CHESS AS A WAY TO TEACH THINKING[1]

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While much recent research on decision-making and problem solving stresses the limits of rationality and how far we humans deviate from "good" decisions, chess is a situation in which humans can make unusually sound decisions. In fact, young children—not normally known for their rationality—can compete with adults on an even basis and make good decisions that appear rational or analytic. This raises some very interesting questions for educators: How can children, before reaching the stage of formal operations, think so logically? Studying the best thinking of which children are capable and how they develop those skills may yield some valuable ideas for educators.

Chess and Education

The United States Chess Federation sells buttons that say "chess makes you smart." Among the presumed educational benefits are improved concentration and mental discipline, better skills in planning, and an appreciation of the consequences of actions. Chess educators have argued that chess is beneficial, not just for the intellectually gifted, but also for learning disabled and hyperactive children. Among parents and chess teachers, countless case studies attest to the educational benefits of chess. When we started our research on chess, however, we found very little experimental research with children. In a rare study, Christiaen (1978) studied fifth graders for two years during which an experimental group studied chess after school, one day a week. After the two years, the experimental group performed better on Piagetian tasks, significantly better on school tests, and better on standardized tests than did the control group. Chi (1978) demonstrated that child players could remember more pieces from a chess scene than adult non-players could, thus demonstrating that knowledge can be more important than age when subjects are asked to recall a complex array. Chi suggests that some of the age differences typically reported in developmental studies may be attributable to differences in knowledge about the stimuli rather than to memory factors alone.

Chess Research With Adults

DeGroot (1946) found that chess masters could look at a chess scene briefly, then reconstruct it from memory, whereas less skilled players could place far fewer pieces. When given a board with pieces presented in random places, however, masters did no better than novices. This shows that the master player does not simply have a better memory; the master has a memory for *meaningful* configurations. Later Simon and Chase (1973) explained this phenomenon in terms of "chunking." At higher levels of knowledge, a person sees and manipulates information in larger chunks. A literate person, for example, can remember many letters if they are arranged in meaningful words and sentences, but not nearly as many if they are in a random list.

DeGroot's findings have been crucial in shaping how we think about cognition. In *Search for Excellence*, for example, Peters and Waterman (1982) quote the classic chess studies to show that the manager who thoroughly understands his or her organization will be better able to process information efficiently and thereby make superior judgments.

Children Who Play Chess

Most people naively believe that any child who becomes proficient at chess must be an extremely rare prodigy (probably with grandmasters for parents). On the contrary, particular chess coaches consistently produce strong players, year after year—even though the specific children move on. In many cases, the parents know little or nothing about chess. Thus, while the individual's talent is important, the training a child receives appears to be equally important. In fact coaches often say that given a few months of training, any motivated and bright 10 year old can become a proficient player. In other words, the skills we will be discussing are not limited to a select few extremely gifted children; they are trainable skills. Our sample consisted of 24 elementary children (grades 1 through 6) and 35 junior high and high school students, mostly from one small school where over 100 students belong to the chess club. Our sample consisted of the top players from the club plus other top players in the state. Grade and skill rating were correlated ($r = .48$), but elementary players were among the top-ranked players. Thus, all of the children could perform a highly complex cognitive task as well as most adults, and all have competed in tournaments with adults.

How Children Play Chess

The nature of expertise. As one progresses toward expertise, he or she (1) obtains increased knowledge which becomes organized in more efficient and abstract ways, (2) uses processes that become more automatic (and intuitive) through experience, and (3) takes a more global

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(rather than a detailed, analytic) perspective. In some superficial ways, children operate like experts: they tend to use intuition rather than careful analytic processes and often ignore many of the details. Because children's limited information processing capacities prevent them from being analytic, they must acquire expertise in ways that differ from adults. Krogius (1976) offers some startling data showing that grandmasters who learned chess as a child played at their peak for more years and made fewer blunders than grandmasters who learned chess as adults. He compared early acquired chess knowledge to a native language; chess was for those players a first language. We agree. And just as first language acquisition differs from adult second language learning, chess competencies achieved as a child may be qualitatively different (and superior) from those acquired as an adult.

Heuristics and the avoidance of detail. In one study (Horgan, in preparation), we found that pre-adolescent children typically did not look ahead more than one move (even those with ratings above the mean for adult tournament players). This means that although an adult and a child may perform equally well, the child actually performs in much less time and with much less deliberate analysis. This is possible because the child uses more heuristics and avoids details. Heuristics are ways of simplifying complex inputs. Children must constantly simplify because their schemas (knowledge representations) are less well developed. Pushing these schemas to their limits and subjecting them to evaluation may speed up the process of developing more elaborate schemas. In Piagetian terms, assimilation and accommodation occur cyclically as schemas evolve. The rapid testing and retesting of schemas may accelerate development. But more importantly, constant revision may keep schemas flexible and the acquisition and revision processes active. In other words, teaching children to perform a complex task like chess may give them problem-solving advantages later—at least with chess, and possibly with other similar situations.

