*Issues In Educational Research, Vol 13, 2003*
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# Does the playing of chess lead to improved scholastic achievement?

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The effect of playing chess on problem solving was explored using Rasch scaling and hierarchical linear modelling. Subjects were 508 students from Grades 6 - 12 in an Australian Independent boys school, with a strong tradition in the game of chess. Of these 508 students, 64 were regular players of competitive chess. Data from the Australian Schools Science Competition were Rasch scaled and placed on a single scale for all the grades. Multilevel analysis using hierarchical linear modelling was employed to test the effects of the hypothesised variables. No significant effect of the playing of chess on the scholastic performance was found, suggesting that previous results showing positive effects may have been due to other factors such as general intelligence or normal development. It is suggested that this combination of Rasch scaling and multilevel analysis is a powerful tool for exploring such areas where the research design has proven difficult in the past.

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## Introduction

The game of chess has long been associated with strategic thinking and problem solving. De Groot (1965, 1966) explored the difference between expert and novice chess players. Experts and novices were shown chess boards with pieces in position from an actual game for a period of five seconds. Experts were able to recall the positions of 20 or more pieces, while novices were only able to recall four or five. On the other hand, when presented with pieces placed randomly on the board and not from a game, the experts performed no better than the novices. Chase and Simon (1973) have suggested that the experts are able to chunk the information into meaningful patterns related to the game. More recently, in the literature concerned with expert performance, chess is often used as a target domain (Ericsson et al 1990, Ericsson, 1996, Charness et al 1996, Ericsson & Lehmann 1996). This is partly due to the interval scale of performance which is afforded by the international rating scale devised by Elo (1986). This has allowed the use of such statistical techniques as regression analysis to explore the factors associated with expert performance. The consistent finding in this literature on expert performance is that expertise in chess depends upon deliberate practice and serious study of the game (Ericsson et al 1990, Ericsson 1996, Charness et al 1996, Ericsson & Lehmann 1996). One particular suggestion (Charness et al 1996) is that, contrary to popular belief, there is a lack of evidence for the view that innate talent is important in the development of chess expertise. Indeed it is suggested that what has been regarded as talent, may well be a product of motivation and practice.

Chess enthusiasts have long argued that the playing of chess leads to improved scholastic attainment and greater self-confidence. It is suggested that the playing of chess develops skills of creative thinking, critical thinking and the ability to concentrate and to solve problems. Certainly, there is no doubt that playing competitive chess demands considerable concentration skills. Even at the junior chess level, games are often as long as three hours.

Playing chess also demands an ability to project possible positions of pieces and so could help develop visual and spatial abilities. Similarly, chess demands skills of logical thinking. It might be argued that these sorts of skills and abilities should transfer to other scholastic areas. The famous chess master Kasparov has promoted chess in schools and a number of programs have emerged which have been fostered by the various chess associations, particularly in the United States. In an interview reported by Harrell (1999), LaFreniere, the Coordinator of the Washington Chess Federation Scholastic Chess Program said,

Chess is the single most powerful educational tool we have at the moment, and many school administrators are realising that. (Harrell, 1999 on net)
Although not always widely published beyond chess circles, there have many research projects on the effects of chess on student performance in the classroom. Frank (1974) explored the relationship between playing chess and other scholastic abilities. He found that there was a significant correlation between chess playing and spatial and numerical abilities and that there was a positive correlation between playing chess and the change in numerical and verbal aptitudes. Christiaen (1976) randomly divided 40 fifth grade students into experimental and control groups. The students were given a number of tests of cognitive development at the end of their fifth grade studies and again at the end of their sixth grade studies. The experimental group received 42 one-hour chess lessons. The tests at the end of both the fifth and the sixth grade showed significant differences in favour of the chess group.

Ferguson (1983) studied the effects of chess treatment and computer treatment on groups of academically gifted students in Grades 7 to 9. The chess treatment group showed a significant difference in the growth of originality. Horgan (1987) advocated the teaching of chess as a means of developing a child's intellect. Ferguson (1987) showed that a group of sixth grade students who had not previously played chess, showed significant development in memory and reasoning skills when they played chess daily over a period of nine months. Margulies (1991) found that elementary pupils, who played chess, showed a significant improvement in reading ability when compared to their non-chess playing fellows. Gaudreau (1992) has reported that in a group of fifth grade students, those who had their mathematics instruction enriched with chess, developed significantly better problem solving abilities than those who had received a normal mathematics program. Much of this material has been summarised by Dauvergne (2000).

