

Cognitive Benefits of Chess Engagement: Impact on Executive Functions and Problem-Solving Abilities

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ABSTRACT

This review examines whether cognitive skills associated with chess engagement transfer to non-chess cognitive tasks, academic performance, and real-world problem-solving. It addresses two questions: (first) to what extent chess-related executive-function benefits transfer to general cognitive and academic settings, and (second) how effectively chess-related problem-solving applies to decision-making beyond the game. A structured literature review synthesized fifteen journal articles published between two thousand and sixteen and two thousand and twenty-six, selected for their relevance to executive functions, working memory, attention, critical thinking, mathematical problem-solving, and decision-related outcomes. The findings were mixed. Some studies reported benefits in specific measures, including working memory, concentration, processing speed, visual perspective-taking, mathematical problem-solving, or risk preferences. However, controlled studies also found no consistent improvement in broad academic achievement or in several cognitive and non-cognitive outcomes. Evidence for far transfer to everyday decision-making was particularly limited, while findings from cross-sectional and correlational studies could not establish causal effects. Overall, chess may be a useful supplementary educational activity, especially when instruction explicitly teaches problem-solving strategies that learners can apply in other contexts. Chess engagement alone, however, should not be assumed to improve general cognitive or academic abilities. Further controlled research with follow-up assessments and authentic real-world measures is needed.

Keywords: chess education, executive functions, problem-solving skills, cognitive transfer, far transfer

INTRODUCTION

Chess requires several cognitive skills, including attention, working memory, planning, and problem-solving. Because of these demands, researchers have examined whether chess engagement may support cognitive development. However, the benefits of chess may depend on the skills being measured, the type of instruction provided, and the research design used. Therefore, the relationship between chess and cognitive improvement needs to be examined carefully.

Previous studies have examined the relationship between chess engagement and cognitive skills such as working memory, inhibitory control, planning, and problem-solving. However, findings remain mixed regarding whether these skills improve beyond chess-specific tasks and transfer to academic performance or real-world situations.

The purpose of this article is to critically evaluate the extent to which executive function and problem-solving gains derived from chess engagement transfer to non-chess cognitive tasks and real-world scenarios. Additionally, this paper aims to analyze the conflicting empirical evidence regarding near-transfer versus far-transfer effects and identify the contextual factors that influence cognitive transfer.

Specifically, this review addresses the following research questions:

1. To what extent do executive function enhancements acquired through chess practice transfer to general, non-chess cognitive tasks and academic settings?
2. How effectively do problem-solving skills developed during chess play apply to real-world decision-making and problem-solving scenarios?

METHODS

The literature search used Google Scholar and Semantic Scholar and included searches of relevant academic repositories and publisher platforms, including PubMed Central, ScienceDirect, SAGE Journals, Elsevier, and Frontiers. ResearchGate, SINTA, and DergiPark were also checked where relevant. The final search was conducted on 10th October 2026. The search terms and source-specific search procedures were recorded to document the literature identification process.

The search focused on articles published between 2016 and 2026. The review included English-language journal articles that were relevant to the research questions. The initial search identified 35 records across the academic search platforms, publisher platforms, repositories, and supplementary sources listed above. 17 from Scholar, 4 from Frontiers, 5 from Semantic Scholar, 2 from ScienceDirect, 1 from Research Gate, 1 from Sinta, 1 from Dergipark, 1 from BBC, 1 from CNN, 1 from APNews, 1 from Instagram.

The articles were selected using a PRISMA-based process, consisting of identification, screening, inclusion and manual hand search. First, duplicate records were removed.

From the 35 identified records, 3 duplicate records were removed, leaving 32 records for screening.

Next, the titles and abstracts of the 32 records were screened based on their relevance to the research topic and research questions. 5 articles were excluded because they were not sufficiently related to the topic, cannot access, years of publication is not relevant, and did not address the research questions. The remaining 27 full-text articles were assessed for eligibility.

The current selection notes state that seven reports could not be retrieved. If the preceding counts are confirmed, 20 reports remained available for full-text assessment, while the draft lists 15 studies in the final synthesis.

