group meeting.

4.3.2 Action step

Video-tape children engaged with mathematical games

Evaluate teachers' reflections on the use of games

4.3.1 Monitor implementation and effects

The video recordings took place in each of the four classes. I suggested to my co-researchers to interact with the children during the recording. During the recording the children were interviewed extensively by their teacher or by me to elicit information about their thinking and understanding. The recording though at times quite noisy, as it took place

in the natural environment of the classroom, captured valuable insights into the children's thinking and understanding, and it also demonstrated the teacher's significant role in eliciting thinking and understanding. Teachers wrote their personal reflections on the effect of the use of games in their classrooms.

4.3.3 Monitoring of implementation and effects

At this point in the research I took part in the first validation group meeting in DCU with three Masters students conducting action research and our thesis supervisor Margaret Farren. She arranged a link to Jack Whitehead at Bath University using videoconferencing. The purpose of this validation meeting was to discuss and clarify claims that can be made about action research findings. We were each given the opportunity to present a question to Jack about our action research. As action research by definition is about improving practice my question was 'what evidence do I need to show that, improvement in my learning, other teachers' learning and children's learning has taken place?' His advice was to focus on the nature of the learning: my own learning as I am trying to help children improve their learning, the children's learning and my influence on my colleagues learning.

I replayed the videotapes many times and took written notes. I decided to use the video evidence to identify how the games provide a window on children's thinking and understanding through the interaction between the pupils and the teacher, how this influences appropriate instruction for specific children and the teacher's role in the process. I selected and analysed critical incidents that revealed important insights into children's thinking. Cohen et al. (2000:310) claim 'there will be times when reliability as consistency in observations is not always necessary'. They further state 'sometimes one event can occur

which reveals an extremely important insight into a person or situation'. These critical incidents are presented as a series of vignettes from each of the classes.

The beginnings of a constructivist approach to teaching and learning were evident. Support was modified according to the needs of the child, a form of instruction referred to as scaffolding. The opinion of Vygotsky related by Sperry (1997:15) states that 'children in the early stages of learning need a great deal of support or 'scaffolding' in order to grasp a task. Later this guidance or set of prompts is gradually reduced so the child can master the skill independently'. This concept of scaffolding is referred to in the mathematics curriculum. 'The teacher breaks down the task and makes the task manageable for the individual child, thus supporting the development of the child's own problem solving skills. Through discussion the child becomes aware of the characteristics of a task' (Government of Ireland 1999:4).

Junior Infant Class (tape 1 index mark 9:04-09)

The game being played was 'spill the beans'. The task was to use the comparison words, by identifying the colour of the counters that had more, less or the same as the other colour and placing the appropriate word beside each array of counters. Conor poured out the beans, arranged them in two rows to show 6 red and 4 white. Michelle said 'we got the same'. Conor replied 'they are not the same'. The teacher observing the conversation interacted with the two children.

Teacher: Which colour are there more of Michelle?

Michelle: White and red

Teacher: Which one is there more of? (Michelle pointed to red)

(Michelle pointed to red) Teacher: Which one is that?

Michelle: Red

Teacher: Now find the word that says more

(Michelle searched through the three words and picked out 'more' and placed it below the red counters)

Teacher: If we have more red counters, that means we have l. l.l.....

Michelle: Less white counters

(She then placed less above white)

It was Michelle's turn to 'spill the beans'. This time it was 7 red and 3 white. Michelle commented incorrectly 'it's the same as yours Conor'.

Conor: Less than, white, more than, red (he placed the words correctly beside the red and yellow counters)

Conor spilled the beans: 4 red, 6 white

Teacher: Now Michelle, what have we got here?

(Michelle placed the words correctly on the table)

Teacher: So, which one has more this time?

(Michelle moved her finger along the white row of counters)

Teacher: Which colour is that?

Michelle: White

Teacher: So if we have more whites, that means we have

Michelle: Less red

Teacher: Do you want to count how many of each you have Conor?

Conor counted each group by pointing and saying each number name as he counted quietly and then said aloud 6 and 4.

The different ability between the two children was apparent as they played the game. The weaker child needed a lot of encouragement from the teacher to express her mathematical thinking. She was very reluctant to use the mathematical language and instead used gestures to communicate. Her partner in contrast the more able child needed the challenge of an additional task of counting. The interaction of the teacher reflected the opinion of Bright (1996:21) who maintains 'mathematical instruction seems more likely to be effective if it builds on what the children know and then challenges them to think in more sophisticated ways'.

Senior Infants (tape 1 index mark 12:12-19)

The game being played in groups of two children was 'connect four'. The task was to roll a die and then cover a numeral that was one more than the number shown on the game card. The winner was the child who had four consecutive counters horizontally, vertically or diagonally.



Photograph 4.3: Number grid, counters and die used in the game '1 more'

Tom threw the die to show 5

Teacher: What's your number Tom?

(Tom counted by pointing to each dot on the die.)

Tom: 5

Teacher: What have you to cover?

Tom: 6

Teacher: Why?

Tom: Because it's 1 (hesitated), 5 more than (hesitated) 6 more than 5

Teacher: Is it?

Tom: Yes

Teacher: Think about it, you rolled 5 and you are going to cover 6. Why?

(No response)

Teacher: What do you think Tom? What's the difference between 5 and 6?

Tom: 6 is more than 5

Teacher: How much more is it?

Tom: Lots

Teacher: It's lots more is it?

Tom: Yeah

Teacher: Look at the 5 on the die. Have you still got 5 there? How would you make that 6, what would you need? How much more does this need to be 6? (Teacher pointing to the die)

Tom: 1 more

Teacher: So how much more than 5 is 6?

Tom: It's 7

Teacher: How much *more than* (with emphasis) 5 is 6?

No response

Teacher: What did we do to 5 to get to 6?

There was still no response. His partner was waiting patiently for him to answer. Teacher then asked her to help him.

Niamh: You have to cover 1 more than 5

Teacher: Yes that's the rule. What's 1 more than 5 Tom?

Tom: 6

The game continued. On Tom's next turn he rolled 1. He communicated that he will cover 2 because it's 1 more. The last turn that I observed he rolled 3 and again began to get a little confused with the language but with much less questioning replied 4 is 1 more than 3.

Labinowicz (1985:55) cautions against, accepting a child's success at a simplified task as an indicator of something more complex. While the child was successful each time in recognising the number he had to cover on the game board, questioning revealed he did not clearly understand the incremental relationship between two consecutive numbers. His strategy was to use a counting word sequence to say the next number without understanding the relationship between the number on the die and the number he covered.

Labinowicz (1985:48) views that a delay in development of number meanings by young children, 'limits their abilities to quantify collections of objects, to develop efficient counting strategies, and to use counting as a reliable problem-solving tool'. He suggests that this general lack of flexibility, or inability to see one number in relationship to others in

young children's counting suggests that their counting-word sequence has been internalised as a total unidirectional entity. Labinowicz (1985:48) recommends that teaching methods, congruent with children's counting capacities and constraints might include natural problem solving contexts that encourage counting, observing children at play and adapting questions for young children. This recommendation suggests that, continued practice of playing suitable counting games, coupled with appropriate intervention on the part of the teacher may help Tom develop an understanding of number.

Senior Infants (tape 1 index mark 12:19)

The game being played was 'ladybirds'. There were six children engaged in this activity. Each child had a turn at placing the ladybirds on the leaf, under leaf or on the table. All the children recorded the numbers being placed in each location and wrote a number sentence to add the numbers together. The first child placed 7 on the leaf, 1 under the leaf and 2 on the table. The children lifted the ladybird to check how many had been placed under it even though this had been done overtly. The number story was recorded as $7+1+2=10$. Each child used the language plus and equals appropriately. As the next child was placing the ladybirds I suggested trying to remember how many were put underneath. All children successfully did this except one child who lifted the ladybird to check. The resulting number sentence was $7+2+1=10$.

The child who had placed the ladybirds first said ‘this is a bit like mine, it’s just with the 2 switched around’. I noticed that one of the children had written $7+21=10$. I asked her to read her number sentence aloud. Before she did this she corrected her mistake by placing + between 2 and 1. When questioned about what she did, she answered ‘I put a plus in there’. I then asked ‘what would happen if you forgot to do this?’ She replied ‘I don’t know’. Another child then said, ‘it would make a different number all together, it would make 21’. This game highlighted the instructional role for the teacher by identifying what to help the children learn next. The inability of one child to justify the relevance of ‘+’ in the number sentence suggests that she did not clearly understand the meaning of the symbol and her use of it was procedural. Bransford et al. as cited in The National Council of Teachers Of Mathematics (2000:20) state that students who memorize facts or procedures without understanding often are not sure when or how to use what they know, and such learning is often fragile. The National Council of Teachers Of Mathematics (2000:80) recommend that concrete models can help students represent and develop number sense and also bring meaning to students use of written symbols. However it is suggested that using materials, especially in a rote manner, does not ensure understanding. ‘Teachers should try to uncover students’ thinking as they work with concrete materials by asking questions that elicit students’ thinking and reasoning’ The National Council of Teachers Of Mathematics (2000:80). Carpenter and Lehrer (1999:26) insist that students cannot be expected to develop critical knowledge structures by practicing procedures. ‘Students need time to develop knowledge structures, and instruction should offer students extended opportunities to develop relationships through the tasks that they engage in’. The revised curriculum recommends that mathematical symbols should only be used when they are appropriate to

the child's level of understanding. Behrend (01:40) comments that 'students need time, and sometimes a step backward, to make the leap forward and see connections between the concrete and the abstract'.

The ability of child who did recognise that the absence of the symbol created a new number infers she is developing good number sense. This can also be said of the child who pointed out that ' $7+1+2$ is a bit like $7+2+1$ '. This is evidence of understanding the commutative property of addition. Askew (1998:163) believes that frequently children are given tasks to do in mathematics that they can already do easily. He recommends 'rather than offering 'safe' tasks based on children's firm understandings, challenge them to use mathematics at the edges of their understanding'. These children were probably ready for the following type of problems:

- There were some ladybirds in the garden when I went out to play. 3 flew away and now there are 2 under the leaf, 1 on leaf and 4 on the ground. How many were there when I went out to play?
- There were 8 ladybirds in the garden. Some flew away. There are 3 left. How many flew away?

First Class (Tape 1 index mark12:48)

The children were playing the game 'go fish'. Anghileri (2000:29) comments 'number pairs that together combine to make ten can be memorized to provide important 'benchmarks' as known facts from which other combinations can be derived'. She notes

that there are many games and puzzles based on number bonds to ten or complements of ten. Go fish is an example of one of these games. Children were arranged in groups of four to play this game.



Photograph 4.5: A child in first class playing 'go fish'.

Two children explained the rules of the game.

John: See you have to make up the numbers that get to ten. If you need a card you just.....

(interrupted by second child)

Laura: You just ask them and if they don't have it they say 'go fish' and you pick up two cards.