In summary, it is argued that chess can be an intrinsically motivating learning tool. Performance at chess cannot be blamed on anyone else and students must accept the consequences of their actions. They must develop skills of planning, of problem solving, evaluating a wide range of alternatives, concentration, and self-discipline. It is clear that the devotees of the game of chess are convinced of its worth as a powerful educational tool. They argue that it is a simple and cheap means of helping students to develop important cognitive skills.

**Some research problems**

The studies reported and discussed above are to be found predominantly on various web-pages, in the chess literature and in the teachers' journals rather than in the literature of cognitive psychology. However, there has been a continuing interest in chess in cognitive psychology, but not its effect on scholastic achievement. Perhaps this reflects the quasi-experimental nature of much of the research or perhaps it is a result of the view that those who play chess are the smart students who would have performed equally well without chess.

The learning and the playing of chess take a considerable period of time and practice and any improvement in scores in cognitive tests may be confused with the normal development of the students. Thus the usual experimental design for investigating the effects of an instructional intervention has an experimental group and a control group and utilises a pre-test and post-test arrangement, which compares one group with the other. In school situations, such designs can be very difficult to maintain effectively, with so many other intervening factors. For example, the two groups will often be two intact class groups and so the "random assignment of students" to the groups is in reality a random assignment of treatments to the groups. Moreover, as intact groups, it is likely that their treatments may differ in a number of other ways. For example, they may have different teachers, or the very grouping of the students themselves may have an effect. In addition, there is the risk that any positive effect may be due to a Hawthorne effect rather than the treatment itself.

It seems that the traditional pre-test and post-test experimental designs have led to results which while encouraging, have not been conclusive and need further support. The difficulties in experimental design make it desirable to use statistical control, employing regression analysis procedures, to take into account the effects of other factors.

## A study into the scholastic effects of chess

It has been suggested then that the learning and playing of chess helps students to develop a range of cognitive skills. (Harrell, 1999 on net). These skills include planning, problem solving, evaluating a wide range of alternatives, concentration, and self-discipline. If this is the case, then students who play chess ought to perform better at those scholastic tasks that involve these skills.

This study seeks to investigate whether there is any effect associated with chess playing in a group of students for whom some data are readily available. This study seeks to avoid the problems mentioned above by the use of statistical control in order to distil out the effects of the other factors. It does this by using data from the Australian Schools Science Competition which is Rasch scaled and then uses hierarchical linear modelling to explain this data in terms of the other variables, including the playing of chess.

### The Australian schools science competition

The Australian Schools Science Competition is an Australia wide competition that is held every year. Students in Grades 3 - 12 compete in this multiple-choice test. The competition is administered by the Educational Testing Centre of the University of New South Wales. Faulkner (1991) outlined the aims of the competition and gave a list of items from previous competitions. Among its aims are the promotion of interest in science and awareness of the relevance of science and related areas to the lives of the students, and the recognition and encouragement of excellence in science. An emphasis is placed on the ability of students to apply the processes and skills of science. Since the science syllabi throughout Australia vary, the questions that are asked are essentially independent of any particular syllabus and are designed to test scientific thinking. Thus, the questions are not designed to test knowledge, but rather to test the ability of the candidates to interpret and examine information in scientific and related areas. Thus students may be required to analyse, to measure, to read tables, to interpret graphs, to draw conclusions, to predict, to calculate and to make inferences from the data given in each of the questions. It seems logical then that involvement in chess should confer an advantage to individual students in the Australian Schools Science Competition.

It is hypothesised then that students who play chess regularly should perform better in the Australian Schools Science Competition than those who do not, when controlling for the other variables that may be involved.

**Rasch scaling and item response theory**

The Rasch model of test scaling has come into prominence over recent times and it has become the basis of many testing programs throughout the world. Snyder and Sheehan (1992) provide a good introduction to the principles of Rasch scaling. The power of the Rasch scaling method is that the measurement of the performance of the students taking the test is independent of the test items and that the difficulty of the test items is independent of the group of students used to calibrate them. Essentially, this model assumes that the likelihood of a student correctly answering a question will depend upon the difference between the difficulty of the item and the performance level of the student, both measured along a continuum, known as the latent trait continuum.

