Introduction

Background

Numerous claims are made about the academic benefits of teaching chess to children. Chess enthusiasts talk about how it enhances their mathematical and reading skills, how it improves concentration and develops logical reasoning, and that children can learn to strategise and employ creative thinking. As far back as 1893, Alfred Binet, investigated the link between mathematics and chess. He found that over 90% of leading chess players were good at doing mental calculations and also had good memories. So in 1894, he conducted one of the first psychological studies into chess. He wanted to know whether chess players could play blindfolded. He found that some of the chess masters could play from memory, but none of the intermediate players could.

In 1925, three Russian psychologists, Djakow, Rudik and Petrovsky, conducted a series of tests on chess masters, and concluded that their memory ability was only greater than non-players as far as chess was concerned. In other areas there was no difference.

In 1973, W. Chase and H Simon demonstrated superior memory for chess positions by chess masters by "chunking". They found the better the player, the better the recall of chess positions. Beginner players could only recall the correct location of four pieces in 5 seconds, whereas grandmasters could recall the location of all of the pieces.

In Belgium, a study was conducted by Johan Christiaen (1974 – 6) to investigate the effect of chess instruction on children's cognitive development. 40 students participated over a two year period, when their average age went from 10½ to 12½ years. Half of them were randomly selected to attend mandatory chess lessons (the experimental group) once a week for 1½ years, and the rest were not (the control group). All the students were then given a battery of tests, including Piaget's tests for cognitive development (the "balance beam" test and the "liquid" test), plus a series of aptitude tests as well as school exams. The chess group showed better results in all the tests, but significantly so in the school's examinations. However, since no pre-test was given at the outset, (in order not to alert the students as to the nature of the experiment), the reliability of the results is questionable, since it may be that the chess group had a higher academic ability at the outset. Also, the teachers were aware of the ongoing research, so could unwittingly could have allowed it to influence their teaching.

In Texas USA, Jim Latrap (1998) conducted a study to investigate the extent to which elementary students' participation in a chess club (one hour a week for 2 years), affected their standardised test scores. He targeted four elementary schools in a large affluent middle class environment. Comparisons were made between the 3rd grade scores (pre-test) of students who attended the chess club, and those who did not. In all, there were 67 chess students, and 504 non-chess students. For the 3rd grade scores, the chess group performed slightly better (but not significantly so) in reading than the non-chess group, and marginally better in Maths than the non-chess group. For the 5th grade scores , the chess group were significantly better than the control group for both reading ($p<.001$) and mathematics ($p < .005$).

However, the chess group were already better than the control group at the outset, even if not significantly so. Also there appears to be a problem with the selection process. The chess group was predominantly male – 74.6% as opposed to 50.8% in the control group. Also, 52.3% of the chess group were "academically able " or "gifted and talented" compared with 33.5% in the control group, which suggests elf-selection in the sampling.

In Zaire (1973-4) Frank and D'Hondt conducted a study in which 92 students aged 16 years, were randomly assigned either to compulsory chess lessons, or to be part of the control group. The chess group met for an hour, twice a week, for one year. Chess instruction included lectures, tests, simultaneous games and practice. Psychometric tests were administered before and after the intervention. It was found that the chess group performed better than the control group for numerical aptitude and verbal ability.

In New Brunswick, Louise Gaudreau (1992) carried out a study on students over a 5 year period. There were 437 participants divided into three groups Group A, the control group, received traditional maths lessons throughout the study. Group B received traditional maths in the 1st grade, and thereafter, a combination of traditional maths with chess and problem solving instruction. Group C received the enriched maths curriculum beginning in the 1st grade. As 5th graders they were then tested for any differences. There were no significant differences among the groups for basic calculations on the standardised tests, but there were statistically significant findings for both group B and group C in the problem solving part of the test, and also on the comprehension section.