The children at this table proceeded to play the game.

Laura: Do you have a 10? (to the child beside her)

John: No, go fish

M: Why do you need a 10

Laura: A big 10, you get a 10 and then that makes 10.

(The child then picked up two cards and placed all her cards facing up on the table: 6 clubs, 2 spades, 8 clubs, 4 spades, 1 spade and 5 clubs)

M: Now can you make ten?

Child touched her forehead, looked at the 6 clubs, and then used her fingers to count on to 10. Recognising that she needed 4 more now, she picked up 4 spades.

This child did not have instant recall of number bonds to ten and efficiently used her fingers to find the solution. Thompson (1997:157) proposes that one of the actions to be incorporated into classroom teaching is 'to legitimate and encourage the use of fingers and counting procedures particularly for simple addition and subtraction. The next two incidents are further examples of how this action was incorporated into the teaching and learning experience.

Emma: Do you have a 4?

Jack: No, go fish

M: Why did you ask for a 4?

Emma: Because it makes a 10

M: What makes 10

Child 3: 4 and 3

M: Does it, does 4 and 3 make 10

Emma: Ahmm yeah

(Emma's teacher came over to help her)

Class teacher: Let me see what might we put with 3 to make 10.

Emma: 4

Class Teacher: Let me see, we will use your fingers. You have 10 fingers. We have 3 (covering 3 of the child's fingers). The teacher then pointed to each of the other fingers as child 3 counted them.

Emma: 7

Teacher: Do you have a 7?

Child 3 then picked up 7 and 3 to make a number bond of 10.

First Class (Video Index 13:02)

Jill was one of the children at the next group whom the teacher identified prior to introducing games to her class as 'not really liking maths'. She was busily observing the other children playing the game and not looking at her own cards. I noticed that she was holding 5 hearts, 4 clubs and 6 spades in her hands.

M: Can you make 10 there yourself?

(Jill didn't respond)

M: Can you make 10 there with any of those cards?

Jill: 5 andahmm 6 and 4 is 10 (rather surprised) is it?

M: You tell me if that is 10, find out yourself (I placed the cards on the table for her to count the clubs and spades)

Jill: Yes it is (expressed with delight)

M: How can you show that this is 10

Jill: I'm just adding, I just know that 6 and 4 is a 10

M: But you had it in your hand a minute ago and did you know it then?

Jill: You do the 6 first. This is the 6 and this is the 4 (using her fingers to show 6 and 4) and it adds up to 10.

M: How do you know that that is 10?

Jill: Because 5 and 5 is 10 (pointing to the 5 fingers on each hand)

M: Now you have only one card left. What are you looking for now?

Jill: Ammm.....

M: What is that card?

Jill: 5

M: What do you need with that to make 10

Jill: Another 5

M: Good girl

Second Class

Three vignettes presented from the video recordings that took place in second class demonstrate the development of the children's meta-cognitive awareness as a result of skilful questioning by the teacher while the children were playing the games. Anghileri (2000:127) explains the term 'meta-cognitive' as the ability to consider different procedures. The procedures occur at a cognitive level, while reflecting on them occurs at a 'higher' level of awareness.

(tape 2 video index 12:28)

The game being played was 'guess my number'. The children explained very clearly the rules of the game. Shane told me that someone hides a number between 1 and 100 in a box and the other children have to guess the number. When asked what clues are given, Colm answered you have to say more or less. Deirdre began the game by 'hiding' 48 represented with base ten material. Children then began to guess the hidden number.

	Round 1	Clues	Round 2	Clues
Eoin	54	less	51	less
Jane	43	more	49	less
Colm	45	more	48	correct number

Children were questioned on the strategies they used to guess the number. Eoin explained that he decided not to guess higher than 54 because of the first clue given. The children were asked to suggest a 'quick way' of guessing a number was between 1 and 200.

Eoin: I don't know

Teacher: Where might you start?

Eoin: 50 or something

Colm: The units, no

Teacher: Which number might you choose first to try to guess the number the quickest?

Colm: 1

Eoin: If you picked 1, then you could say 2, 3, 4, 5,

Teacher: How many guesses would that take?

Eoin: 200

Teacher: If you started by guessing 100, if the number was between 1 and 200 would that tell you anything?

Eoin: Yeah, if they said more it would be between 100 and 200 and if they said less it would be between 100 and 1

Teacher: So how many numbers would you have ruled out altogether?

Eoin: 100

Teacher: So you would have only to guess 100, so how would you rule out loads of numbers again?

Eoin: If you picked 50 and they said less.

Further questioning followed to tease out an efficient strategy for guessing the number. Askew (1998:160) believes that a ‘teacher plays a key role in helping the children develop and extend ideas’. Askew describes acting as a critical friend, a helpful strategy to challenge the pupils by gently provoking them to think about what is going on. He outlines a questioning, observing and listening style of interacting. He states, ‘although listening may seem like an obvious skill, listening carefully to the reasons that children provide is considerably more difficult than simply listening out for responses which fit with what you as the teacher already know’. Further examples of both the class teacher and myself acting as critical friends are revealed in the final two vignettes.

Second Class (tape 2 index 12:37)

Colm began by explaining the game ‘make the biggest number’, ‘there are numbers under those cards and you have to try and make the biggest number because if you get 1 you might want to put it into units and like 9 you put it into hundreds’. Eoin explained further ‘you pick up one card at a time instead of picking three it would be too easy’.

Round I

	H	T	U
Jane			0
Eoin			3
Colm			0
Deirdre	9		

The class teacher asked ‘who is think is most likely to have made a right decision?’

The children unanimously answered Deirdre. She then asked them to explain their reasoning. Shane explained that you can't get any higher. The children were then questioned about Jane's and Colm's decision, Eoin again replied 'you can't get any lower'.

Round 2

	H	T	U
Jane	9		0
Eoin	7		3
Colm	7		0
Deirdre	9		2

The chances of making a wrong decision were discussed after round 2. Chance is a new strand of the revised curriculum, which these children will not encounter formally until third class. The children's response were as follows:

Eoin: Three chances, wait two, 8 and 9.

Deirdre: Two chances, 1 and 0.

Jane: None because there is no number that is higher.

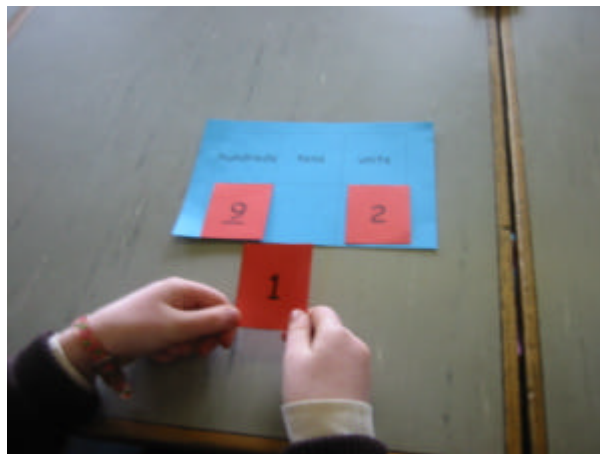
Colm: I could get an 8 or 9 in my next go, there is a better chance of getting a lower number next time.

Round 3

	H	T	U
Jane	9	8	0
Eoin	7	7	3
Colm	7	2	0
Deirdre	9	1	2

Eoin, Jane and Colm acknowledged that they had made right decisions.

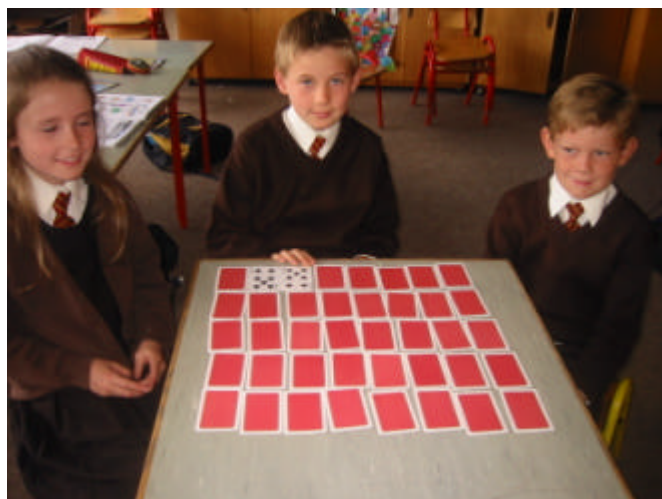
Deirdre understood her wrong decision. 'I got 2 and put it in the units and then I got 1 and had to put it in the tens. I made 912 but I could have made 921'.



Photograph 4.6: Make the biggest number

Second Class (tape 2 index 12:50)

Jane explained that the game double compare is played by placing a deck of cards without the picture cards, eight across and five down. 'You have to try and get over 10 when you pick up two cards.'



Photograph 4.7: Double compare played by children in second class.

Jane turned over 7 spades and 7 clubs and said that she has 14 and it was more than 10. The teacher asked the other children if they agreed with the answer. Deirdre turned over 9 clubs and 8 clubs and said that makes 17. The teacher then asked her, 'did you have to add them to know that it was more than 10', to which she responded 'I had to add them up'. The teacher clarified this question further. 'When you saw 9 and 8 did you immediately know it was more than 10 or did you only know because you said 9 and 8 makes 17?' When Deirdre didn't respond to this question, it was repeated to the other children. Jane explained, 'well 9 and 2 is over 10 and that is over 9 and 2'. Jane's response made her reasoning skills explicit. A discussion of an efficient strategy to add 9 and 8 followed. Eoin's suggestion was to add 1 from 8 to 9 to make 10 and then add 7. Deirdre noticed that it was almost a double, 9 and 9.

The approach to teaching that I identified in this classroom is congruent with Battista and Larson's (1999:23) definition of a constructivist approach to teaching, 'the goal is to guide students in building mathematical structures that are more complex, abstract, and powerful than those they already possess'.

The second part of the monitoring phase in this cycle coincided with a second validation meeting in DCU at which I engaged in dialogue with my thesis supervisor and three masters students to consider the following questions about my research:

1. Is the description and explanation for the teacher-researcher's learning comprehensible?

2. Are the values that constitute the enquiry as ' educational' clearly revealed and justified?
 3. Is there sufficient evidence to justify the claims being made?
 4. Is there evidence of the teacher-researcher's educational influence in the learning of others?
-
1. The description and explanation for my own learning is comprehensible as I present evidence of greater understanding of my own practice as facilitator of curriculum implementation through each cycle. This learning involved recognising that teachers need professional support in understanding the range of mathematical skills outlined in the revised mathematics curriculum. The children's understanding of mathematics is dependent on the development of these skills. Eliciting understanding is crucial in the mathematics class in order to plan appropriate instruction for children and is dependent on skilful questioning on the part of the teacher.
 2. I revealed and justified the educational values of the enquiry to the research team at the start of the enquiry and embodied them in practice as I facilitated curriculum implementation: the implementation of a mathematics curriculum that promotes understanding, the role of social interaction in learning, individual learning styles were accommodated, active engagement with children to elicit understanding.
 3. Evidence to support the claims and influence on educational influence in the learning of others includes video evidence, transcripts of audio- taped group meeting and teachers personal reflections.