A number of computer programs have been developed to assist with the analysis of data from test items. One of these is the QUEST program (Adams and Siek-Toon Khoo 1993), which allows the results of tests to be analysed to determine whether they fit the Rasch model and provides estimates, both of the abilities of the students and the difficulties of the test items. In a recent study (Thompson 1998), it was found that the Australian Schools Science Competition data fit the Rasch model well, allowing the estimates of the item difficulties and the student abilities to be plotted on the same scale. The Rasch Scaling process allows the possibility of placing the tests at each of the grade levels on the same scale, thereby allowing direct comparisons between the grade levels. The study by Thompson (1998) showed that it is possible to put the results from the different grade levels on the same scale using concurrent equating, which provides good agreement with the expected results. This involves scoring all of the items and subjects at the one time, relying on the common items to establish the difficulty levels of all of the items across the range. This method was tested in comparison to other equating procedures by Mohandas(1998) and concurrent equating provided good agreement with the expected results. It is therefore possible to put the items and subjects from all the grade levels onto one scale.

**Factors affecting performance in the science competition**

The performance of an individual student in the Science Competition may be influenced by a number of factors. Since all of the students from Grades 6 -12 can be placed according to their performance on a single scale, clearly their grade level will be an important factor influencing their performance. Similarly, the basic ability of the student, as might be measured using a standardised IQ test, and the grouping of the students in their classes could reasonably be expected to have an effect on the individuals. As well, it is hypothesised that the playing of chess might be a factor that will have a measurable effect. Other factors that may affect the performance of the students are their individual involvement in other pursuits, such as music. In order to examine the relative effect of each of these factors it is necessary to use hierarchical linear modelling analysis.

These hierarchical linear models are discussed by Bryk and Raudenbush (1992), Raudenbush and Bryk (1997), and Keeves and Sellin (1997). Such models allow a researcher to postulate and subsequently to test statistical hypotheses associated with relationships between the outcome variable and the factors that may affect it. In hierarchical linear models, the researcher can examine the effect of the various factors, both within and between individuals and at the group level and any possible interactions between them. The outcome variable is represented as a function of the various characteristics. Thus in the example of the Science Competition, the outcome variable is the Rasch scaled score of the individual and the variables of IQ and chess playing can become level one variables in an hierarchical model.

First, there is the b etween student within the class group equation

$$Y_{ij} = \beta_{j0} + \beta_{j1}(IQ) + \beta_{j2}(chess) + r_{ij} \quad (1)$$

In equation (1) $Y_{ij}$ represents the performance of student i in group j and $\beta_{j0}$ represents the baseline performance. Each of the coefficients represents the extent to which the performance of a student is affected by the variable in the brackets. The coefficient $\beta_{j1}$ represents the effect of student IQ and the variable is the measured IQ of the student, whilst $\beta_{j2}$ represents the effect of playing chess and its associated variable is a dichotomous variable indicating whether the student plays chess or not. The term $r_{ij}$ represents the random error. An important feature of hierarchical linear models is that these coefficients will vary from student to student.

At the second or macro level of a hierarchical linear model, the coefficients in the Level 1 equation are expressed as an outcome variable in a linear equation of Level 2 variables at the second or between class group level. For example, the coefficient $\beta_{j1}$, the effect of IQ on the performance of student i, may be expressed as a function of grade level. Likewise, the intercept $\beta_{j0}$ may be expressed as a function of grade level and other treatment conditions.

Thus, a researcher may build a model as follows in equations (2) and (3), as a between class group equation

$$\beta_{j0} = \gamma_{00} + \gamma_{10}(grade) + \gamma_{10}(other\ treatment) + u_{j0} \quad (2)$$

$$\beta_{j1} = \gamma_{01} + \gamma_{11}(grade) + \gamma_{11}(other\ treatment) + u_{j1} \quad (3)$$

It can be seen then that a layered or hierarchical model is being employed. The values of the various coefficients need to be estimated using the data available from the Australian Schools Science Competition. Recent advances in computational technology make such estimations possible. One program which does this by an iterative method using empirical Bayes estimation procedures based on maximum likelihood estimates is HLM, developed by Raudenbush and Bryk (1996). With this facility, it is possible to estimate the effects of the various parameters and their inter-relationships at each of the levels of the hierarchical linear model.