In the South Bronx NYC, Stuart Margulies (1990 – 1992) conducted a study to look at changes in reading scores after chess instruction. Mid-elementary school children joined chess clubs at school. In the 1st year, they received instruction by chess masters. In the 2nd year, they also participated in computer-supported chess activities. Chess club membership was voluntary. Before the study began, students were assessed, using a standardised reading test. In this instance, the "control" group was the National Norm for the same grade students in the same school district. Students in the chess group made greater improvements than the national norm. However, since the chess group had higher pre-test scores than the control, Margulies aimed to address the selection bias, by comparing the chess group scores with those of a non-chess control group, consisting of children with pre-test scores comparable to the chess group. But again, the chess group showed more gains than the control group. However, Margulies himself, is quick to point out that "chess participants form a pool of intellectually gifted and talented students. Students who join this group make contact with a core of high achievers and thereby develop more academic interest, speak at higher levels of standard speech……"

In all of the studies mentioned, there have been some serious concerns with the lack of rigour in the experimental conditions. In some ways this is inevitable. For example, a chess club, by its voluntary nature, is necessarily self-selecting its participants in the experimental condition, and likewise, those who chose not to belong to the chess club. Teachers may influence learning outcomes simply by knowing about the experiment that is taking place, and unwittingly varying their teaching strategies in favour of the chess group. In some of the research, pupils may have opted in or out of chess programmes at will. Any number of different tests have demonstrated (or not) different aspects of educational benefits. Again, this has been inevitable due to the wide age range that has been variously tested. Tests need to be age appropriate, and also culture appropriate. In tha case of the Zaire study (Frank and Hondt), their methodology could be criticised as the tests used were not designed for an African culture, and the results were, perhaps unsurprisingly, low.

DeGroot (1977) suggests that there are actually two types of benefit to young people learning chess. First, “low level gains” in which pupils improve their concentration, learn to lose, and come to understand that improvement comes with learning. And secondly, “high-level gains” such as increase in intelligence, creativity and school performance.

This Study

This study aimed to show the cognitive benefits that can be acquired by even very young children when they are taught how to play chess. The experimental sample consisted only of children aged 8 – 9 years who have received 30 hours of mandatory chess tuition while in year 3, when they were aged 7 – 8 years. Thus all the children were the same age and had had exactly the same amount of chess tuition. The control group also consisted of 8 – 9 year olds, but they had not had any chess tuition. Thus the groups were not self-selecting and the research has greater validity than previous studies. The teachers themselves could not exert any extraneous influence on the results, since the tests were conducted by the researcher at a particular moment in time (approximately ⅓ way through year 4). The number of pupils tested was quite large – 483 – to further validate findings. And by checking the class profiles for National Curriculum maths levels, it was ensured that a similar spread of ability was found in both the experimental condition and the control, thus eliminating confounded results.

This research is the first of its kind in the UK in that it is looking specifically at the possible educational advantages of learning chess at a very young age. Testing at such a young age is necessarily constrained by the subject matter taught at this level, and also by the attention span of young children. And so it was proposed to focus the testing mainly on familiar subjects – mathematics and non-verbal reasoning in a 'Quiz' lasting no more than 30 – 40 minutes. The term 'quiz' was deliberately used so as not to alarm pupils who might be understandably anxious about having to do a Test.

The experimental group (the chess players) are part of the "Chess in Schools and Communities" Initiative (CSC) set up by International Chess Master, Malcolm Pein. The CSC teaches chess for one hour a week to a particular year group, as a mandatory part of the school curriculum. It can be year 2, 3, 4 or 5. But Year 3 seems to be a popular choice, so they offered the largest sample, and were therefore selected for this study. The control group consisted of children who, either did not have chess taught in their schools, or were in schools where chess is taught to the year 5's, and they have that education to come.

The research 'Quiz was devised in consultation with a pn experienced primary school teacher. It was intended to have as wide a variation in terms of level of difficulty, in order to be as inclusive as possible, but not so mush as to be either too easy for the more able, or too intimidating for the less able. And the questions were written in a familiar style, and printed in a large familiar font, in order to look as user friendly as possible. Four areas of cognitive thinking were under scrutiny, tested by a range of questions from easy to difficult, plus a few questions that required the pupils to think "outside the box". The answers were categorised by the cognitive skills they tested, so that each pupil had a set of 5 results – an individual score for each of numeracy, spatial awareness, logical deduction and problem solving, as well as an overall score.