Satisficing. Another reason children's moves are faster is because they do not generate long lists of alternative moves—they satisfice. That is, they search until they find a satisfactory move (not necessarily the best move), then cease generating alternatives. In one study (Horgan, Horgan, & Morgan 1986), we asked children to identify which of several boards were most similar. Younger subjects stopped their search as soon as they found a superficial similarity. They were capable of seeing a deeper, more significant similarity, but few spontaneously spent the necessary time for the search. Satisficing can be a very useful and efficient heuristic, but it may lead to errors.

Process feedback. For experience to aid learning, the player must receive feedback about decisions. Children may be less defensive about their errors and able to learn more from experience. Foreign language teachers often report that children are less intimidated and more willing to risk "sounding funny." Children, because they are in a constant learning mode, may learn more from feedback than adults. At any rate, chess offers unusual opportunities for *process* feedback. In tournaments, players write down all their moves. They then replay their games with coaches or other players, trying rejected alternatives and testing what the outcome might have been. This multilevel feedback and evaluation benefits all learners and is far superior to simply knowing whether one won or lost the game. Because children's schemas are naturally fluid and open to modification, children may be able to learn faster as a result of this high quality feedback.

Calibration. Process feedback may be especially effective for well-calibrated learners. Calibration refers to the correlation between one's subjective assessment of one's own knowledge or skill and an objective measure of one's knowledge or skill. In general, people are poorly calibrated (Glenberg, Sanocki, Epstein, & Morris, in press). With poor calibration, the utility of feedback is limited. With accurate calibration, feedback becomes much more beneficial. Chess players are well calibrated with regard to their skill level because of the existence of a rating system based on win/loss records against players at different levels. If a player's rating is 1100, he or she cannot truly believe he or she is at the master level! Children quickly learn that, in general, those with higher ratings will win more matches. We've found young players to be brutally honest about their performance; this is no doubt due to the fact that their ratings are public knowledge and have great credibility.

The rating system provides a real-life lesson in probability theory for children. Despite their ignorance of standard deviations and probability theory, we've found elementary children to be remarkably accurate in estimating the probability of wins against rated opponents. (The U.S. Chess Federation provides mean and standard deviation for the rating system so it is possible to calculate the probability of a win.) We presented several top elementary players with the type of problem that adults (even graduate students trained in statistics) typically get wrong:

> Imagine that you will play in two tournaments. In which of the two are you more likely to win all your games?
>
> 1. A seven round tournament where rounds 1-3 you play someone rated 200 points (one standard deviation) below you and rounds 4-7 you play someone 100 points below you.
> 2. A four round tournament where rounds 1 and 2 you play someone 100 points below you, round 3 someone 200 points below you, and round 4 where you play someone 100 points *above* you.

The children (who are admittedly unusually bright and among the top 10 players in the country in their age range) correctly chose 2 and gave the reason that "with more rounds you have more chances to mess up." (Probability of winning all rounds in 1 is .10 and in 2 is .13). On this type of problem, people typically do not consider

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disconfirming evidence—they don't estimate probabilities by considering the probability of *losing.* In conjunctive situations people tend to overestimate probabilities. These children corrected for that bias by considering the probabilities of their losses. Probability theory is notoriously counter-intuitive. If chess develops correct intuitions about probabilities, there could be tremendous educational advantages.

Training

Without training or study, few chess players play well. Just learning to move the pieces and playing with other novices results in very slow progress. We visited schools where enthusiastic teachers who knew little about chess encouraged daily play. We found players with no sense of strategy and very little skill. What they lacked was (1) teaching of principles, (2) process feedback (they only experienced outcome feedback whether they had won or lost); and (3) specific chess drills. We will consider each of these three topics.

1. *Teaching of principles.* Coaches do not wait for players to discover the principles. They are taught explicitly. Opening systems are memorized and practiced. Players are urged to study chess theory. Information is presented as a systematic body of knowledge. When most educators think of gifted and highly motivated students, they assume discovery learning is preferred and memorization is undesirable. What we've found is that young chess players are very adept at and enjoy memorizing openings, learning their names, and classifying them. This pleasure in acquiring a large database is seen, particularly among boys, in collecting information from baseball cards or information about many kinds of dinosaurs. Children acquire a large set of "book moves," moves that are described in text. The result is children who can learn more book moves in less time than adults, but children who also do not get bogged down in detail. Children's games are usually strongest in the opening, where the moves tend to be more book moves, and where principles are rather concrete (e.g., "move both center pawns two squares each"). Starting off well gives these children an advantage (and no doubt teaches them the value of studying!).

2. *Process feedback.* A major part of learning and improving chess play comes from feedback. Going over games in detail with an expert and replaying games with different strategies offers the opportunity for rapid improvement. Learning to analyze one's own performance objectively provides an excellent lesson in how to maximize skill. In chess, a player has little opportunity to rationalize losses; children learn to be objective about their own performance. In addition, their improvement is readily measured by increased ratings.