Adhering to Whitehead's advice at the videoconference validation meeting that I should focus on the nature of my influence on my colleagues learning I now present their reflections on the use of games in their classroom.

Reflections of Teacher of Junior Infants

I found the experience very beneficial and feel participation has been rewarding for both teacher and pupils. The children loved the fun element as well as the experience of playing in a competitive situation with the whole group and observing certain rules. Once rules were explained and demonstrated they really worked extraordinarily well and guided and checked each other. There was very little need for teacher intervention (except to assess). The fact that they understood the objective of each game was obvious from their ability to carry out the correct procedure or make the correct response when their turns came. The groups were of mixed ability boys and girls who learned also from each other. Paired games also involved mixed abilities.

Clearly experiential work with concrete materials is an invaluable as a way of learning. The advantage on this occasion was that the materials were thoughtfully and specifically designed, produced, presented, stored and supplied in sufficient quantities to teach specific objectives. This is the ideal situation. This factor, I feel, is what restrains busy practising primary teachers from implementing the necessary practical steps needed and acknowledged by all to develop understanding and concepts in all children.

Unfortunately they may remain an aspiration in a time-pressed classroom with large numbers of children. I wish everyone could be handed the materials as I was. I will be spending my equipment money more discerningly in future.

Reflections of Teacher of Senior Infants

I have enjoyed taking part in this study. The whole approach was very good – relaxed and yet stimulating. I guess we were all learning as it went along (pupils, teachers and facilitator). The team worked really well together and shared thoughts, ideas and experiences openly and honestly.

The children in my class have really enjoyed maths over the last few weeks – in fact they have been doing maths unknown to themselves. The big advantage of these games is that they are simple and also the fact that they are played in pairs – the children loved that. We had not done that before. They are so familiar with the games now that they get the games themselves and get ahead and play the games. Even now when they are finished work in other subject areas, they go ahead and get the games, find a partner who is also finished their work and get along and play the game and enjoy themselves – its working on auto pilot now. I would like to extend it to a group of children playing the game, perhaps four to six children playing the one game - or perhaps first class might be time enough for that. The card game has sparked a great interest in playing cards and this has extended into the home. Some children are playing cards at home now, learning new games at home, coming in and teaching other children how to play their game.

At first I did think it would be very difficult to organise these games in the classroom, that there would be discipline problems, noise levels would be too high, but in fact the children were so keen to play the games that they were so well behaved in anticipation of getting their game. The noise level was just a lovely hum of learning and enjoyment. They didn't seem to prefer one game over the other – they loved them all – I

thought there would be a rush for one particular game when I let them freely pick what they wanted. Each picked their favourite game and later played the other games.

I guess what we need now is someone to hand us a new set of games to develop another aspect of the curriculum. I will continue to use these games as the children are learning so much from them and getting a greater understanding of number. I am convinced that the way forward in the teaching of maths is the use of games and concrete materials and I think to get the children talking about what they are doing is so important. In the past a lot of the maths class was in silence as children filled a page in a maths book and know one knew what they were thinking or how they were figuring it out.

Reflections of Teacher of First Class

While the games were being played I helped some children but mostly observed them. I noticed strengths and weaknesses with different children and I always included re-enforcement of any of these weaknesses in the next day's maths lesson. The rules were adapted by me to increase the children's understanding. The children changed the rules to increase the difficulty. The games presented no difficulty to me because I was given very good equipment with sufficient materials for everyone to participate. The noise level was acceptable because all were actively engaged in learning.

I felt that the games helped the children to sharpen their understanding. 'Go fish' helped to break up 10 and to make 10. The tens and units helped place value. The children were actively involved in their own learning.

Reflections Teacher of Second Class

Overall I found the games to be a positive addition to my maths classes. They made the children think in a more practical way about the relationship between numbers. I think

some games were more beneficial than others, some needing modification to match the ability of the children for example “21 More” : children quickly learned the sum of 21 +1 ,2, 3, 4, 5, 6, after which the game served only to entertain rather to extend the children’s understanding of number.

The games helped identify very quickly who had grasped various concepts and the level of understanding each child has reached. In “Guess my Number” some children failed to realise that numbers could be eliminated by listening to each other’s guesses. In “Go Fish” most children quickly learned the combinations of numbers that make 10 whereas other children asked for cards at random. All children enjoyed the games and engaged in conversations relating to the games and they taught and learned from each other. This type of spontaneous “maths talk” tends not to take place in more formal lessons. There were however some organisational difficulties.

It took some time to set up the games as seating had to be re- arranged and games had to be distributed and explained with a full class. The games were introduced to the class at a time when they were preparing for First Holy Communion and it was very difficult to find time to play the games, observe and write up observations, not to mention classifying these observations into the various skills identified in the revised curriculum.

I felt that teacher led questioning, direction and monitoring were necessary and beneficial. It was difficult to do this without another teacher’s help with the rest of the class. Some of these difficulties would be overcome or lessened if the games were played from the beginning of the year, regularly and from year to year. The meetings with other teachers were beneficial. Listening to other teacher’s observations helped outline the

progression of skills acquisition from year group to year group as well as pointing out common organisational difficulties.

Chapter 5: Conclusion and recommendations

5.0 Conclusion

The purpose of this study was to facilitate curriculum implementation on the revised primary curriculum. The study engaged teachers in professional dialogue about improving their practice. Reflection on the philosophical underpinnings of the revised mathematics curriculum based on the most advanced educational theories and practices, was the stimulus to developing an educational enquiry in my school leading to knowledge and understanding of practice. The ultimate aim was to endeavour to improve practice in a cyclical process alternating between action and critical reflection.

Curriculum implementation provides an opportunity to educators to critically reflect on their practice. Participation in the change process ensures commitment to enhancing the education of the children in their care. In this study curriculum implementation involved a collaborative planning process among colleagues where respect, openness, trust and support were valued as teachers participated in the change process.

I identified my role as facilitator of curriculum implementation as that of providing support, advice and sharing my educational values in an effort to enhance the quality of provision for mathematics education in my school. Curriculum implementation process began with a reflection of the underlying principles of the revised curriculum, which places children at the centre of the learning process. A defining feature of the revised mathematics

curriculum is the focus on the process of learning. A review of writings on mathematics education emphasised the importance of children learning mathematics with understanding and the need to structure a learning environment in the classroom that supports this kind of learning.

Mathematical games were explored as a strategy to enable children learn with understanding. This strategy highlighted the social nature of children's learning as they expressed their mathematical thinking and understanding to their peers and their teacher. The use of the games identified the interactive nature of teaching and learning which requires active engagement with children to elicit understanding in order to plan appropriate instruction. Individual differences among the learning styles were accommodated. The children were actively involved playing games designed to deepen and connect their understanding. They explained what they were doing and justified their decisions. The children were challenged to communicate their thinking to other children, which clarified their own understanding and also helped to develop other children's understanding. The children were intrinsically motivated and actively engaged in their own learning.

The teachers engaged in the study embraced the challenge of curriculum implementation. As a team we worked collaboratively towards an understanding of the range of skills outlined in the revised curriculum. The learning environment was characterised by trust, openness, respect and a willingness to share insights. The research team created their own learning opportunities by reflecting on their own practice and observing their colleagues practice. The commitment to curriculum change throughout the school was indicated by their willingness to share their experience of using games with

other teachers in the school. Evidence of the use of the games as an invaluable assessment tool was presented.

The action research methodology used in this enquiry enabled curriculum implementation that resulted in improvement in learning: children's learning, teacher's learning and my own learning. Effective mathematics teaching requires understanding what students know and need to learn. Teachers need professional support in understanding the range of mathematical skills outlined in the revised mathematics curriculum. The children's understanding of mathematics is dependent on the development of these skills. Active learning contexts need to be carefully structured to ensure that these skills are developed with understanding. Teachers need to question skilfully to elicit understanding in the mathematics class in order to plan appropriate instruction for children.

Winter's (1996:13-14) outlines six key principles in the conduct of action research: reflexive critique, dialectical critique, collaboration, risking disturbance and theory and practice transformed. These principles were integrated into my methodology to ensure scientific rigour. Reflexivity insists upon modest claims and questioning these claims. Modest claims were made from reflections on my own practice, interviews, classroom observations and statements gathered from participants. The reflexive basis of these accounts is made explicit so that claims may be transformed into questions. Dialectics is the art of discussion and starts with the notion of a contradiction. The contradiction existed in the educational values that I held were a contradiction in practice. The action research process allowed me to engage with curriculum implementation, which enabled my values to be embodied in practice as I facilitated curriculum implementation. Collaboration was central to the research process. This involved taking participants viewpoints into

consideration and their questioning of my statements and actions allowed me gain insight into my own practice. Validation groups provided further opportunities to question my statements and actions, which enabled me to clarify my understanding of the learning, that was taking place in the study.

As a researcher I have engaged in a process where the purpose is to change and improve. This process is investigated and reported. My report shows evidence that change and improvement in practice has taken place. The fact that I am hopeful that this enquiry will contribute to a living educational theory is taking a personal risk. Theory and practice are mutually dependent phases of a change process, which represents the strongest case for practitioner action research. The theory of the enquiry based in practice is in itself transformed by the transformation of practice.

As practitioners endeavour to improve some aspect of their practice, Whitehead (1989:1) states 'I believe that a systematic reflection on such a process provides insights the nature of the descriptions and explanations which we would accept as valid accounts of our educational development. I claim that a living educational theory will be produced from such accounts'. This study has produced a validated account of my improved learning as facilitator of educational change and makes the modest claim that it contributes in some way to living educational theory. The study enabled me to: identify my educational values, clarify their meaning as they emerged in practice, transform them into living standards and share my values with other teachers to transform their practice.

5.1 : Recommendations

In order to explore the full potential of the use of games as enabling children to express their mathematical thinking, teachers need to skilfully ask questions so that they

can recognise landmarks of children understanding. Teachers collaborating with colleagues to observe, discuss, and reflect on their practice will enhance their professionalism and engage them in the change process of curriculum implementation. There must be provision of time for professional dialogue to ensure participation in the change process. Teachers need time also to develop suitable resources to implement the curriculum that are appropriate to the children's learning needs.

Appendix A

Co. Kildare.
14th May 2002

Dear Parents/Guardians,

I am currently conducting a study on the implementation of the revised mathematics curriculum in your child's class. This study will be submitted by me to Dublin City University as a requirement of the course Master of Science in Education and Training Management.