It follows then, that it may be possible using a hierarchical linear model, to partition out the effects of the variables such as IQ, together with the effect of playing chess, which is of interest in this study, and to estimate the effect of each of these variables on student performance.

**Research question**

Does regular involvement in competitive chess relate to a positive effect on student performance in the Australian Schools Science Competition? If, as is hypothesised, the regular playing of chess is a significant factor in the performance of the students, then it ought to be possible to measure this effect and to test its statistical significance and compare it to other factors, such as normal yearly development or learning.

## Research methods

This study uses data from an independent boys school with a strong tradition of chess playing. The school fields teams in competitions at both the primary and secondary levels and so a significant and identifiable group of the students plays competitive chess in the organised inter-school competition and practise chess regularly. Each of these students played a regular fortnightly competition and was expected to attend weekly practice, where they received chess tuition from experienced chess coaches. The students had also taken part in the Australian Schools Science Competition as part of intact groups and data from 1999 for Grades 6 - 12 were available for analysis. IQ data were readily available for the students in Grades 6 -12. Subjects, then, were all boys (n= 508) in Grades 6 -12, for whom IQ data were available. Of these 508 students 64 were competitive chess players. Rasch scaling, with concurrent equating, was used to put all of the scores on a single scale. These scores were then used as the outcome variable to be explained using a hierarchical linear model, and the variables of IQ, chess playing, other class level factors, grouping and grade to see if the playing of chess had a significant effect on the performance of the students. A dichotomous variable was used to indicate the playing of chess, with chess players being given 1 and non-players 0. Chess players were defined as those who represented the school in competitions on a regular basis.

## Results

The individual responses for all of the subjects for the 249 different items of the science competition data were analysed using the QUEST program (Adams and Siek-Toon Khoo 1993). These items were arranged in such a way as to allow for concurrent equating of items common to more than one of the grade level tests. It was found that of the 249 items, only eight did not fit the Rasch model with their infit mean square values being outside the acceptable range. These items were deleted from the analysis and the program was run once again. The use of concurrent equating allowed the performance ability of each subject to be placed on a single scale regardless of the grade level. The performance ability scores were then used as the outcome variable in a hierarchical linear model to be explained by the various parameters involved.

The initial model that was explored was as follows in equation (4).

$$Y_{ij} = \beta_{j0} + \beta_{j1}(IQ) + \beta_{j2}(chess) + r_{ij} \quad (4)$$

In this Level 1 model, the outcome variable (the Rasch scaled performance ability score) is expressed as a function of IQ, and playing chess. At Level 2, the model sought to explain the coefficients at Level 1 in terms of factors associated with the grouping of the subjects as shown in equations (5) and (6).

$$\beta_{j0} = \gamma_{00} + \gamma_{10}(grade) + \gamma_{10}(other\ treatment) + u_{j0} \quad (5)$$

$$\beta_{j1} = \gamma_{01} + \gamma_{11}(grade) + ;\gamma_{11}(other\ treatment) + u_{j1} \quad (6)$$

and so on.

In each case, the other treatment was exploring whether the grouping of the students in their classes had any effect on the outcome.

This model was improved by the elimination of variables that did not prove to have a significant effect. The final model was as follows in equations (7), (8), (9) and (10). Level-1 model

$$Y = B_0 + B_1*(IQ) + B_2*(CHESS) + R \quad (7)$$

In this Level 1 model, the outcome variable Y, the Rasch scaled performance scores measured by the Science Competition test are equal to an intercept or base level B0, plus a term that expresses the effect of IQ, with its associated slope, B1, and a term which expresses the effect of playing chess and its associated slope B2. There is also an error term R. Thus the outcome variable Y is explained in terms of IQ and involvement in chess at Level 1.

In the Level 2 model, the effect of the Level 2 variables on each of the B terms in the Level 1 model is given in equations (8), (9) and (10). Level-2 Model

$$B_0 = G_{00} + G_{01}*(GRADE) + U_0 \quad (8)$$

$$B_1 = G_{10} + U_1 \quad (9)$$

$$B_2 = G_{20} + U_2 \quad (10)$$

Thus in equation (8), the constant term $B_0$ is expressed as a function of Grade, with an associated slope $G_{01}$. Values of each of these terms are estimated and the level of statistical significance evaluated to assess the effect of each of the terms.