The inclusion criteria may include:

Studies were included if they met the following criteria:

- 1.They were directly related to the research questions on chess and cognitive transfer.
- 2.They were written in English.
- 3.They were published in peer-reviewed journals between 2016 and 2026.

4. Their full texts were accessible for assessment.
 5. They used experimental, quasi-experimental, or relevant observational or correlational designs.
- The selection process is presented in Figure 1.

Data Analysis

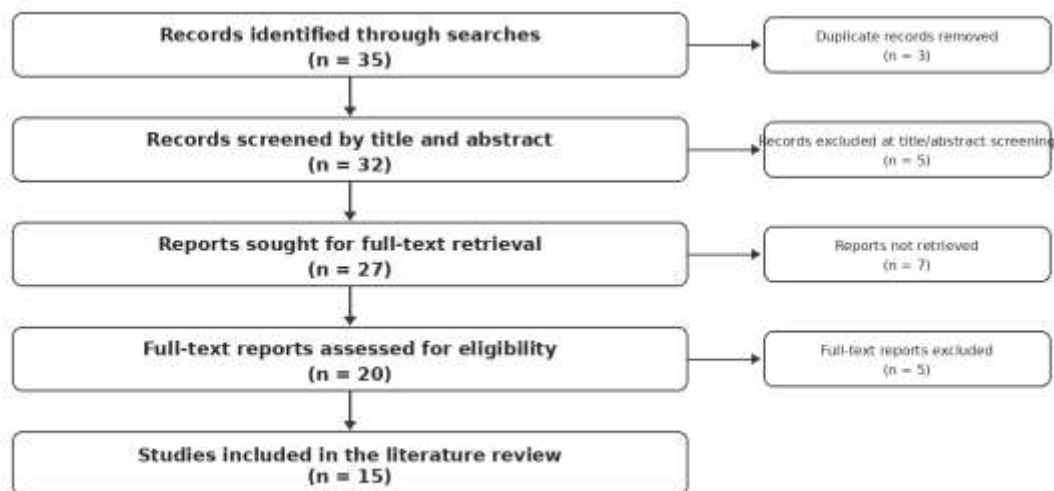


Figure 1. PRISMA-style flow of study selection.

Each study meeting the inclusion criteria was thoroughly analyzed to understand the research design, intervention population, measurement instruments, and key findings. Data extraction was specifically focused on variables addressing Research Question 1 (executive function enhancements and their transfer to general cognitive/academic tasks) and Research Question 2 (the application of chess problem-solving to real-world decision-making scenarios). Results across different studies were cross-compared to identify patterns of consistency, contradiction, or variation in effect sizes, particularly distinguishing between near-transfer and far-transfer effects. Findings sharing similar characteristics were categorized into core themes, including inhibitory control, working memory, abstract reasoning, metacognition, mathematical problem-solving, and risk/behavioral preferences. All findings were tabulated into a working literature analysis table and synthesized into a critical narrative to comprehensively answer both research questions.

RESULTS AND DISCUSSION

Table 1. Summary of the Included Studies1q

No.	Author & Year	Research Focus	Context	Main Finding	Related RQ
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[1]	Trinchero & Sala (2016)	Transfer of chess problem-solving heuristics to mathematical problem-solving.	931 primary-school pupils assigned to two chess-training conditions or a control group. One condition explicitly taught problem-solving heuristics; the other did not.	The group whose chess instructors explicitly taught problem-solving heuristics outperformed both the other chess-training group and the control group on mathematical problem-solving. The school-teacher chess group did not differ from the control group. This suggests that transfer may depend on explicitly teaching and applying general heuristics, rather than chess practice alone.	RQ 1
[2]	Jerrim et al. (2018)	Randomized controlled trial involving more than 4,000 children in England; academic		The trial found no evidence that chess instruction improved	RQ 1





		outcomes included mathematics, reading, and science test scores.		mathematics, reading, or science scores. Because this is a large randomized study, it provides an important counterpoint to claims that chess reliably transfers to general academic achievement.	
[3]	Joseph et al. (2018)	Effects of chess learning on cognitive processing speed.	Pre-test/post-test control-group study with 178 schoolchildren in Grades 3–9 in India: 88 in the chess-training group and 90 in an extracurricular-activity control group. Training lasted one year	The chess-training group showed a statistically significant improvement in processing-speed scores relative to the control group, measured with the Coding and Symbol Search subtests of WISC-IV India. The study supports a possible cognitive benefit, although broader transfer to real-life performance was not directly tested.	RQ 1