Ethical Considerations

For every school, permission was first sought from the Head, who then signed a consent form (see appendix page 1). Only first names were written on the papers in case of a possible query after, but otherwise anonymity was guaranteed. There was a great effort made to make the papers as user friendly as possible, so that less able children felt they could attempt at least some of the questions, and they were told they could have questions read out to them, so that children with reading difficulties did not feel excluded in any way. For the same reason, most of the answers required only numbers, and words were kept to an absolute minimum.

The test was always referred to as a ‘Quiz’, so as not to alarm pupils, who might be nervous about doing a test. They were also told that it was just as important to know what they could NOT do as well as what they could do, to allay concerns about their performance. It was important that pupils did not feel pressurised to take part, and any pupil who expressed a wish not to take part, did not have to do so, although in the event, all the pupils were happy to take part.

The Hypothesis

The ability to play chess enhances cognitive ability for numeracy, spatial awareness, logical deduction and problem solving, and ‘chess’ pupils will show significantly higher scores than ‘non-chess’ players in a ‘Quiz’ based on mathematical and non-verbal reasoning, designed to test these skills.

The Null hypothesis

Chess pupils will not show significantly higher scores than non-chess players in a ‘Quiz’ designed to test ability for numeracy, spatial awareness, logical deduction and problem solving.

Method

Participants

28 primary schools were originally selected for the research with year 4 pupils. In 14 of the schools, chess is taught to year 3 pupils, and in 14 of the schools, chess is either not taught and never has been, or they teach chess to the year 5 pupils, which would not affect this study. Thus there were 2 groups of pupils being tested. In the first – the experimental group – pupils now in year 4 (aged 8 –9 years) had had mandatory chess tuition (30 hours) while in year 3 (aged 7-8 years). In the second – the control group – pupils (also in year 4) had not had any chess tuition.

The selection of schools was made in conjunction with Chess in Schools and Communities (CSC) tutors. Four areas in the country were targeted, namely Bristol, Manchester, Teeside and Liverpool. Since the CSC was initially set up as a charity to help disadvantaged children, most of the schools involved in the programme are similar to each other in terms of background and ethos, and by matching the ‘chess schools’ with similar ‘non-chess schools’, a uniformity of participants was achieved. The only exceptions to this were found in Bristol, where a variety of schools are involved in the CSC scheme. Here, the selection of schools was made in conjunction with a schools facilitator, who through his work, is familiar with all the primary schools in Bristol, and he was not only able to advise which schools could be matched up in each condition, but was also instrumental in obtaining the permission of those School Heads.

In all, 14 schools participated in the study – 8 in Bristol, 3 in Manchester, 2 in Teeside and 1 in Liverpool (see appendix). There were 201 pupils (boys and girls) in the experimental condition, and 282 pupils (boys and girls) in the control group.

Design

The study had an Independent Groups Design with 2 conditions.
In the first condition, the experimental group, the year 4 pupils had had 30 hours of mandatory chess tuition while in year 3.
In the second condition, the control group, the year 4 pupils had had no chess lessons.

Thus the Independent Variable (IV) was chess, and the Dependant Variables (DV) were the scores for numeracy, spatial awareness, logical deduction, problem solving, and the overall scores.

Apparatus and Materials

Pupils were assessed by means of a 'Quiz' containing 19 maths and non-verbal reasoning questions (see appendix page 2 - 17). These were loosely based on the type of questions set in the National Curriculum Key Stage 1 and 2 papers and also the optional National Curriculum optional Year 4 papers. The 'Quiz' was printed using Century Gothic font size 20. It was designed to take about 30 – 40 minutes, although pupils could take longer if they wished. The questions were approved by an experienced primary school teacher, who also devised the mark scheme (see appendix).