Initially, the HLM program makes estimates of the various values of the slopes and intercepts, using a least squares regression procedure and then using an iterative process improves the estimation using a maximum likelihood estimation and the empirical Bayes procedure. Table 1 shows the reliability estimates of the Level 1 data.

**Table 1:** Reliability estimates of the Level 1 data

| Random Level-1 coefficient | Reliability estimate |
|---|---|
| INTRCPT1, $B_0$ | 0.664 |
| IQ, $B_1$ | 0.324 |
| CHESS, $B_2$ | 0.019 |

Table 2 shows the least -squares regression estimates of the fixed effects.

**Table 2:** The least -squares regression estimates of the fixed effects

| Fixed Effect | | Coefficient | Standard Error | T-ratio | Approx degrees of freedom | P-value |
|---|---|---|---|---|---|---|
| For INTRCPT1, $B_0$ | INTRCPT2, $G_{00}$ | -1.645 | 0.178 | -9.221 | 504 | 0.000 |

| | | | | | | |
|---|---|---|---|---|---|---|
| | GRADE, $G_{01}$ | 0.217 | 0.200 | 11.034 | 504 | 0.000 |
| For IQ slope, $B_1$ | INTRCPT2, $G_{10}$ | 0.040 | 0.002 | 19.089 | 504 | 0.000 |
| For CHESS slope, $B_2$ | INTRCPT2, $G_{20}$ | 0.120 | 0.091 | 1.323 | 504 | 0.186 |

Table 3 shows the final estimations of the fixed effects.

**Table 3:** The final estimations of the fixed effects

| Fixed Effect | | Coefficient | Standard Error | T-ratio | Approx degrees of freedom | P-value |
|---|---|---|---|---|---|---|
| For INTRCPT1, $B_0$ | INTRCPT2, $G_{00}$ | -1.572 | 0.327 | -4.81 | 20 | 0.000 |
| | GRADE, $G_{01}$ | 0.208 | 0.057 | 5.69 | 20 | 0.000 |
| For IQ slope, $B_1$ | INTRCPT2, $G_{10}$ | 0.036 | 0.003 | 13.67 | 21 | 0.000 |
| For CHESS slope, $B_2$ | INTRCPT2, $G_{20}$ | 0.056 | 0.091 | 0.619 | 21 | 0.542 |

Table 4 shows the final estimation of the variance components.

**Table 4:** Final estimation of variance components

| Random Effect | Standard Deviation | Variance Component | df | Chi-square | P-value |
|---|---|---|---|---|---|
| INTRCPT1, $U_0$ | 0.222 | 0.049 | 15 | 52.09 | 0.000 |
| IQ slope, $U_1$ | 0.007 | 0.000 | 16 | 29.84 | 0.019 |
| CHESS slope, $U_2$ | 0.053 | 0.003 | 16 | 20.48 | 0.199 |
| Level-1, R | 0.606 | 0.367 | | | |

In order to calculate the amount of variance explained by the model, a null model, with no predictor variables was formulated. The estimates of the variance components for the null model are shown in Table 5.

**Table 5:** Estimated variance components for the null model

| Random Effect | Standard Deviation | Variance Component | df | Chi-square | P-value |
|---|---|---|---|---|---|
| INTRCPT1, $U_0$ | 0.602 | 0.362 | 21 | 357.7 | 0.000 |
| Level-1, R | 0.749 | 0.561 | | | |

Using the data from Tables 4 and 5, the amount of variance explained is calculated as follows:

$$\text{Variance explained at Level 2} = \frac{0.362 - 0.049}{0.362} = 0.865$$

$$\text{Variance explained at Level 1} = \frac{0.561 - 0.367}{0.561} = 0.346$$

In addition, the intraclass correlation can be calculated.

$$\rho = \frac{\tau_{00}}{\tau_{00} + \sigma^2} = \frac{0.362}{0.362 + 0.561} \text{ \&nbs p;} = \frac{0.392}{0.362 + 0.561}$$

This intraclass correlation represents the variance within groups compared to the total variance between and within groups. Thus the model is explaining 33.9 per cent (0.392 x 0.865) of the variance in terms of grade levels. The remaining 21.0 per cent ((1 - 0.392) x 0.346) is explained as the variation brought about by IQ and the playing of chess. In all 54.9 per cent of the variance in scores is explained by the model and 45.1 per cent is unexplained.