[4]	Atashafrouz (2019)	Effects of chess on problem-solving, working memory, and concentration	Experimental pre-test/post-test study of 40 male Grade 10 students in Ahvaz, Iran; 20 received 15 chess-training sessions over four months and 20 formed the control group.	Chess training significantly improved working memory and concentration compared with the control group. However, the difference in problem-solving ability was not statistically significant. The mixed findings suggest that gains may be specific to some cognitive functions rather than broad problem-solving transfer.	RQ 1
[5]	Gao et al. (2019)	Chess expertise and visual perspective-taking under different executive-function demands.	Two laboratory experiments involving 30 children aged 11–12: 15 experienced chess players and 15 non-chess players, assessed using a visual dot-perspective task.	Experienced chess players performed better on the perspective-taking task when it placed higher demands on executive functioning. The advantage disappeared when executive-	RQ2





				function demands were reduced. As the groups were compared rather than randomly assigned to chess training, the result indicates an association with expertise, not a causal training effect.	
[6]	Islam et al. (2021)	Effects of chess instruction on academic outcomes and non-cognitive preferences, including risk and time preferences.	Randomized field experiment involving primary-school students in Bangladesh; outcomes included mathematics, other academic measures, creativity, attention/focus, risk preferences, and time preferences.	Chess instruction reduced risk aversion almost one year after the intervention. Mathematics scores and some time-preference measures also improved, but these non-risk findings became less conclusive after accounting for multiple-hypothesis testing. No significant effects were found for other academic outcomes,	RQ 1, RQ 2





				creativity, or attention/focus	
[7]	Tachie & Ramathe (2022)	Use of chess to support metacognition and mathematics learning.	Comparative school-based study involving 51 learners: 25 from schools offering chess	Learners from chess-training schools made fewer contextual errors and were better at applying the steps needed to solve the mathematics tasks than the comparison learners. The authors interpret this as evidence that chess may support metacognitive application in mathematics. Because learners came from different schools without random assignment, the result should not be taken as	RQ 1, RQ 2





				conclusive causal evidence.	
[8]	Baig et al. (2025)	Whether chess training improves executive functions and transfers to daily-life activities.	Quasi-experimental comparison of children aged 8–12. The chess group attended a chess workshop and the comparison group attended another educational workshop of similar frequency and duration. Executive functions were assessed before and after with BRIEF-2 reports from teachers and parents.	The chess group improved on executive-function measures according to teachers' reports, but not according to parents' reports; the control group showed no relevant significant improvement. The disagreement between informants means transfer to daily life is not consistently established.	RQ 1, RQ 2
[9]	Choi et al. (2025)	Causal effects of educational chess on critical thinking, attention, patience, and risk aversion	Experimental phase-in chess program in schools in Catalonia, Spain, involving 12-year-old students, with outcomes compared after one academic year	No statistically significant differences emerged between the treatment and control groups in critical thinking, attention, patience, or risk aversion. The chess group improved only in chess knowledge	RQ 1, RQ 2





				and playing proficiency. The results caution against assuming that chess skills automatically transfer to wider cognitive or non-cognitive outcomes	
[10]	Darwish et al. (2025)	Relationship between chess proficiency and cognitive	Correlational study of 120 Grade 10 students in Riyadh, Saudi Arabia. Chess Elo ratings were compared with Trail Making, Stroop, and Backward Digit Span performance.	a small negative association with Stroop errors ($r = -.177$). No significant association was found with Backward Digit Span working-memory scores. The pattern is consistent with limited and domain-specific transfer, but the correlational design cannot establish that chess caused these differences.	RQ 1, RQ 2
[11]	Halawa et al. (2025)	Relationship between chess participation/proficiency and critical-thinking ability in Indonesian high-school students.	40 students aged 15–18 from three high schools in Binjai, Indonesia. The study reported chess ratings and pre-/post-	Chess proficiency was positively correlated with critical-thinking scores ($r = .663$, $p < .001$), and reported post-intervention	RQ1, RQ 2