To facilitate this study your permission is sought to audio-tape, photograph and video the children engaging in maths activities. If you have any concerns please contact your child's teacher or myself. Please detach and return the consent form below to your child's teacher.

Yours Sincerely,

Mairéad Ryan

Please mark the appropriate box, sign and return to your child's teacher.

I give permission to audio-tape, photograph and video _____ engaged in maths activities.

I do not give permission to audio-tape, photograph and video _____ engaged in maths activities.

Parent's/Guardian's signature

Appendix B

Staff Meeting February 27th 2002

I am researching the teaching of mathematics as a requirement of the M.Sc. in Education and Training Management At Dublin City University. This study follows on from an action research project that I conducted last year in my own classroom. This earlier project began with the recognition of the fact that when children record correct answers in their copies or textbooks, these answers do not necessarily imply understanding. I decided to focus on place value for the duration of the project, as some children were experiencing difficulty with this concept. The children worked together playing maths games using dice and base ten materials to reinforce renaming tens to units. These activities developed into group problem solving tasks involving addition and subtraction of two digit numbers using the base ten materials. The project lasted about six weeks and during this time no textbooks were used. Following this I reverted back to the textbooks and again assigned each child a partner who demonstrated the task with concrete material to the child who was recording.

At the end of the project I felt that all the children had significantly improved understanding of place value based on informal assessments. They seemed to be enjoying the activities and frequently asked ‘when are we playing the maths games’. I feel that this approach to teaching maths gives the children an opportunity to talk maths in a structured environment. Traditionally, mathematics has been a “silent subject” with children quietly listening to a teacher or completing written worksheet assignments. In order to foster

arithmetic understanding and thinking, children need to be active. The understanding gained from this study has influenced the way I now structure the mathematics class. I have adopted an activity based approach to teaching mathematics in my own classroom that: aims to implement a mathematics curriculum that promotes children's understanding, accommodates individual differences among the learning styles of the pupils, exploits the role of social interaction in developing mathematical understanding and recognises the interactive nature of teaching and learning which requires me to engage actively with children to elicit understanding in order to plan appropriate instruction.

The revised curriculum presents constructivist learning as central to the mathematics curriculum. Constructivism is a theory of learning based on the work of the educationalist Vygotsky. It places emphasis on understanding and building on students thinking. Children do not construct knowledge alone. They invent mathematical ideas together and learn to communicate these ideas. They test ideas and approaches based on their prior knowledge and experience. "When working in a constructivist way children usually operate in pairs or small groups to solve problems co-operatively". Primary Curriculum (1999:3) This theory reflected in practice involves the manipulation of concrete materials, symbols, language and pictures. With your help I propose to introduce a constructivist approach to teaching mathematics through the use of co-operative games. As a starting point I would welcome your opinions about the teaching of mathematics as it is currently practiced in this school, resources or lack of resources, time allocated to the different areas of the maths curriculum, classroom organisation and particular areas of difficulty. I would greatly appreciate access to some of your classrooms to try out games with the children two or three times a week for four to six weeks. The games will concern areas of the

curriculum suggested by you. On completion an evaluation of the project will be conducted to establish the successes or failures associated with this approach

Appendix C

Notes of First Meeting

Should be doing more activities. Teacher of second class said, 'I can see the value in the games. I enjoyed playing them myself, there is a fun element. Children really enjoy games, they are very motivated. They can talk, while they are talking they are learning and while they are learning they are talking. But getting organised is the problem. There is certainly cheap equipment available'.

- Cheap equipment available: cards, dominoes, games
- Value of games: enjoyment, more focused, guided activities, discussion
- How do you ensure children are learning?
- Recording practical activities versus use of a textbook
- Class size
- Use of resources
- Storage
- Furniture
- Selection of a strand of number

Teacher of junior infants was concerned if there is going to be more emphasis on practical activities how would this be recorded and remarked that a textbook provides a record of children's work. I sought the teachers' opinions on why activities and games aren't used in maths classes. Storage, finding time getting or making the resources, quantity, furniture and grouping of the children were mentioned

Appendix D

Appendix E

Skills Development: Junior and Senior Infants

Applying and Problem Solving:	Pupil 1	Pupil 2	Pupil 3
Select appropriate materials and processes for mathematical tasks			
Select and apply appropriate strategies to complete tasks or solve problems			

Recognise solutions to problems			
Communicating and Expressing:	Pupil 1	Pupil 2	Pu
Discuss and explain mathematical activities			
Record results using diagrams, pictures and numbers			
Discuss problems pictorially or orally			
Integrating and Connecting:	Pupil 1	Pupil 2	Pu
Connect formally acquired mathematical ideas with formal mathematical ideas			
Recognise mathematics in the environment			
Recognise the relationship between verbal, concrete, pictorial and symbolic modes of representing numbers			
Carry out mathematical activities that involve other areas of the curriculum			

Reasoning:	Pupil 1	Pupil 2	Pu
Classify objects into logical categories			
Recognise and create sensory patterns			
Justify the processes/results of activities			
Implementing:	Pupil 1	Pupil 2	Pu
Devise and use mental strategies/procedures for carrying out mathematical tasks			
Use appropriate manipulatives to carry out tasks and procedures			
Understanding and Recalling:			
Understand and recall terminology			

Appendix F

Junior Infants Games List

One More (Kamii 2000:170)

Materials: A game board, a die, 10 counters of 4 different colours

Number of players: Four

The children take turns rolling the die and placing a counter on the number rolled plus one, anywhere on the board. The person to use up first is the winner. Transparent counters enable the players to see the numbers covered which aids checking each other's addition.

5	2	6	3	4	7	3
5	7	2	6	5	2	5
4	7	2	5	3	7	6
6	5	6	7	6	4	3
2	7	3	6	2	5	4

take turns rolling the die and placing a counter on the number rolled plus one, anywhere on the board. The person to use up first is the winner. Transparent counters enable the players to see the numbers covered which aids checking each other's addition.

This can be adapted to 2 more, 1 less, 2 less than the number rolled. The numbers on the game board require modification.

Line-Up or Card Dominoes (Wrigley 1999:32)

Materials:A deck of cards with the picture cards and number cards 6 –10 removed

Number of players: Two – Four

The cards are dealt equally. The children take turns putting down one card at a time trying to make a matrix in the middle of the table consisting of four rows (hearts, diamonds, spades and clubs) going from 1 to 5 in order.

If the first player puts down a 1 of spades, for example, the second player can put down a 2 of spades or a 1 of any other suit. If the second player puts down a 2 of spades, the third player can put down a 3 of spades or a 1 of any other suit. All the numbers have to be placed in order within each suit, without skipping any.

Anyone who does not have a card that can be played must pass. The first player to use all cards is the winner. This can be modified by beginning with 5 and proceeding in descending order.

Compare and Double Compare (Original)

Materials: Number cards and interlocking cubes

Number of players: Two initially and later increase the number when children can compare more than two numbers.

The cards are dealt in a pile face down to each child. Each player turns over a card and selects that number of cubes to form a tower. Each child has to compare his or her tower and state 'I have more than you or I have less than you'. Rule of the game can change between the player with more than keeping both cards or the player with less than keeping both cards. If both numbers are the same, each player turns over the next card, and the player with the larger number/smaller number takes all four cards.

This can be further modified into an addition game; double compare where two cards are turned. The winner is the player whose total is greater or less than the opponent.

Before or After (Kamii 2000:157)

Materials: Playing cards with picture cards removed

Number of players: Two – Four

All 40 cards are dealt, and the players keep them in a face-down stack. The first player turns over the top card of his stack and discards it in the centre of the table. The next player turns over the top card of his stack and tries to use this card to make a pair with a number that comes immediately before or after it. (If there is a 5 on the table, for example, a pair can be made with either a 4 or a 6.) If a pair can be made, the second player can take both cards and keep them. If not, the card has to be discarded in the centre of the table.

Play continues until pairs cannot be made any more. The winner is the person who collected more pairs than anyone else.

Further modification of this game could be two before or two after.

Guess My Number (Kamii 2000:169)

Materials: Cubes

Number of Players: Whole class or a small group of children

The leader thinks of a number within the range 1-10. The rest of the class tries to guess it. Children's responses are recorded on the blackboard and encouraged to communicate their thinking and reasoning.

Build a Tower (Original)

Materials: Interlocking cubes

Number of players: Partner activity

Instruction to partner 1: Build a stack of four.

Instruction to partner 2: Build a stack one more than four.

(Partner 2 can use the four belonging to his partner as a referent set)

Give a variety of directions that use more and less.

Senior Infants Games List (Kamii 2000:170)

One More

Materials: A game board, a die, 10 counters of 4 different colours

Number of players: Four

5	2	6	3	4	7	3
5	7	2	6	5	2	5
4	7	2	5	3	7	6
6	5	6	7	6	4	3
2	7	3	6	2	5	4

The children take turns rolling the die and placing a counter on the number rolled plus one, anywhere on the board. The person to use up all the counters first is the winner. Transparent counters enable the players to see the numbers covered which aids checking each others addition.

This can be adapted to 2 more, 1 less, 2 less than the number rolled. The numbers on the game board require modification.

Line-Up or Card Dominoes (Wrigley 1999:32)

Materials: A deck of cards with the picture cards removed

Number of players: Two – Four

The cards are dealt equally. The children take turns putting down one card at a time trying to make a matrix in the middle of the table consisting of four rows (hearts, diamonds, spades and clubs) going from 1 to 10 in order.

If the first player puts down a 1 of spades, for example, the second player can put down a 2 of spades or a 1 of any other suit. If the second player puts down a 2 of spades, the third player can put down a 3 of spades or a 1 of any other suit. All the numbers have to be placed in order within each suit, without skipping any.

Anyone who does not have a card that can be played must pass. The first player to use all cards is the winner. This can be modified by beginning with 10 and proceeding in descending order.

Ladybirds on the leaf (Original)

Materials: A cardboard leaf and ten paper ladybirds

Number of players: Four-Six

Children arrange the ladybirds on the leaf, under the leaf and on 'the ground'.

Children discuss and record results

Compare and Double Compare (Original)

Materials: Number cards and interlocking cubes

Number of players: Two initially and later increase the number when children can compare more than two numbers.

The cards are dealt in a pile face down to each child. Each player turns over a card and selects that number of cubes to form a tower. Each child has to compare his or her tower and state 'I have more than you or I have less than you'. Rule of the game can change between the player with more than keeping both cards or the player with less than keeping both cards. If both numbers are the same, each player turns over the next card, and the player with the larger number/smaller number takes all four cards.

This can be further modified into an addition game; double compare where two cards are turned. The winner is the player whose total is greater or less than the opponent

Before or After (Kamii 2000:157)

Materials: Playing cards with picture cards removed

Number of players: Two – Four

All 40 cards are dealt, and the players keep them in a face-down stack. The first player turns over the top card of his stack and discards it in the centre of the table. The next player turns over the top card of his stack and tries to use this card to make a pair with a number that comes immediately before or after it. (If there is a 5 on the table, for example, a pair can be made with either a 4 or a 6.) If a pair can be made, the second player can take both cards and keep them. If not, the card has to be discarded in the centre of the table.