The ‘Quiz’ was specifically designed to test 4 key areas of pupil ability, namely, numeracy, spatial awareness, logical deduction and problem solving. Questions 1, 2, 4, 6, 7. 8, 9, 10, 13, 17 and 19 tested numeracy ability. Questions 3, 4, 5, 10, 12, 15, 16 and 18 tested spatial awareness. Questions 10, 16 and 17 tested logical deduction, and questions 2, 8, 11, 14, 15 and 18 tested problem solving ability. So some questions tested more than one skill. Marks were awarded as follows:

- Numeracy – a maximum of 26 marks
- Spatial awareness – a maximum of 12 marks
- Logical deduction – a maximum of 13 marks
- Problem solving – a maximum of 10 marks
- Overall ‘Quiz’ total – a maximum of 40 marks

Some examples of ‘Quiz’ questions

Question 6

Write numbers in the boxes to make this sum correct.

4 X ☐ + ☐ = 17

Now write **different** numbers in the boxes to make the sum correct.

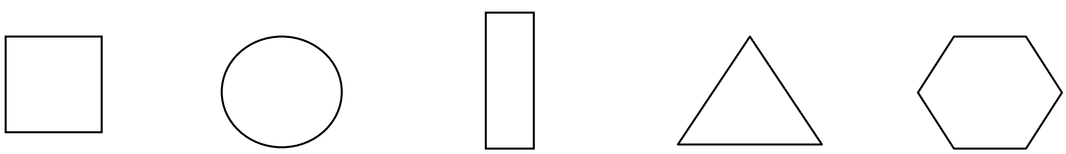
4 X ☐ + ☐ = 17

Question 10

Which is the odd one out on each line?

Draw a circle around it.

20	5	23	15	30
X	H	I	P	O
18	74	3	26	10



Before the research was carried out, a test run was done on 3 pupils (not taking part in the research) to iron out any unforeseen problems with the ‘Quiz’, but there appeared not to be any, and the ‘Quiz’ remained unaltered.

Procedure

Letters detailing the proposed research, and requesting permission (see appendix page 1) were sent to the Heads of the selected schools. Where the schools were happy to participate, contact would then be made with the year 4 teachers, to arrange a mutually convenient time for the research to be carried out. At this stage, the teachers were also asked to fill out a Year 4 profile form detailing National Curriculum Maths levels for the class (see appendix page 18). This was to ensure a similar spread of ability in both conditions. Of the 28 schools originally targeted, 14 actually took part (see appendix page 19). The research was carried out from 28th November 2012 to 11th February 2013 (See appendix page 20).

At each school, before the ‘Quiz’ was done, the pupils were told they were taking part in psychology research, and just what that entailed, although they were not necessarily aware of the chess element. They were advised that the ‘Quiz’ contained a mixture of easy and difficult questions, and that some questions which looked easy were hard, and some questions that looked difficult were actually quite easy. They were told to answer as many questions as possible and have fun, and that it was just as important to the research to know what they couldn’t do, as well as to know what they could do. This was to allay any concerns in those pupils who found the ’Quiz’ particularly difficult. Also, if pupils or their teacher requested it, questions could be read to them (so as not to disadvantage any pupils with reading difficulties).

Pupils were given as much time as they needed. 30 – 40 minutes was usually ample time, but they could have more. As each pupil finished, their paper was collected, and they then did ‘quiet reading’, while the others completed theirs.

When all the papers had been collected, pupils were thanked for their contribution to the research, and then there was an opportunity for them to ask questions (which they invariably did).

Pupils were asked to write their first names only on the papers in case of any possible query afterwards, but otherwise anonymity of pupils was maintained.

The papers were then taken away to be marked, and the results were entered – question by question – on to individual mark sheets, one per pupil (See appendix page 21). At every stage, papers were numbered and cross-referenced, to ensure easy access for referencing. Each pupil’s marks for numeracy, spatial awareness, logical deduction, problem solving and their overall marks were then entered into SPSS for analysis, and independent t-tests performed for comparisons between the 2 conditions for each of these skills and overall scores. In addition, the scores for each individual question were also entered into SPSS for analysis, and independent t-tests performed to look for comparisons between the 2 conditions for each individual question.