## Discussion and interpretation of the results

In order to interpret the results, Table 2 is examined. The term $G_{00}$ represents the baseline level, to which is added the effect of the grade level to determine the value of the intercept $B_0$. The value $G_{00}$ represents the effect of the grade level and since this is statistically significant, it can be concluded from this that the students improve by 0.21 of a logit over one grade level, taking into account the effect of IQ and playing chess. The next important value is the term $G_{10}$, which indicates the effect of IQ on the performance in the Science Competition. Clearly this has a significant effect and even though the value seems very small, being 0.036, it must be remembered that it involves a metric coefficient for a variable whose mean value is in excess of 100 and has a range of over 50 units.

Of particular interest in this study is the value $G_{20}$. This represents the effect of playing competitive chess on the performance abilities of the students. It suggests that, taking into account the effects of IQ and grade level, students who play chess competitively, are performing at a level of 0.056 of a logit better than others, when controlling for the other variables of grade and IQ. This is approximately equivalent to one quarter of a year's work. However this result was not found to be significant. One possible explanation of this lack of significance is that the playing of chess has contributed to the individual student IQ and so the benefits of playing chess have been absorbed into the IQ variable.

This study has examined a connection between the playing of chess and the cognitive skills involved in problem solving. The results have not shown a significant effect of the playing of chess on the scholastic achievement of the students, when controlling for IQ and grade level.

## Conclusion

The purpose of this study is to explore the relationship between the playing of chess and improved scholastic achievement. The difficulty in the research design associated with the intact groups of students has been overcome using the combination of Rasch scaling to place scores on a single scale and statistical control using a hierarchical linear model to obtain an estimate of the effect of playing chess and its statistical significance. The results of this study do not provide support for the hypothesis that the playing of chess leads to improved scholastic achievement. It is possible that the methodology of controlling for both grade level and IQ has removed the effect that has traditionally been attributed to chess, suggesting that those students who have been interested in chess have tended to be the more capable students. That is, the students who performed more ably at a particular grade level tended to have a higher IQ and there did not seem to be any significant effect of the playing of chess. This study provides a very useful application of both Rasch scaling and HLM and this method of analysis could be repeated easily in other situations.

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**Acknowledgments**

I am indebted to Professor John Keeves for his continued support and his insight into the complex problems of educational research.

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**Please cite as:** Thompson, M. (2003). Does the playing of chess lead to improved scholastic achievement? *Issues In Educational Research,* 13(2), 13-26.
http://www.iier.org.au/iier13/thompson.html

## The Case for Chess as a Tool to Develop Our Children's Minds


***By Dr Peter Dauvergne***

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July, 2000

**Abstract**


This article surveys educational and psychological studies to examine the benefits for children of studying and playing chess. These show that chess can

- Raise intelligence quotient (IQ) scores
- Strengthen problem solving skills, teaching how to make difficult and abstract decisions independently
- Enhance reading, memory, language, and mathematical abilities
- Foster critical, creative, and original thinking
- Provide practice at making accurate and fast decisions under time pressure, a skill that can help improve exam scores at school
- Teach how to think logically and efficiently, learning to select the 'best' choice from a large number of options
- Challenge gifted children while potentially helping underachieving gifted students learn how to study and strive for excellence
- Demonstrate the importance of flexible planning, concentration, and the consequences of decisions
- Reach boys and girls regardless of their natural abilities or socio-economic backgrounds

Given these educational benefits, the author concludes that chess is one of the most effective teaching tools to prepare children for a world increasingly swamped by information and ever tougher decisions.



## The Case for Chess as a Tool to Develop Our Children's Minds

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***July, 2000***

Is chess an art? A science? Some claim it's both. Yet let's be honest, it's really just a game. Fun, challenging, creative: but still a game, not much different from tennis, cricket, football, or golf.

But there is one striking difference to these other popular games. While learning to play almost any game can help build self-esteem and confidence, chess is one of the few that fully exercises our minds.

Many of us could probably use this exercise, although it may be a bit late for some. (At least for those of us old enough to read an article like this voluntarily!) It's not, however, too late for our children.