			intervention scores on the Watson–Glaser Critical Thinking Appraisal	scores were higher than pre-intervention scores. However, the report describes a correlational design while also reporting an intervention, provides no non-chess control group, and contains inconsistent descriptions of the intervention period. Therefore, the results should be treated as preliminary rather than proof of causal transfer.	
[12]	Campitelli et al. (2025)	Chess expertise in planning, cognitive reflection, inter-temporal choice, and risky choice.	Comparison of 25 chess players and 25 non-chess players on the Tower of London task, Cognitive Reflection Test, inter-temporal choice, and risky-choice tasks.	Chess players outperformed non-chess players on planning and cognitive-reflection tasks and were more likely to choose delayed future rewards. Although chess	RQ1, RQ2





				players made more choices consistent with expected value in risky-choice tasks, evidence for a group difference on risk-taking was weak. The observational expertise design cannot establish that chess caused these differences.	
[13]	Yakushina et al. (2025)	Executive-function skills among preschool children who attend chess classes.	Cross-sectional study of 88 typically developing children aged 5–6: 44 attended chess classes and 44 did not. Executive-function measures included visuospatial working memory.	Children attending chess classes had significantly higher visuospatial working-memory scores than non-chess-playing children ($U = 731$, $p = .05$). The cross-sectional design cannot determine whether chess improved working memory or whether children with stronger working memory were more likely	RQ 1





				to attend chess classes	
[14]	Gerhardt et al. (2026)	Chess-based cognitive remediation and executive functions/quality of life in adolescents with mental disorders	Quasi-experimental pilot study in an adolescent psychiatric setting. Participants aged 13–17 received usual multidisciplinary treatment; the intervention group additionally attended weekly 90-minute chess sessions for six weeks	The pilot did not find significant effects on cognitive flexibility, inhibitory control, or sustained attention. It reported a positive effect on psychological well-being and a possible benefit for working memory. The small clinical sample and pilot design limit generalization to students without mental-health conditions	RQ 2, RQ1
[15]	Kilci et al. (2026)	Comparison of cognitive flexibility, inhibitory control, and working memory in chess and esports players.	Comparative cross-sectional study of 30 chess players (mean age	Esports players performed significantly better on measures of cognitive flexibility	RQ 1





			approximately 24) and 30 esports players (mean age approximately 24), using the Berg Card Sorting Test, Bivalent Shape Task, and Corsi Block Test	and inhibition speed, while the groups did not differ significantly in Corsi working-memory scores. Since the comparison group consisted of esports players rather than non-players, the results do not demonstrate that chess training improves executive functions; they show that cognitive profiles may differ by activity.	
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Discussion

3.1 Findings for Research Question 1

Research Question 1 asks: To what extent do executive function enhancements acquired through chess practice transfer to general, non-chess cognitive tasks and academic settings? The reviewed studies indicate that the extent of transfer differs by cognitive domain and by the way chess is taught and evaluated.

Some studies report positive findings in specific cognitive domains. Atashafrouz (2019), for example, found improvements in working memory and concentration among male high-school students who completed chess training, although the difference in problem-solving ability was not statistically significant. Joseph et al. (2018) reported improvement in processing-speed scores following a year-long chess program, while Yakushina et al. (2025) found higher visuospatial working-memory scores among preschool children attending chess classes than among children who did not attend them. However, the latter study used a cross-sectional design, so it cannot establish whether chess caused the difference or



whether children with stronger working-memory skills were more likely to participate in chess classes. These findings therefore suggest possible benefits in particular cognitive measures, rather than a general improvement across all executive functions.

Evidence concerning cognitive flexibility, inhibition, critical thinking, and related skills is also inconsistent. Gao et al. (2019) found that experienced young chess players performed better on a laboratory visual perspective-taking task when the task placed greater demands on executive functioning. The advantage was not observed in the lower-demand condition, and the comparison between experienced players and non-players does not prove a causal training effect. Darwish et al. (2025) reported modest associations between chess proficiency and selected measures of cognitive flexibility and inhibitory control, but did not find a significant association with backward digit-span working memory. Halawa et al. (2025) reported a strong relationship between chess ratings and critical-thinking scores, as well as higher post-intervention scores. Nevertheless, the study had no non-chess control group and contained inconsistencies in its description of the design and intervention period. Its findings should therefore be interpreted as preliminary evidence rather than conclusive proof that chess improves critical thinking.