Results

The SPSS analysis (please see appendix II page 1-3) reveals the following information;

Table 1 – Mean & Standard Deviation for Chess & Non-chess pupils

	Chess		Non-playing	
Test Type	Mean	SD	Mean	SD
Numeracy	12.19	6.29	9.60	5.47
Spatial Awareness	4.81	2.54	3.52	2.48
Logical Deduction	5.38	2.43	4.26	2.41
Problem Solving	3.54	2.19	2.37	1.82
Overall Score	16.57	7.84	12.79	6.94

Table 2 – Marks available & percentages of correct answers

		% of correct answers	
Test Type	Marks Available	Chess	Non-playing
Numeracy	26	46.9%	36.93%
Spatial Awareness	12	40.05%	29.31%
Logical Deduction	13	41.41%	32.79%
Problem Solving	10	35.37%	21.86%
Overall Score	40	41.42%	31.99%

N.B. Some of the questions tested more than one dimension, so the total mark scored by each pupil (out of 40) is not the sum of the individual dimensions

(numeracy out of 26, spatial awareness out of 12, logic out of 13 and problem solving out of 10)

Table 3 – Results of the independent t-tests

For numeracy	$t(392.730) = 4.71$, $p < .001$	Significant
For spatial awareness	$t(481) = 5.57$, $p < .001$	Significant
For logical deduction	$t(481) = 5.02$, $p < .001$	Significant
For problem solving	$t(381.052) = 6.19$, $p < .001$	Significant
For total scores	$t(397.729) = 5.47$, $p < .001$	Significant

So for each of the mathematical skills, as well as the overall scores, the chess players achieved significantly higher scores than the non-chess players, and the hypothesis was accepted.

An analysis using SPSS on the individual questions was also carried out and reveals the following information (see appendix II page 3-9 for full details)

Table 4 – Mean and Standard Deviation for Chess & Non-chess players

	Chess		Non-playing	
	Mean	SD	Mean	SD
Question 1	0.53	0.50	0.39	0.49
Question 2	0.46	0.50	0.30	0.46
Question 3	0.31	0.47	0.23	0.42
Question 4	0.53	0.50	0.40	0.49

Question 5	0.69	0.47	0.48	0.50
Question 6	0.63	0.48	0.46	0.50
Question 7	0.53	0.50	0.56	0.50
Question 8	0.82	0.85	0.42	0.68
Question 9	0.56	0.50	0.46	0.50
Question 10	1.99	1.13	1.64	1.04
Question 11	0.03	0.17	0.00	0.00
Question 12	0.03	0.18	0.00	0.06
Question 13	0.29	0.46	0.21	0.40
Question 14	0.04	0.20	0.04	0.19
Question 15	0.12	0.33	0.02	0.16
Question 16	0.25	0.43	0.16	0.37
Question 17	3.16	1.72	2.46	1.67
Question 18	2.07	1.42	1.59	1.38
Question 19	3.52	2.55	2.96	2.25

Table 5 – The t-test results for each individual question

Question 1	number	$t(424.296) = 3.19,\ p < .005$	Significant
Question 2	number / problem	$t(408.448) = 3.50,\ p < .005$	Significant
Question 3	spatial	$t(404.424) = 2.01,\ p > .01$	Not sig.
Question 4	number / spatial	$t(425.823) = 2.76,\ p < .01$	Significant
Question 5	spatial	$t(448.792) = 4.69,\ p < .001$	Significant
Question 6	number	$t(439.207) = 3.70,\ p < .001$	Significant
Question 7	number	$t(481) = -0.68,\ p > .01$	Not sig.
Question 8	number / problem	$t(367.018) = 5.56,\ p < .001$	Significant

Question 9	number	t (481) = 2.17, $p > .01$	Not sig.
Question 10	number/logic/spatial	t (481) = 3.50, $p < .005$	Significant
Question 11	problem	t (200) = 2.48, $p > .01$	Not sig.
Question 12	spatial	t (481) = 2.67, $p< .01$	Significant
Question 13	number	t (398.089) = 2.18, $p > .01$	Not sig.
Question 14	problem	t (481) = 0.25, $p > .01$	Not sig.
Question 15	spatial / problem	t (265.832) = 3.82, $p < .001$	Significant
Question 16	spatial / logic	t (387.483) = 2.27, $p > .01$	Not sig.
Question 17	number / logic	t (481) = 4.45, $p< .001$	Significant
Question 18	spatial / problem	t (481) = 3.77, $p < .001$	Significant
Question 19	number	t (397.165) = 2.49, $p > .01$	Not sig.