3. *Specific chess drills.* Chess coaches use a number of interesting training techniques. One is the use of chess problems. Much like case studies constructed for business students, these are problems designed to illustrate a specific principle. Irrelevant details are omitted. Like other kinds of puzzles, they are highly motivating since the learner knows there is a solution.

Paradoxically, players are trained to both play faster and to play slower. Children tend to play fast without much evaluation of alternatives, so coaches have them take more time with moves. In our studies, we found that longer analysis time was correlated with a deeper level of analysis. But coaches also stress speed training. In general, children approach the world in a whirlwind fashion, acquiring schemata rapidly (often inaccurately). If they spent too much time analyzing all the new information available to them, they would not learn as rapidly as they do. Playing chess rapidly forces a global perspective and hence helps develop intuitions. Since children often ignore details anyway, they easily learn to take in the "big picture." Playing fast keeps alive the rapid acquisition of schemata.

Another common training technique is to practice playing blindfolded. This forces the player to rely on visualization. Children tend to have good visualization skills, so that early and continued visualization practice maintains those skills. When evaluating alternatives several moves ahead, the physical board and pieces can get in the way. The player with good visualization skills can "see" the board as it might look under different lines of play. This practice results in more flexible thinking.

The training has to be geared to the child's level. We observed coaches putting positions and moves into context for students at different skill levels. We felt that this foregrounding might be one key to the success of the training. To test this hypothesis, we replicated the DeGroot study with children (Horgan, Horgan, & Morgan, 1986), but with one task modification. On half the trials, before seeing the board, the child was given a brief general comment mentioning the strategic/tactical considerations, but not mentioning any specific chess piece. We reasoned that if what experts "have" is a global representation around which to organize the board, then children ought to improve their performance if they, too, had some organizing principle. That is, some help with organizing the information could compensate for the children's lower memory abilities and level of knowledge.

When boards were presented without the context, performance was correlated with age, r = .377 and with rating, r = .301. When boards were presented with contexts, age and rating were less important. The context "levelled" the performance, resulting in lower correlations, r = .167 for age and r = .230 for rating. This means that with the context, there were fewer age differences and skill level differences. What's more, context helped the primary and junior high children the most. High schoolers actually did worse with the context. The primary grade children are in a transition from preoperations to concrete operations and the junior high students are in a transition from concrete operations to formal operations. The overall pattern suggests that providing a global organizing principle may or may not be helpful, depending on the cognitive stage of the child.

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During transition periods or early in a new stage, children may be most open to different ways of organizing information. During stable periods, they may prefer their own organizing principles.

Implications

While adults progress to expertise from a focus on details to a more global focus, children seem to begin with a more global, intuitive emphasis. This may be a more efficient route to expertise as evidenced by the ability of preformal operational children to learn chess well enough to compete successfully with adults. Educators, rather than trying to "stamp out" the intuitive, quick judgments, would do well to encourage these judgments as well as encouraging careful, analytic thought. Many pet phrases of teachers discourage quick judgments: "look before you leap," "neatness counts," "go slow." It may be that practice in making fast judgments forces the integration of a child's rapidly expanding knowledge base. The combination of forcing quick judgments and encouraging analytic processes may speed the acquisition and revision of schemas. Complex problems should be approached from both the intuitive and the reflective modes.

One clear lesson from our observations and research is the importance of taking advantage of the cognitive level of the learner. If, for example, the learner is in the data acquisition mode (as evidenced by vast store houses of knowledge about one area, such as baseball), then now is the time for memorization of facts. The training technique of playing blindfolded takes advantage of the child's natural visualization skills and practice preserves those skills. The memory results show that appropriate foregrounding, introduced at the right time, can greatly enhance performance. The same information at the wrong time, however, can reduce performance.

Helping learners think logically is not easy. But our observations and research show that young children can be taught to think clearly and with discipline, to plan ahead, and to make sound decisions. Learning these skills early in life can only benefit later intellectual development. We've seen that the way children acquire these skills differs in fundamental ways from adults. Implications for education are basically twofold: teach children, emphasizing their natural capabilities, to take a global perspective and to acquire and organize data quickly, and attend to the processes of their thought rather than the outcomes.

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NOTES

The Critical and Creative Thinking Program at the University of Massachusetts, Boston, is sponsoring its second national summer program in Boston during July, 1987. The Program is aimed at teachers, school administrators, and others interested in teaching thinking. The main focus of the program is on translating an understanding of critical and creative thinking and of techniques for teaching thinking into practical applications in the classroom, the curriculum, and the school/school system. There will be week-long, one-credit courses on topics of importance about thinking and teaching thinking; three-week, three-credit seminars and curriculum development courses; plus a special administrative planning seminar. Other events in this period include three one-day practitioner's conferences with lesson demonstrations and discussion, discussion groups and videotape demonstrations.

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