Other studies provide important counterevidence to broad claims about transfer. In a randomized controlled trial involving more than 4,000 children in England, Jerrim et al. (2018) found no evidence that chess instruction improved mathematics, reading, or science test scores. Similarly, Choi et al. (2025) found no statistically significant effects of a school chess program on critical thinking, attention, patience, or risk aversion after one academic year, although students improved in chess-specific knowledge and proficiency. Gerhardt et al. (2026), in a small pilot study involving adolescents with mental disorders, found no significant effects on cognitive flexibility, inhibitory control, or sustained attention; possible benefits were reported for working memory and psychological well-being. Because the Gerhardt et al. study involved a clinical population, its results should not be generalized directly to school students without mental-health conditions. Kilci et al. (2026) also found no significant difference in working-memory scores between chess players and esports players, while the esports group performed better on selected flexibility and inhibition measures. Since this was a comparison between two groups with different activity experience, it does not demonstrate the effects of chess training relative to no training.

The results may depend partly on whether instruction explicitly teaches learners how to apply problem-solving strategies beyond the game. Trinchero and Sala (2016), in a study involving 931 primary-school pupils, found that the group whose chess instructors explicitly taught problem-solving heuristics outperformed both the other chess-training group and the control group on mathematical problem-solving. The chess group that did not receive this explicit heuristic instruction did not outperform the control group. This result suggests that transfer may be more likely when learners are taught to recognize and reuse a general strategy, rather than simply being given opportunities to play chess. Islam et al. (2021) similarly found that chess instruction reduced risk aversion almost a year after the intervention. However, the reported improvements in mathematics and some time-preference outcomes became less conclusive after adjustments for multiple hypothesis testing, and the study did not find significant effects on several other academic and non-cognitive outcomes.

Taken together, the evidence provides a qualified answer to RQ1. Chess practice is associated with improvements in some specific measures, including processing speed, concentration, visuospatial working memory, or performance on selected executive-demanding tasks. However, the results are not consistent across cognitive domains, and robust experimental studies do not show that chess reliably improves general academic achievement. The evidence for near-transfer to related tasks is more promising than the evidence for far-transfer to broad academic or everyday cognitive outcomes. The findings therefore do not support the claim that chess automatically produces a general enhancement of executive functions.

3.2 Findings for Research Question 2

Research Question 2 asks: How effectively do problem-solving skills developed during chess play apply to real-world decision-making and problem-solving scenarios? Compared with research on chess-specific performance and selected academic tasks, direct evidence of transfer to real-world situations is limited.

The clearest evidence of transfer to a different problem-solving domain comes from studies of mathematics. Trinchero and Sala (2016) found that mathematical problem-solving improved when chess instruction included explicit teaching of heuristics. Tachie and Ramathe (2022) also reported that learners from schools offering chess training made fewer contextual errors and applied steps in mathematical problem-solving more successfully than learners from comparison schools. However, because the latter study did not randomly assign learners to conditions, differences between schools or students could have influenced the results. In addition, mathematical word problems are structured academic tasks; success on such tasks does not by itself establish that the same skills will be applied effectively to complex decisions in everyday life.

Mathematics tasks provide evidence of transfer to a different academic domain, but they do not directly demonstrate transfer to everyday decision-making. Likewise, laboratory tasks involving planning, cognitive reflection, or risk-related choices measure specific decision-related processes rather than real-life decisions. Therefore, the findings should be interpreted as evidence of possible transfer to selected tasks, while direct evidence of transfer to everyday situations remains limited.

Some studies have examined outcomes that are closer to decision-making. Islam et al. (2021) found a reduction in risk aversion that remained evident almost a year after the chess intervention. Campitelli et al. (2025) found that chess players performed better than non-players on planning and cognitive-reflection tasks and showed differences in inter-temporal choice. However, the study compared existing chess players with non-players rather than randomly assigning participants to chess training, so the differences could reflect pre-existing characteristics or selection into chess. In addition, laboratory planning and choice tasks are indicators of decision-related processes, not direct evidence that chess improves decisions in everyday settings.