Play continues until pairs cannot be made any more. The winner is the person who collected more pairs than anyone else.

Further modification of this game could be two before or two after.

Guess My Number (Kamii 2000:169)

Materials: Cubes

Number of Players: Whole class or a small group of children

The leader thinks of a number within the range 1-20. The rest of the class tries to guess it. Children's responses are recorded on the blackboard and encouraged to communicate their thinking and reasoning.

Build a Tower (Original)

Materials: Interlocking cubes

Number of players: Partner activity

Instruction to partner 1: Build a stack of four.

Instruction to partner 2: Build a stack one more than four.

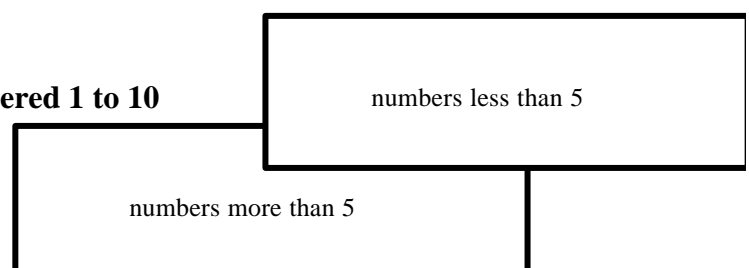
(Partner 2 can use the four belonging to his partner as a referent set)

Give a variety of directions that use more and less.

Play by the Rules (Wrigley 1999:17)

Materials: Two suits of cards numbered 1 to 10

Number of players: Two



The cards are shuffled and spread out face down on the table. Each child has a different rule card. Players take turns to turn over a card. If the card satisfies their rule card, then they can keep it. If not it is turned down face down on the table and the next player has their turn. The first player to collect 10 cards wins the game.

Go Fish (Kamii 2000:184)

Materials: pack of playing cards without colour cards

Players: 2-4

Each player gets 5 cards and the remaining cards are left in a pile in the centre of the table. The object of the game is to get pairs that add up to 10.

Players check their cards for pairs to 10 or a 10 card and put them aside.

(face up so all players can check they add up to 10)

Each player takes turns requesting a card to make 10 from the person to his left. If the other player doesn't have the card he says, " go fish!" and the player has to take a card from the pile and wait until his next turn to put down a pair.

When a player puts down a pair he has to pick up 2 cards from the pile until all cards are gone. The winner of the game is the one who has the most pairs to ten.

How Many Behind My Back? (Original)

Materials: Unifix cubes

Players: 2

Player 1 shows Player 2 a number of connected cubes. Player 1 then puts the cubes behind her back and breaks off some. She then shows Player 2 only how many she broke off. Player 2 has to figure out how many more are behind Player 1's back.

Spill the beans (Original)

Materials: Two colour counters

Number of players: Two

Children take a given number of counters, spill them, and record which colour comes up more or if there is an equal number of each.

First Class Games List

Ten More (Kamii 2000: 170 adapted)

Materials: A game board, a die, 10 counters of 4 different colours

Number of players: Four

15	12	16	13	14	16	13
15	17	12	16	15	12	15
14	11	12	15	13	11	16
16	15	16	11	16	14	13
12	11	13	16	12	15	14

The children take turns rolling the die and placing a counter on the number rolled plus one, anywhere on the board. The person to use up all the counters first is the winner. Transparent counters enable the players to see the numbers covered which aids checking each others addition.

This can be adapted to 11 more than the number rolled etc. The numbers on the game board require modification.

Line-Up or Card Dominoes (Wrigley 1999:32)

Materials: A deck of cards with the picture cards removed

Number of players: Two – Four

The cards are dealt equally. The children take turns putting down one card at a time trying to make a matrix in the middle of the table consisting of four rows (hearts, diamonds, spades and clubs) going from 1 to 10 in order.

If the first player puts down a 1 of spades, for example, the second player can put down a 2 of spades or a 1 of any other suit. If the second player puts down a 2 of spades, the third player can put down a 3 of spades or a 1 of any other suit. All the numbers have to be placed in order within each suit, without skipping any.

Anyone who does not have a card that can be played must pass. The first player to use all cards is the winner. This can be modified by beginning with 10 and proceeding in descending order.

Compare and Double Compare (Original)

Materials: Number cards (1-20) and base ten blocks

Number of players: Two initially and later increase the number when children can compare more than two numbers.

The cards are dealt in a pile face down to each child. Each player turns over a card and selects that number of blocks. Each child has to compare his or her amount of blocks and state 'I have more than you or I have less than you'. Rule of the game can change between the player with more than keeping both cards or the player with less than keeping both cards. If both numbers are the same, each player turns over the next card, and the player with the larger number/smaller number takes all four cards.

This can be further modified into an addition game; double compare where two cards are turned. The winner is the player whose total is greater or less than the opponent.

Make the Biggest Number (Kamii 2000:158)

Materials: 50 cards, 5 each of the numerals 0-9, base ten blocks

Number of players: Two – Four

All the cards remain in a box, face down. Each player draws 2 cards and tries to make the biggest two-digit number possible. The child uses the dienes material to represent the number. The child with the bigger number takes all the cards played in this turn.

Guess My Number (Kamii 2000:169)

Materials: Cubes

Number of Players: Whole class or a small group of children

The leader thinks of a number within the range 1-50. The rest of the class tries to guess it. The leader will say whether the guess is more than or less than the selected number. Children's responses are recorded on the blackboard and encouraged to communicate their thinking and reasoning.

Roll a Tower (Original)

Materials: Interlocking cubes and a die

Players: Two- Four

The first player rolls the die, collects the same number of cubes and builds it into a tower. The second player repeats. After three rolls each the highest/lowest tower is the winner.

Build a Tower (Original)

Materials: Interlocking cubes

Number of players: Partner activity

Instruction to partner 1: Build a stack of eight

Instruction to partner 2: Build a stack two more than eight.

(Partner 2 can use the eight belonging to his partner as a referent set)

Give a variety of directions that use more and less.

Animal Olympics (Kamii;159)

Materials: 39 cards numbered 1-39

Number of players: Two – Four

Five cards are dealt to each player, in a face down row. The players are not allowed to look at the cards received. The remaining cards are placed in a face-down stack. The object of the game is to be first to get five cards in the correct order, face up, from the lowest number on the left to the highest number on the right.

The first player takes the top card of the face-down stack and trades it for one of his face-down cards. If the number drawn is large, a good place for it is at the end. If the number is small the other end of the row is more suitable. The first player then gives the replaced card to the next player, and it is the second player's turn to decide which one of his cards should be replaced.

Go Fish (Kamii 2000:184)

Materials: pack of playing cards without colour cards

Players: 2-4

Each player gets 5 cards and the remaining cards are left in a pile in the centre of the table. The object of the game is to get pairs that add up to 10.

Players check their cards for pairs to 10 or a 10 card and put them aside (face up so all players can check they add up to 10).

Each player takes turns requesting a card to make 10 from the person to his left. If the

other player doesn't have the card he says, " go fish!" and the player has to take a card from the pile and wait until his next turn to put down a pair.

When a player puts down a pair he has to pick up 2 cards from the pile until all cards are gone. The winner of the game is the one who has the most pairs to ten.

How Many Behind My Back? (Original)

Materials: Unifix cubes

Players: 2

Player 1 shows and tells Player 2 a number of connected cubes. Player 1 then puts the cubes behind her back and breaks off some. She then shows Player 2 only how many she broke off. Player 2 has to figure out how many more are behind Player 1's back.

Spill and Compare (Original)

Materials: Two colour counters.

Number of players: Two

Children take a given number of counters, spill them, and record which colour comes up more or if there is an equal number of each.

Sixes (Original)

Materials: 2 dice

Players: Two

The first player rolls the dice and adds up the scores. If the total is less than six the player writes down the score. If it is more than six the other player is given the score. Player two rolls the dice and adds up the scores. If the total is less than six the player writes down the score, if it is more than six the other player is given the score. After five rolls each of the players add up their scores or alternatively collect base ten material as each score is awarded and trade for tens when appropriate.

Pairs (Wrigley 1999:45)

Materials: 2 suits of cards 1-10

Players: Two

This game is similar to sixes. Shuffle the cards and spread them out face down on a table. Players take turns to pick up two cards. If the total turned over is more than ten then the player keeps the cards. If the total is less than ten the other player is given the cards. When all the cards have been used, the player with the most cards wins. (Follow-up class discussion how much more than ten/ less than ten was the total?)

Guessing Totals (Wrigley 1999:18)

Materials: A set of cards 1-10 for each player

Players: Two

Players shuffle their cards. Both players place their piles side by side face down. They take turns to guess the total of the top cards in each pile, before they are turned over. Each player must guess a different number, then they turn over the top card in each pile. The player who guessed nearest to the total wins. (Base ten material or unifix cubes can be used to compare results.) The game continues until all the cards have been used. The player who finishes with the most cards wins the game.

Second Class Games List (Kamii 2000: 170 adapted)

Twenty-one More

Materials: A game board, a die, 10 counters of 4 different colours

Number of players: Four

25	22	26	23	24	26	23
25	27	22	26	25	22	25
24	27	22	25	23	27	26
26	25	26	27	26	24	23
22	27	23	26	22	25	24

The children take turns rolling the die and placing a counter on twenty-one more than the number rolled anywhere on the board. The person to use up all the counters first is the winner.

Transparent counters enable the players to see the numbers covered which aids checking each others addition.

This can be adapted to 31 more, 31 less than the number rolled etc. The numbers on the game board require modification.

Line-Up or Card Dominoes (Wrigley 1999:32)

Materials: A deck of cards with the picture cards removed

Number of players: Two – Four

The cards are dealt equally. The children take turns putting down one card at a time trying to make a matrix in the middle of the table consisting of four rows (hearts, diamonds, spades and clubs) going from 1 to 10 in order.

If the first player puts down a 1 of spades, for example, the second player can put down a 2 of spades or a 1 of any other suit. If the second player puts down a 2 of spades, the third player can put down a 3 of spades or a 1 of any other suit. All the numbers have to be placed in order within each suit, without skipping any.

Anyone who does not have a card that can be played must pass. The first player to use all cards is the winner. This can be modified by beginning with 10 and proceeding in descending order.

Compare and Double Compare (Original)

Materials: Number cards (1-100) and dienes blocks

Number of players: Two initially and later increase the number when children can compare more than two numbers.

The cards are dealt in a pile face down to each child. Each player turns over a card and selects that number of blocks. Each child has to compare his or her amount of blocks and state 'I have more than you or I have less than you'. Rule of the game can change between the player with more than keeping both cards or the player with less than keeping both cards. If both numbers are the same, each player turns over the next card, and the player with the larger number/smaller number takes all four cards.