Chess is one of the most powerful educational tools available to strengthen a child's mind. It's fairly easy to learn how to play. Most six or seven year olds can follow the basic rules. Some kids as young as four or five can play. Like learning a language or music an early start can help a child become more proficient. Whatever a child's age, however, chess can enhance concentration, patience, and perseverance, as well as develop creativity, intuition, memory, and most importantly, the ability to analyse and deduce from a set of general principles, learning to make tough decisions and solve problems flexibly.

This is undeniably a grand claim. The remainder of this paper outlines some of the arguments and educational studies to justify and support this.

## Concentration, Patience, and Perseverance

To play chess well requires intense concentration. Some of the world's top players can undeniably look distracted, sometimes jumping up between moves to walk around. A closer look, however, reveals that most of these players are actually in deep concentration, relying on strong visual recall to plan and calculate even when they are away from their game. For young, inexperienced players, chess teaches the rewards of concentration as well as provides immediate penalties for lapses. Few teaching tools provide such quick feedback. One slip in concentration can lead to a simple blunder, perhaps even ending the game. Only a focused, patient and persistent young chess player will maintain steady results – characteristics that are equally valuable for performing well at school, especially in school exams.

**Analysis, Logic, and Problem Solving**

Playing chess well involves a combination of aptitudes. A 1973-74 study in Zaire by Dr Albert Frank (1974) found that good teenage chess players (16-18 years old) had strong spatial, numerical, administrative-directional, and paperwork abilities. Dr Robert Ferguson (1995, p. 2) notes that "This finding tends to show that ability in chess is not due to the presence in an individual of only one or two abilities but that a large number of aptitudes all work together in chess." Even more significantly Frank's study found that learning chess, even as teenagers, strengthened both numerical and verbal aptitudes. This occurred for the majority of students (not just the strong players) who took a chess course for two hours each week for one school year. Other studies have added that playing chess can strengthen a child's memory (Artise).

A 1990-92 study in New Brunswick, Canada, further shows the value of chess for developing problem solving skills among young children (Gaudreau 1992). By integrating chess into the traditional mathematics curriculum teachers were able to raise significantly the average problem solving scores of their students. These students also scored far higher on problem solving tests than ones who just took the standard mathematics course. Primary school chess has now exploded in New Brunswick. In 1989, 120 students played in the provincial school chess championship. Three years later over 19,000 played (Ferguson 1995, p. 11).

Chess has also been shown to foster critical and creative thinking. Dr Ferguson's four-year study (1979-83) analysed the impact of chess on students' thinking skills in the Bradford Area School District in the United States (grades 7-9). These students were already identified as gifted, with intelligence quotient (IQ) scores above 130. Using two tests (Watson-Glaser Critical Thinking Appraisal and the Torrance Tests of Creative Thinking) Ferguson (1995, pp. 4-6) found that after spending 60-64 hours playing and studying chess over 32 weeks students showed significant progress in critical thinking. He further found that chess enhances "creativity in gifted adolescents." He concluded that "it appears that chess is superior to many currently used programs for developing creative thinking and, therefore, could logically be included in a differentiated program for mentally gifted students".

Playing chess, however, is not only valuable for developing the skills of gifted children. Average and even below average learners can also benefit. Chess teacher Michael Wojcio (1990) notes that "even if a slow learner does not grasp all of [the strategies and tactics in chess], he/she can still benefit by learning language, concepts, and fine motor movement." During a program run by Dr Ferguson from September 1987 to May 1988 all members of a standard sixth grade class in rural Pennsylvania were required to take chess lessons and play games. This class had 9 boys and 5 girls. At the start of this study students took IQ tests, producing a mean IQ of 104.6. Students then studied chess two or three times per week while playing most days. They were also encouraged to participate in tournaments. After this intensive chess instruction a group of seven boys managed to finish second in the 1998 Pennsylvania State Scholastic Championship. Significantly, at the conclusion of the study tests showed a significant increase in both memory and verbal reasoning skills, especially among the more competitive chess players (Ferguson 1995, pp. 8-9).

Chess has even been shown to raise students' overall IQ scores. Using the Wechsler Intelligence Scale for Children a Venezuelan study of over 4,000 second grade students found a significant increase in most students' IQ scores after only 4.5 months of systematically studying chess. This occurred across all socio-economic groups and for both males and females. The Venezuelan government was so impressed that all Venezuelan schools introduced chess lessons starting in 1988-89 (summarised in Ferguson 1995, p. 8).