Evidence concerning daily-life transfer is also mixed. Baig et al. (2025) assessed executive functions through reports from teachers and parents. Improvements were identified in teachers' reports for the

chess group, but these changes were not confirmed by parents. This disagreement makes it difficult to conclude that the observed changes consistently generalized beyond the school context. Gao et al. (2019) provide evidence of a relationship between chess expertise and performance on a laboratory perspective-taking task, but their study did not measure real-world interpersonal decisions. Likewise, Halawa et al. (2025) reported an association between chess proficiency and critical thinking, but the methodological limitations of the study prevent a strong conclusion about whether chess training caused these outcomes.

Overall, the answer to RQ2 is that transfer to real-world decision-making has not been established consistently. Chess involves planning, anticipating an opponent's responses, comparing alternatives, and considering consequences. These processes provide a plausible basis for transfer, but the existence of similar processes in chess and everyday decisions is not sufficient proof that transfer occurs. The strongest evidence in the reviewed studies concerns performance on specific mathematical or laboratory tasks and selected decision-related measures. More research is needed to show whether chess training produces sustained improvements in real-life choices, social problem-solving, or decision-making across different contexts.

3.3 Implications and Limitations

The findings suggest that chess may be useful as a supplementary educational activity, especially when it is used to teach explicit strategies for planning and problem-solving. Teachers should not assume that playing chess alone will improve academic achievement or executive functions generally. Instead, instructors could make the intended transfer explicit by asking learners to describe how they identify a problem, generate and compare possible solutions, anticipate consequences, evaluate a choice, and reflect on the result. Learners can then be guided to apply the same steps to mathematics or other learning tasks. This approach is consistent with the results of Trinchero and Sala (2016), in which explicit instruction in problem-solving heuristics was important to the transfer effect.

Several limitations should be considered when interpreting this review. First, the studies used different research designs, age groups, training durations, comparison groups, and measurement instruments. Their findings cannot therefore be combined as if they estimated one common effect. Second, some positive findings came from cross-sectional or correlational studies, which cannot establish causality. Third, several studies had relatively small or specific samples, including male high-school students, preschool children, and adolescents receiving mental-health treatment. Fourth, outcomes such as laboratory perspective-taking, mathematical problem-solving, and reported daily-life executive functions capture different forms of transfer and should not be treated as interchangeable. Finally, direct evidence about real-world decision-making was limited. The present synthesis is qualitative and does not calculate a pooled effect size; consequently, it cannot quantify the overall magnitude of chess-related benefits.

Future research should use adequately powered randomized controlled designs, active comparison groups, clearly described chess curricula, and validated measures collected both immediately after

training and at follow-up. Researchers should also predefine the outcomes to reduce uncertainty caused by multiple statistical tests, include reports or observations from more than one setting, and assess transfer to authentic academic and everyday problem-solving situations. Such studies would help clarify which learners benefit, which cognitive domains are affected, and whether any gains persist beyond chess-specific performance.

CONCLUSION .

This review examined whether cognitive skills practiced through chess can transfer to other tasks, academic settings, and everyday decision-making. The findings suggest possible benefits in selected outcomes, including working memory, concentration, processing speed, and mathematical problem-solving. However, the findings varied across studies, and strong evidence for general academic improvement was limited.

For the second research question, the findings suggest that chess-related problem-solving may transfer to some structured tasks, particularly when teachers explicitly explain how strategies can be applied beyond the game. However, evidence of sustained improvement in everyday decision-making remains limited.

Overall, chess may be a useful supplementary educational activity, but its benefits should not be assumed to extend to all cognitive skills or real-life situations. Future research should use well-designed controlled studies and follow-up assessments to examine which skills improve, under what conditions, and whether these benefits persist beyond chess-specific tasks.

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ADDITIONAL NOTES

During the preparation of this literature review, the authors used ChatGPT to assist with organizing the literature analysis, developing preliminary drafts of selected sections, and improving language clarity. The authors reviewed and revised the AI-assisted content and are responsible for verifying the accuracy of the information, interpretations, and references against the original publications. The authors take full responsibility for the final content and conclusions presented in this manuscript.