This can be further modified into an addition game; double compare where two cards are turned. The winner is the player whose total is greater or less than the opponent.

Make the Biggest Number (Kamii 2000:158)

Materials: 50 cards, 5 each of the numerals 0-9, dienes blocks

Number of players: Two – Four

All the cards remain in a box, face down. Each player draws 2 cards/3 cards and tries to make the biggest two-digit/three digit number possible. The child uses the dienes material to represent the number. The child with the bigger number takes all the cards played in this turn.

Guess My Number (Kamii 2000: 169)

Materials: Cubes

Number of Players: Whole class or a small group of children

The leader thinks of a number within the range 1-200. The rest of the class tries to guess it. The leader will say whether the guess is more than or less than the selected number. Children's responses are recorded on the blackboard and encouraged to communicate their thinking and reasoning.

Roll a Tower (Original)**Materials: Interlocking cubes and a die**

Players: Two- Four

The first player rolls the die, collects the same number of cubes and builds it into a tower. The second player repeats. After three rolls each the highest/lowest tower is the winner.

Build a Tower**Materials: Base ten material**

Number of players: Partner activity

Instruction to partner 1: Build a stack of eight

Instruction to partner 2: Build a stack twenty more than eight.

(Partner 2 can use the eight belonging to his partner as a referent set)

Give a variety of directions that use more and less.

Animal Olympics (Kamii 2000: 169)**Materials: 99 cards numbered 1-9**

Number of players: Two – Four

Eight cards are dealt to each player, in a face down row. The players are not allowed to look at the cards received. The remaining cards are placed in a face-down stack. The object of the game is to be first to get 8 cards in the correct order, face up, from the lowest number on the left to the highest number on the right.

The first player takes the top card of the face-down stack and trades it for one of his face-down cards. If the number drawn is large, a good place for it is at the end. If the number is small the other end of the row is more suitable. The first player then gives the replaced card to the next player, and it is the second player's turn to decide which one of his cards should be replaced.

Go Fish (Kamii 2000: 184)

Materials: pack of playing cards without colour cards

Players: 2-4

Each player gets 5 cards and the remaining cards are left in a pile in the centre of the table. The object of the game is to get pairs that add up to 10.

Players check their cards for pairs to 10 or a 10 card and put them aside (face up so all

players can check they add up to 10).

Each player takes turns requesting a card to make 10 from the person to his left. If the other player doesn't have the card he says, " go fish!" and the player has to take a card from the pile and wait until his next turn to put down a pair.

When a player puts down a pair he has to pick up 2 cards from the pile until all cards are gone. The winner of the game is the one who has the most pairs to ten.

Spill and Compare (Original)

Materials: Two colour counters

Number of players: Two

Children take a given number of counters, spill them, and record which colour comes up more or if there is an equal number of each.

Sixes (Original)

Materials: 2 dice

Players: Two

The first player rolls the dice and adds up the scores. If the total is less than six the player writes down the score. If it is more than six the other player is given the score. Player two rolls the dice and adds up the scores. If the total is less than six the player writes down the score, if it is more than six the other player is given the score. After five rolls each of the players add up their scores or alternatively collect dienes units as each score is awarded and trade for tens when appropriate.

Pairs (Wrigley 1999:45)

Materials: 2 suits of cards 1-10

Players: Two

This game is similar to sixes. Shuffle the cards and spread them out face down on a table. Players take turns to pick up two cards. If the total turned over is more than ten then the player keeps the cards. If the total is less than ten the other player is given the cards. When all the cards have been used, the player with the most cards wins. (Follow-up class discussion how much more than ten/ less than ten was the total?)

Guessing Totals (Wrigley 1999:18)

Materials: A set of cards 1-10 for each player.

Players: Two

Players shuffle their cards. Both players place their piles side by side face down. They take turns to guess the total of the top cards in each pile, before they are turned over. Each player must guess a different number, then they turn over the top card in each pile. The player who guessed nearest to the total wins. (Base ten material or unifix cubes can be used to compare results.) The game continues until all the cards have been used. The player who finishes with the most cards wins the game.

Appendix H

Notes taken by Senior Infant Teacher during observation in a Junior Infant classroom
Tuesday May 14th 2002
10:00 - 10:35

Game: Spill the beans

- two sided counters
- ten counters in each box
- one box between two
- children seated at tables
- words on blackboard: more, less, same

Children played this game for the first time.

- All children actively involved.
- Took turns.
- The person whose turn it was did all – shook, put them in a line and made the statements

There are more yellow than red

There are less yellow than red

They are the same

- Partner was observing and never tried to help them line them up.
- Children's answers/observations were always right so partner didn't have to correct a statement.
- Many children started with the 'less' statement. I feel that children understand the concept of more/less better by doing rather than filling in a page of a maths book and by going around them I know they all understand it – evaluation – I wouldn't know as much from a page in a book.
- Children always lined up discs, never guessed/estimated more or less.
- Even the weakest child in the class managed this game.
- Language of colour also needed for this game. One child didn't know dark blue colour.

Appendix I

M: Mairead Ryan

TJI: Teacher of Junior Infants

TSI: Teacher of Senior Infants

TFC: Teacher of First Class

TSC: Teacher of Second Class

29th April, 2002 Cycle 1

M: What are your reflections on using the games?

TFC: The children enjoy playing them and they can play them when they are tired unlike other maths activities, take part, enjoy it.

(TJI and TSC reported that the children played the games at break time)

TJI: I think doing it as a class, it becomes obvious very quickly who is not grasping the concept, and you notice other children that you might have thought were capable but have difficulty.

TSI: The other children look in when they have finished their work.

SCT: Well I have given them to the whole class because I feel they are of benefit to the whole class.

M: So in that sense, would you think, it is something you value doing?

TJI: I just feel that all the children need this.

TSC: It is very hard at this time of the year, getting time to do it, with Communion coming up.

M: I found last year that I carried out my research between January and march, I felt that was the wrong time. It should be in the first term, but then you don't know the class.

TSC: Also you may not have enough taught either.

TSC: This is only for one strand, you'd want to be doing this for all strands.

TSI: Time, length, and money.

M: What I hope to do at this meeting was to tease out any problems you may have and also to look at these skills and establish if we have a shared understanding with monitoring the development of these skills?

TSC: Sometimes I'm there saying what does that mean, guessing, I'm not sure if I'm right. You couldn't possibly record while they are playing and afterwards it is difficult to think back.

M: Are there too many skills there?

TSC: See apply and problem solving you see these are four. It is enough for me to Cope with just those four. I'm not saying those four, any four.

M: There are six skills on the observation sheet, within each skill there are different parts.

TSI: It loses its impact because there are so many. If we could just look at it and see one word, you have to decipher it yourself first.

M: So which skill do you think is easiest to monitor?

TSC: I don't think I'm familiar enough with those skills to recognise their development in the classroom. Its part of the new curriculum we haven't really got our heads around the terminology.

TJI: The games in infants, I don't think the skills apply immediately to the games we are playing, so their development of the skills are not that instantly obvious, e.g. they don't have to select appropriate material and processes, it's already there. (agreement from other teachers).

TSC: Understand and recalling terminology and facts.

TSI: We are not giving them a change to do that.

TSC: Although I'm supposed to say, I have more than you do, you have less than me is that recall of the facts.

M: Well that would be “communicating and expressing”. Where I think the value of the games myself last year was that communicating and expressing came to the fore.

TSC: Well, it’s probably something that traditionally we don’t do in maths.

TJI: Whereas when they are playing maths games as a group, they are correcting each other and learning from each other, especially the weak child who has been getting the wrong connections, second time he is much sharper. I had to change the term, before and after to beside.

TSC: Double compare, each child puts out two cards, 4 and 6, 3 and 2, adds the number value on the cards. The brighter child realises he has won if their partner has put out 4 and 2, and he puts out 7. He sees that he has won, he doesn’t even need a second card. The weaker children learn from the brighter children to do that.

M: So getting back to the skills and applying this example to the skills. There’s reasoning there, integrating and connecting, the relationship between $4+2$ and 7.

TFC: When brighter children at the table are calculating very quickly, other children merely observing helps development by just watching, over time learning from them.

M: Children are observing the implementation phase.

TJI: That was leading to cheating, children had to turn up their next card and if it came before or after the card on the table they kept both cards. They began to search through their pile of cards looking for the correct card – they know which card they needed. It showed that they were able to associate.

M: That would have been ‘applying and problem solving’.

TSC: It’s very obvious that you are much more clued into these skills than we are.

M: Thinking back on the traditional way of teaching maths, use of a textbook. Do you think using the games addresses the development of these skills better than use of a textbook and whole class instruction.

TSI: It does.

TJI: You have to teach first.

TSC: I find that by 2nd class, the whole concept of more than and less than is there, I don’t have to teach it.

M: Is the game for children too easy then?

TSC: Yes, but they still really enjoy them there is a place for that.

TJI: There is also co-operation and turn-taking.

TFC: A lot of time goes in at the start, teaching the game, even the card game, a lot of children had never held cards before, that tradition of card games seems to be gone, its more computers now.

TJI: Even giving out the cards was a skill they had to learn.

TSC: A few of the children didn't know how to shuffle a deck of cards. I don't think it's that they don't play cards, today at break-time they asked to play any game. They listed plenty of games that they knew.

TSI: Only two children had every held a pack of cards.

TSC: I think it might be an age thing. In two years time you might be surprised. Only one or two said they didn't know, most of them did.

TJI: Even with the dice games, some of the children knew instantly the value of the dots, other had to count.

TSI: I was really surprised in general that so many children had to count the dots.

TJI: I wasn't that surprised with those that had to count but great to see those who didn't need to count.

TSI: Really shocked with children needing to count the five. After all the work on the recognition and formation of five.

TSC: Even with the pattern of five on a dice – should be easy to recognise.

TJI: A bigger die for infants might help.

TSC: Make the biggest number, almost all children knew to put the large digit in the hundreds place. It shows that the children do advance a lot from year to year, there is a big difference in what they knew.

TFC: Your class though were Mariéad's last year so they would have played a lot of these games already – would all the second class be as advanced.

M: Yes a lot of games were played, especially place value games.

TSC: Good point, they are a bright class also.

TSI: The full suit of cards is nearly too much, one suit would be enough – too many to hold, so many shapes, colours, number especially for children who had never seen cards before.

TSC: I asked the children to say - I have more, in the game ‘make the biggest number’ I have less than, I have the most, I have the least. Jean found the language of less and least very difficult – it’s something I needed to teach to her.

TJI: Least is a word that is seldom heard. Most is more commonly used.

M: That’s the argument in the literature on maths that the word more should always be interchanged with less and the same with most/least.

TSC: Do you not think it’s important to use lots of different ways.