So for questions 1, 2, 4, 5, 6, 8, 10, 12, 15, 17 and 18, chess players scored significantly higher than the non-chess players.

In questions 3, 9, 11, 13, 16 and 19, chess players averaged slightly more than the non-chess players, but not significantly so.

For question 14, there was no difference between the two conditions.

For question 7, the non-chess players scored a slightly better average mark than the chess players, but it was not significant.

Discussion

Pupils in the chess condition scored significantly higher than pupils in the control group for each of numeracy, spatial awareness, logical deduction and problem solving, and on overall scores.
Eleven out of the nineteen questions also showed significantly higher scores for the chess pupils.

As hoped, the pupils appeared to enjoy participating in the research, even though some of the questions were designed to be quite challenging to see just what pupils could be capable of. Four of the questions did prove to be too difficult fo the majority of pupils – namely, question 11 (problem solving), question 12, (spatial awareness), question 14 (problem solving) and question 15 (spatial / problem). However, it is interesting to note that the six pupils who correctly answered question 11, were all chess players, seven out of the eight who solved question 12 were chess players, and twenty four out of the thirty one who correctly answered question 15 were all chess players.

It was intended that the experimental condition would consist entirely of schools where chess was taught, and the control would come from schools where chess was not taught, or where it was taught to year 5's. However in some 'chess' schools there were pupils who had not had chess lessons because they had joined the school in year 4, so these pupils' results became part of the control group.

This study is groundbreaking in that it was able to use pupils in the experimental condition who had not chosen whether to join a club to learn chess, but had been taught the game as a mandatory part of the school curriculum, just like Mathematics, English or Science. This meant that there was inevitably going to be a broad spectrum of ability, and there was, with total marks ranging from 1 to 34 in the chess group and 1 to 32 in the control group. But this also ensured that results would not be skewed by, say, a preponderance of able mathematicians in the chess group. That there was a fair distribution of ability was ensured by checking the year 4 class profiles (see appendix page 18) filled in by the teachers in relation to National Curriculum Maths levels.

Another important feature of the study was that chess tuition is carried out in exactly the same way in each school, to a prescribed method. CSC sends in professional tutors, who begin by teaching the children to play a game just using the pawns. Then gradually, week by week, other chess pieces are introduced, until the pupils are able to play a complete game of chess by the end of the first term. The instruction consists of 30 lessons lasting one hour each. Thus there was a consistency of instruction throughout the experimental condition.

An added benefit to these pupils, which may well be the instrumental factor in explaining the extraordinarily significant results, is that for many of these pupils, learning to play chess may be the first time they have been required to sit absolutely still, with complete concentration, and stay focussed for one hour every week. And indeed, it was remarked on, by two of the chess tutors, that it can take two or three lessons, to get some challenging pupils to remain seated in their chairs for the duration of the one hour lesson. However it was also remarked that when these pupils see that it is actually a level playing field, they can become amazingly committed to the game. It is not just the ‘able’ pupils who can shine at chess.

It would have been interesting to carry out research with other year groups, such as the year 3’s who have had chess lessons in year 2, and the year 5’s who have had chess lessons in year 4, and the year 6’s who have had chess lessons in year 5. It would be interesting to know whether there is an optimum time for learning the game. Similarly, it would be interesting to compare the performances of boys versus girls in terms of cognitive ability. Malcolm Pein, the Head of CSC maintains that both boys and girls are equally capable when it comes to playing chess, although girls frequently lose interest in the game once they reach secondary school, hence the preponderance of male chess players. In the future it would be interesting to carry out research into these other year groups, and into any cognitive differences in terms of gender for pupils learning chess. It could encourage girls to pursue the game for longer.

As a preliminary study, this research involved only 14 schools, with only 8 of them currently in the CSC Initiative. There are currently about 175 schools within the scheme, and it is hoped that the positive results form research such as this will encourage more schools to join in and give their pupils added cognitive possibilities. The government has begun to take notice of the scheme, and on

March 20th of this year has pledged £689,000 grant to the CSC Initiative. Perhaps one day, it will be on every primary school's national curriculum.

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