## Solving Problems and Synthesising Information in a Globalising World

The internet, email, and computers are rapidly changing the skills essential to succeed at school and work. As globalisation accelerates, information is pouring in faster and faster. Information that took months to track down a few years ago can now spin off the internet in just minutes. With such easy access and tremendous volumes, the ability to choose effectively among a wide variety of options is ever more vital.

In this world students must increasingly be able to respond quickly, flexibly and critically. They must be able to wade through and synthesise vast amounts of information, not just memorise chunks of it. They must learn to recognize what is relevant and what is irrelevant. They also need to acquire the skills to be able to learn new technologies quickly as well as solve a continual stream of problems with these new technologies.

This is where chess as a tool to develop our children's minds appears to be especially powerful. By its very nature chess presents an ever-changing set of problems. Except for the very beginning of the game — where it's possible to memorise the strongest lines — each move creates a new position. For each of these a player tries to find the 'best' move by calculating ahead, evaluating these future possibilities using a set of theoretical principles. Importantly, more than one 'best' move may exist, just as in the real world more than one best option may exist. Players must learn to decide, even when the answer is ambiguous or difficult.

These thinking skills are becoming ever more valuable for primary and secondary school students constantly confronted with new everyday problems. If these students go to university it will be especially imperative to understand how to apply broad principles to assess new situations critically, rather than rely on absorbing a large number of 'answers'. Far too commonly my own university students do not have these skills. As a result they become swamped by information, vainly searching for the right answer to memorise rather than the various best options.

## Conclusion

The case, then, is exceptionally strong for using chess to develop our children's minds and help them cope with the growing complexities and demands of a globalising world. More and more schools around the world are recognising the value of chess, with instruction now becoming part of standard curriculums. It's of course just a game. Yet it has fascinated and challenged some of the greatest minds of the last century, sparking enough books about how to play to fill an entire library.

Chess is an especially effective teaching tool. It can equally challenge the minds of girls and boys, gifted and average, athletic and non-athletic, rich and poor. It can teach children the importance of planning and the consequences of decisions. It can further teach how to concentrate, how to win and lose gracefully, how to think logically and efficiently, and how to make tough and abstract decisions (Seymour and Norwood 1993). At more advanced levels it can teach flexible planning since playing well requires a coherent plan, yet not one that is rigidly followed regardless of the opponent's response. Chess can also build confidence and self-esteem without overinflating egos, as some losses are inevitable, even for world champions.

Chess can potentially help teach underachieving gifted children how to study, perhaps even leaving them with a passion for learning. Chess tournaments can, moreover, provide a natural setting for a gifted child to interact with other children of all ages, as many tournaments are not divided by age but by ability (unlike most school activities and many other sports). It's common to see a six-year-old playing a twelve-year-old, or a ten-year-old playing a seventeen-year-old. Young players can also perform remarkably well in adult chess tournaments. In 1999-2000 in Australia, for example, a thirteen-year-old won the New South Wales championship, a fourteen-year-old won the South Australian championship, a fifteen-year-old won the Queensland championship, and a thirteen-year-old tied for second in the Australian championship.

Studying chess systematically has also been shown to raise students' IQ scores, academic exam scores (Dullea 1982; Palm 1990; Ferguson 2000, p. 3), as well as strengthen mathematical, language, and reading skills (Margulies 1991; Liptrap 1998; Ferguson 2000, pp. 3-4). Tournament chess games, which involve clocks to limit the total time each player can use, are also a fun way to provide practice at making fast and accurate decisions under pressure, a skill that can help students cope with the similar pressures of school exams. This is also a fun way to practise how to put the mind into high gear, where intense concentration increases alertness, efficiency of thought processes, and ultimately mental performance.

Perhaps most importantly chess is a fun way to teach children how to think and solve an ever-changing and diverse array of difficult problems. With millions of possibilities in every game, players must continually face new positions and new problems. They cannot solve these using a simple formula or relying on memorised answers. Instead, they must analyse and calculate, relying on general principles and patterns along with a dose of creativity and originality – a skill that increasingly mirrors what students must confront in their everyday schoolwork.

In June 1999 the International Olympic Committee officially recognized chess as a sport. This is welcome news for the world's six million registered chess players as well as countless more unregistered players. With such recognition hopefully even more of our children will turn to chess, striving for sporting dreams that will leave them smarter, and ultimately able to cope better in the real world of perpetual problems.

***About the Author***

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