TJI: Which is more correct, bigger and smaller has to do with actual size. I can draw a big five or a small five, has that come up before.

M: I think there should be a school policy on that.

TSC: I think what is needed is a few different ways of saying certain things and draw attention to that. Children are going to come across different terminology, go to different classes different schools, you want their learning to transfer.

M: Listening to children say it in different ways may help child to connect – rather than sticking rigidly to the one way of saying it.

What skills are easier to focus on? Are any of you connecting the games to written recording? Is there a need to link it to recording?

TFC: Well maybe not for the children to record individually because they are not that familiar with the games. But it is good for me to bring it to their attention. Originally the three children that I tested, one very bright child just looked at the problem, wrote it down immediately, another child who would be quite weak worked his way through writing down the problem, then figured out the answer. Third child quite bright but hates maths and doesn’t like writing maths down used the concrete material only and never wrote the problem, made no connection between + and – and the material she was using, just wrote the answers directly down, so for the likes of her it would have to be drawn to attention how you use the symbols at the board at the end of the session to bring it together.

M: That then would involve understanding and recall of terminology and facts. Recognise the relationship between verbal, concrete and symbolic modes of representation numbers. So what we are using would be concrete talking about it verbal, in your case pictorial cards, and symbolic would be recording it. All these skills

have to be developed. Try to be more selective by questioning what does the 'game do'.

TSC: Again you are much more familiar with these skills, you can see clearly.

TJI: You can relate to the physical doing. With selecting appropriate materials, in Infants I have to suggest what they should use. They want to automatically know what to do get cubes, draw it.

M: Well even say the game 'One more' can they select four cubes and pick one more.

TJI: Oh so its not the material.

M: Oh no, its not that I'll use counters or cubes, that's my understanding. Process is, do I add or subtract.

Select and apply appropriate strategies e.g. $5=6$, by second class the children would probably be able to see that as $(5 + 5) + 1$, by senior infants children's strategy might be counting on from five junior infant children might count all.

Recognise the solution would mean that the child knows that he has found the answer – is he still looking for more cubes/counters.

TSC: Yes you have that, they don't know where to stop.

M:I think the communication and expressing is fairly straightforward.

TJI: Sometimes in the first test there, Evan he got all the answers when questioned be answered I don't know I just did it. It takes a lot of teasing to help them through steps, to help them show how they got their answer.

TSI: My weaker children will never give the answer, the brighter child always gives the answer. I put out 5 and I put out 3, very slow to make the connection she had to verbalise it every time.

TSC: Could she give you the answer?

TSI: Sometimes and sometimes not.

M: Is there development of the skill integrating and connecting?

TSI: Jellybeans involve guessing using knowledge of number informal way.

M: Maybe yes, recognise relationship between verbal, concrete, you could probably focus on that.

TSC: Well the fact that when they look at a card, the number is represented pictorially and symbolically – you are talking about it.

M: So then use the game as a way of linking all methods of representing. Involving other areas of the curriculum other than from a social point of view – sharing, turn-taking.

TSC: Well that's not really a 'curricular area'

M: Now reasoning, categorise objects into logical categories, is that coming into the games?

TSC: Cards involve categorisation.

M: Recognise sensory patterns. You could use the cards for that.

TSC: Reasoning comes into guess my number, giving the clue its more than that, rules out a lot of numbers.

TSC: I feel I'm not getting what I want done in the maths, if I use the games at the maths lesson.

M: Could you see yourself putting a game around the area of maths that you are teaching at the moment as a methodology for teaching?

TSC: It would depend on the topic, yes.

M: Do you think most of them could?

TSC: Yes probably.

TFC: I'm sure it would be of benefit.

TSI: But the fun element of the game, the children are learning unknown to themselves. You could teach a lesson on the same thing.

TFC: At the end of the month, if you are to give them a decent change to work to show an improvement, you need to be doing it every day.

TJI and TSC: I'm not doing it everyday. I'm doing it as often as I can.

M: That's the whole point, this is a natural inquiry, it shouldn't be contrived.

TSC: Well isn't that realistic. If you are doing anything in maths ordinarily there are days you just don't get around to it.

TJI: Before and after will take a lot of time for infants, its time to them – before school, after school, to see it as a linear thing, tying it to number, left to right to reading, it's a lot to take in.

TSI: The two concepts together, make it quite difficult, spend some time for month one, then focus on the other. I find it difficult to combine the two.

TJI: You are confusing them too e.g. four comes up, then seven it's not beside it, its far away from it. At the other game I'm trying to get the children to use greater than/less than rather than far away and near.

M: I wouldn't correct the children too much, that's their way of reasoning.

TJI: Oh I haven't, but there's an inconsistency in language that makes it difficult for children who are weak.

M: Do you think the game exposes the difficulties children have, trying to communicate and express.

TJI: It does, but as well it will help them to make sense of it.

M: That brings us almost to the end of the implementing, we said that – devise mental strategies - probably wouldn't happen much with the infants.

TSC: Can you remind us of what it means.

M: Strategies would be back up to – adding in their mind. I took these directly from the curriculum. I would have put manipulative first, from that mental strategies.

TSC: So I suppose with that I'd say some children have reached a much more advanced stage of that than others. Its very hard to know how much impact you have on changing that. You know when I tested the three children the way Colm had all this business of rounding up to e.g. $35 + 72$, he'd automatically know, bring this to 70 and the 35 then the 2. How do you get children to do this?

M: Do children devise it themselves.

TSC: Did he learn that from you Mairead last year, or did anyone teach him? How did he come to that understanding of numbers.

M: Then alternatively how do you bring the children that aren't at that level of understanding. I think you have to use a lot of materials to develop that strategy e.g. $5 + 6 = 5 + 5 + 1$ is very difficult for a weak child.

TSC: If you start to formally teach all you do you confuse children who don't have it.

TSI: They will only know it for that sum that day, they don't relate it.

(Teacher of first class left the meeting as it was approaching the end of the school day and she had to dismiss her class)

TSC: They don't understand what you are doing. You know listen to and discuss other children mathematical understanding - see the faces of some of the children, what is he talking about?

TSI: Are they bored?

TSC: No its good for them in the sense that they are very interested because bright children understand what is being said, but the others I wonder are they being confused even more, do they actually learn from it.

M: I think over time they would.

TSC: Well they probably would.

M: I did a thing today – flash and fill 5 over 5, could recognise 5 and 3 was 8, because 2 were missing. Surprised when they used counters, they actually counted. Didn't apply the card game to the cubes.

SCT: I wonder if you said how did you figure it out, talked about it, you would take the fun element out of the game if you trash it out too much.

M: Well it was grand while I was just showing them the card, hid it behind my back, when they couldn't see it again they had to remember it, two were missing.

TSI: But was it the bright ones were shouting out the answers.

M: Well I think that's what happens generally in a maths class you think you are doing an oral lesson, what's happening is that the brighter children are willing to answer, and its only when you go around and listen to individual task you realise they didn't understand what I was saying.

TSI: They wouldn't have copped – 2 is 8.

TSC: Which reinforces the value of recording and doing something that you can see for evaluation. I had that discussion with D. the other day not to get the children to write the answers to comprehension questions. Very hard to zone in on who comprehends and who doesn't if you don't get them all to write.

M: If you are totally going to have a situation of writing down answers to sums you do not knowing if they understand what they have done.

TJI: Sometimes in writing, key words are copied not showing any comprehension, lucky that they hit the right sentence.

M: I hope this meeting has helped to clarify some of these skills and hopefully can you notice the development of some of them in your classroom.

End of group meeting.

15th May Cycle 2

M: Did you gain anything from the visits to the classroom?

TSC: I thought it was interesting to see the difference in the ability of children; between first class and second class; same game interesting to see the progression.

TSI: We don't get a chance to see what happens in other classrooms.

M: Could you stand back and see skills being developed that you can't when you are in the middle of it yourself?

TSI: A little easier when it wasn't your own children we have our own pre-conceived ideas of our own children.

TJI: Games with the ladybird, under the leaf I thought that it was very good. Take three positions, record them and put it together as a sum. Know what they were doing. In infants they haven't done anything at all like that. They have moved on so much in Senior Infants to be able to put that into a number sentence.

TSI: H was shaking the counters and putting them out. She had three rules very well explained, they put them out in two rows the children could clearly see which was more and which was less, some children would hazard a guess first as to which was more and which was less. They needed that structure in Junior Infants to be even able to use the counters was great in Junior Infants.

TJI: I was doing it with ten. Today I brought it down to five and found it far more limiting because I tried to bring in the numbers four is more than one. I don't know if that is a good idea or not. Two tiers to the game first of all, the colour, more green than white. I wanted to move on to only four greens and one white, four is more than one – some got it and some didn't.

M: Before this you just looked at the colour.

TSI: And the long line was helpful.

M: They may not be ready for that.

TJI: Probably not.

M: Maybe just count the number of each colour and later build it into a comparison.

TJI: You have to do it in stages.

TSC: That will stand to them when they are doing pictograms to see them laid out like that, what's more? and what's less?

TJI: What I hope if they had enough of this practice of being able to say the number that down the road maybe not this year in Senior Infants but they may be able to say that 4 is three more than 1, not just 4 is more than 4, 4 continues on with 3 more counters that is the stumbling block in any class, is how many more is that than that. I hope that is where they were heading.

TSI: Well they were putting words on it. Every child in this class could say; There are more green counters than yellow counters, there are less yellow counters than green counters.

TSC: That's very good.

TSI: Whereas with a maths book they might tick a box with that, but they might be copying yours; every child fully understood it.

TSC: The fact that every child will say it makes them understand it more. Sometimes you think something and you do it and you don't fully understand it.

TJI: Speaking clarifies your own thoughts and also when you write it down you see what you are thinking a lot clearer.

M : Did you see any development of skills that could help you. in your class room?
Those that moved up a class may be more advantaged in applying to their classroom.

TFC: My class were all playing these group same games. In S. they had a different activity. I could see they were at home with the activities. One group of children impatient with a child who didn't follow the rules. Siobhan pointed out that child is not living in Ireland long and is a bright child but has difficulty with the English language. Some of them wanted to change games after a few minutes whereas my class didn't play any games of that nature last year, delighted to get any game.

TSC: I saw a child trying to make the number and she couldn't figure out which to use the tens or units used tens for both units and tens.

M: Was she not able to select the appropriate material

TSC: I suppose not. She was counting along the ten, didn't realise it was always going to be ten . She needs a lot of help, she has along way to go.

TFC: She would actually learn from that now. If I had seen her and had sat down with her and said there's ten bricks that you are used to using, that's the same in the base ten.

TSC: Its funny actually she did improve even while I was there, her second go she got the least again, second time around she was much better.

TFC: I encourage those with the most and the least to make their number just to get more children involved in using the base ten materials. Today I used the card games building the 10's memory game, spread out the cards and pick two cards to make ten it actually caught a lot of them. It was good to see them, they were counting away. I saw T. take out his markers and line up the markers and use those, make himself faster. He wanted to win the game.

TFC: He had his own strategy.

TSC: Mine love that go fish game.

TFC: I might try that tomorrow.

M: C. you were saying yesterday rather than seeing a development of skills, you used the games as an assessment tool, can you see areas of difficulty?

TFC: Yes you can, I found as I was giving out the materials, under pressure because S. was coming in and I wanted them given out quickly, you just see problems coming up, we don't have enough tens, are those tens the same as these. You explain as you go along, you do see problems arising. Even today I could see, no movement there were two girls together C. and J. They needed someone with them, to lead them.

TSC: I find that they benefit an awful lot more if you are at the table directing them and asking the right kind of questions, but then you see if we were doing this all the year round you'd have a lot of that done early in the year and they'd have copped on to things and the weaker children wouldn't need that kind of direction maybe.

M: Maybe pair of a more able child with a less able child.

TSC: You wouldn't want to put all the weak children together.

M: You have to monitor that closely then to make sure that these children are being told the answers.

TSC: Well the weak children are sheltered in that situation.

M: Are the weak children not sheltered anyhow in a classroom situations.

All: Oh yeah they are.

TSI: I thought the games would be hard to evaluate and after walking out of the junior infant room, well I thought to myself that that was much better than giving them a page of a maths book for more or less because I knew in the children class had a concept of more and less, whereas a page in a maths book is ticked and they might have copied it.

TSC: Got it right by accident.

TSI: It is easy enough to evaluate and I thought it wouldn't be.]

TSC: They are all engaged in it, aren't they.

M: That's what I noticed when I went into your room yesterday everyone was talking.

TSI: Yes

TFC: Today I needed to cover tens and units subtraction on the board, it was revision, as I wanted to "fill the book" (with emphasis). I said as soon you are finished you can come up for the cards. MY goodness you should have seen the speed they finished.

TSI: Now wasn't that great.

TFC: I was also careful that the ones who were slow didn't get anxious or feel they were punished, they were still given time to complete the exercise and then allowed them time to get the game. It definitely speeded up the first group. Normally I would send those finished first for workcards – more of the same activity.

TJI: When you gave the first game – you saw immediately that this was too much to give, you went back two or three steps, everyday you put another step onto it. It was for the better. These things don't occur to you when you are writing it down, in practice that you see it. It becomes obvious and clear, you modify as you go and hope for the best.

TSI: Well even in my room when they were playing the game with counters mine were using multicoloured counters, H. even suggested just using the two one colour for each child. We did it today, it was fabulous much better, so like you say you learn every day.

TSC: I definitely see that I would try using the games much more throughout the year.

M: That brings me to.....

TJI: The other point Mairead though we don't have the time to stick those counters together, getting the boxes, sorting them out and having the equipment right.

TSC: Handed to you makes such a difference

M: Well that is an issue

All: Oh yes I agree

TJI: If it was left to me, I would put it on the long finger for ever. It might be next year.

M: That is a huge issue, and its an awful pity that's what stopping teachers from using games, who would do this, how do you resolve this issue.

TJI: And its not stuff you can go to a shop and buy. Its not the same, you need a little container, ordinary counters, cards etc.

M: It has to be teacher designed for yourself, but you can't do it , I don't think you have the time.

TSI: No you haven't the time

M: Like, that's just for one.

TSC: Yes its just one section.

M : That brings me to the next thing I wanted to talk about, extending games to other strands could you see a value in it?

TSC: I could but I want to be handed the games again

TFC: It would also make one sharper on what I would spend my maths money on. You are inclined to go for some of the bigger games, shape things like that, I'd now focus on resources for number work. Even the cards alone, using those, at the in service day we had, I thought it was a great idea, but I still didn't go and buy cards. I went and bought other stuff.

TSC: On that day I said I really should get cards, I was thinking even when they were playing that game double compare – more than ten they keep the pair and I found some of the weaker ones they would know when they got more than ten by estimating but very lazy at calculating exact answers. e.g. $7+6$, they knew that 6 was enough more than 7 to make it ten. Too lazy – tried to make them add, I was thinking for younger children the 7 and 6 are there in front of you for counting up if you found it difficult to add in your head. Cards are very good from that point of view.

TSI: You were saying linking the games with the curriculum, you know the ladybird game there was linking with writing, nature element, read a story about a ladybird – plenty of linkage / integration.

M: Video recording tomorrow is that ok with you

H: For how long – (emphasis –not really very enthused)

M: Ten to fifteen minutes. In terms of organising it I was thinking of putting the video on the table, teacher stands behind the video, you need to be there to ask the questions, to elicit

the information from the children, to get discussion going about the game. I can take the other children out of the room or stay. All that will be heard is your voice.

TSI: My children were playing the game eight less than five, more than five, the card five was turned up. Where did that go?

M: Oh yes I saw them putting it in the middle, as a reference set.

TJI: Today when I went back to five counters, when they spilled out, one or two got five the same turned up. What was that more than, we weren't doing zero. Do I say all yellows and no greens, I hadn't anticipated that and when we were doing the tens then we got five and five. Am I doing zero?

M: Well its no harm. You can't at times disregard zero just like when reading you come across sounds that you may not have planned doing. E. mentioned yesterday, about letting other teachers know what is going on. Do you have a view on that, do you see it as necessary?

TSI: I even feel here today, listening to the girls talking about their games that I didn't actually know what they were talking about.

TSC: I understand Catherine but I don't understand Eva's and Helen's. I notice we are quiet when they are talking and they are quiet when we are talking.

TFC: Exactly

M: Would you like another opportunity to observe each other.

TSC: Well what I would love here is a copy of the games for the other three classes. I could see myself using them again.

TSI: Well I was telling N. with her diploma coming up that I have a few lovely games and she asked would it cause havoc in the classroom and I said actually it won't, lovely and simple.

TSC: It's not quiet, it's noisy

TSI: But a different kind of noise.

TSC: Bring the video along to the in service day

TSC: That would be no harm. If others wanted to see more, they could pop in some day.

End of meeting

Meeting 23rd cycle 3

Purpose: To reflect on the over all experience of children playing maths games

How did you introduce the games?

TSC: I taught four children on day one, on day two one child went to each group to explain. That may not work with smaller children.

TFC: I did one group at a time while the others looked on. I taught one group and the other children observed. The captain of each group took their equipment for his group and started playing.

TSC: Mine being older, I had only to explain one game to each group, then the next day children were moved around so that someone at each table knew the game.

TJI: I did a demonstration for the whole class. One child came out to demonstrate and then they all went off and played and managed fine. The card game was a bit harder, I was not able to demonstrate in the same way. I put one group playing and the others all stood around and watched and then they went off and played it I had a lad in on work experience. I showed him what was involved. He took two children at a time, after he left I did it in groups.

M: Do you think introducing a game is difficult?

TSC: It's very hard on your own. Hard enough to just set up and get going, let alone get it going and then try to observe. There is always someone pulling out of you or fighting.

TFC: As you got more used to playing the different games it didn't take as long.

TSC: If you started in September it would be better and do it all year.

TJI: Our games were simple enough, that once you knew they understood what the game was about and what they were supposed to do, they could be quite independent and I was free to dip and out. It was giving out the equipment and that sort of thing that was harder.

M: What role did you adopt while the games were being played, how did you confront misunderstandings?

TFI: I did not interrupt their game too much but if I noticed something, I would go back on that the following day at the start of the maths class.

TJI: I also thought it couldn't go wrong. If it went wrong they corrected each other. They were in mixed ability groups. When a strong child was with a weak child they did get on. I am satisfied that my weakest child now knows what more or less is. She also recognises the words that go with each. That is a big achievement for her.

M: When I was down in your room I heard her say its 'sam now' when she covered the 'e' in same.

TSI: That was a cross curricular activity so.

M: Did any conflict emerge, were the children very competitive?

TSC: They were full of that; she is always dealing, she won three times, I didn't win at all.

TFC: Whoever was called up to get the cards, dealt first time and play went clockwise.

TJI: The captain always started first.

M: Would dealing with conflict issues be a deterrent to you using the games?

TSC: You have some children no matter what kind of game they play, they don't like it when they don't win. They have all these things to learn.

TJI: Yes they always feel hard done by.

TSI: Well the more they played, the better they got at it. Mine loved it when they won. They had a really happy face when they won.

TSC: A lot of games were so quick, they got lots of chances.

TFI: Because it was the classroom situation they don't have a long time to play the game. It is not noticeable if a child does not win.

TJI: And as well as that I think it was an experience that they don't have all the time. You are with a group to play the game you have to finish it and see it through. You can't say I am fed up and I am going away. They have to take their turns and they have to abide by the rules because the others are watching. I thought it was a good experience for them whatever they were learning from it, in itself the social aspect, the participation.

TSI: This week now since they were familiar with it I said go and get one of the games. I hadn't to explain, they found what they needed, found a partner to play with.

TSC: I thought it was good as well they practically liked all the games. They weren't all looking for a particular game. They were quite pleased no matter what they got.

M: In terms of classroom organisation were there any difficulties?

TSC: The noise did my head in, I must be honest.

TJI: No mine weren't noisy, just the usual.

- M: Do you think that the noise level might stop a lot of teachers taking on the use of games? If there is a lot of noise, they may not be able to cope. Maybe if you could get it to an acceptable level.
- TJI: No, I don't think the noise is the problem. The problem is I said it here the last day it is having the games handed to you, specifically for you, all packaged, all ready to hand to the children with a specific aim.
- TFC: I bought tangrams and because I can't find bags small enough I haven't given them out to the children yet.
- TJI: You also have to photocopy the cards, cover them in contact and stick them onto card, number them. That is all time consuming.
- TSI: If think that the templates for the games would need covering to protect them.
- M: The fact that are stored on the computer just means you can print off another set.
- TSI: Well I suppose when they don't have to be done manually, it's not worth the effort'
- M: So do you think a lack of availability of appropriate resources will prevent teachers from implementing this methodology in their classrooms? (General agreement)
- TSC: Quantity is an issue to. Even the boxes of dienes, who do they think they are catering for? I have two boxes which contain one 1000, ten 100's, ten 10's, one hundred 1's. One child in second class would need ten 10's to represent 100.
- TSI: Did it take you a long time to make all the resources.
- M: It did take a long time and I understand that time to develop resources is a big issue.
- TJI: A lot of my planning is an aspiration, after that, I would love to do that and that, after doing the day to day stuff I don't have time.
- M: Did the use of the games present an opportunity to understanding the children's mathematical thinking?(Response was a resounding yes)
- TSC: I noticed one child while playing the game 'go fish' was likely to ask for any card. She just didn't get the concept.
- TFC: I expected that the children in my class would have a better understanding of breaking up a ten.

(End of meeting as teachers had to return to classrooms to dismiss children)

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