

Stalemate? The complex relationship between educational chess and students' skills

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ABSTRACT

Over the last decade, an increasing number of countries have integrated chess as a pedagogical tool and even as core content of their academic curricula. Nonetheless, the evidence regarding the causal effects of chess on a range of skills remains inconclusive. We report new evidence of the impact of learning chess in school on a set of cognitive and non-cognitive skills of 12-year-old students to shed light on this matter. To do this, we take advantage of the implementation of a phase-in program introducing chess into a set of schools in Catalonia (Spain). This experimental setting enables us to estimate the causal effects of practicing educational chess at school on critical thinking, attention, patience, and risk aversion. Results show that, after one academic year, the differences between the treated and control group are not statistically significant for any of these outcomes. Students who took part in the chess program significantly outperformed the students in the control group only in terms of their chess-playing knowledge and proficiency.

1. Introduction

Chess is considered to be a game that requires high-level cognitive processes. Therefore, psychologists have conducted a wide variety of studies analyzing cognition, personality and intelligence associated with the practice of chess (Gobet, 2019). The first experiments addressing chess players' abilities date back to the 19th century and were developed by Binet (1894). Binet's pioneering research was a breakthrough, as he showed that, contrary to Taine's (1870) previous findings, most advanced blindfold chess players rely on experience (*érudition*), creativity and abstract thinking capacity (*imagination*) rather than on their visual memory skills (*mémoire visuelle géométrique*). Later, De Groot (1978) furthered this research on how chess players are able to quickly understand the positions of the pieces to find the best moves. De Groot found that expert chess players can anticipate moves, are endowed with exceptional memories for patterns on the board and have selective perception, that is, they can filter out irrelevant information. This constitutes an intuitive experience enabling them to assess situations and hone their cognitive flexibility to adapt to changes. More recent research

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carried out with chess players studied the relationship between intelligence (Bilalic et al., 2007), planning abilities (Unterrainer et al., 2010), memory (Lane & Chang, 2018) or slow and fast thinking (Blanch et al., 2020) and the practice of chess at different levels with a wide variety of results.

1.1. Chess as an educational tool

The impact of chess on cognitive skills has also led to the study of its potential benefits as an educational tool. Several studies have highlighted that there is a positive association between chess playing at early ages and a wide range of educational outcomes, including the improvement of cognitive, social, and emotional skills (for a literature review, see Blanch, 2022; Burgoyne et al., 2016; Gobet & Campitelli, 2006; Ortiz-Pulido et al., 2019; Sala et al., 2017). Besides, chess is perceived by society as a science game able to foster the development of such competencies as concentration, patience, intelligence, attention, memory, and logic, contributing to students' success (Mirzakhanyan et al., 2017; Stegariu et al., 2023; Trincherio, 2013).

The merits of chess, combined with its relatively low cost of implementation within education, (Jerrim et al., 2018) have motivated a growing number of countries, such as Iran (Kazemi et al., 2012), Denmark (Rosholm et al., 2017), Romania (Gliga & Flesner, 2014), England (Jerrim et al., 2018), Bangladesh (Islam et al., 2021) or Italy (Sala et al., 2015), to introduce chess as a pedagogical tool and even as part of the contents of their academic curricula. Moreover, the European Parliament endorsed the introduction of the Chess in School program into European Union country education systems on March 15th, 2013 (European Parliament, 2013).

1.2. State of the art: the impact of chess on skills

However, research into the causal impact of educational chess on the acquisition of cognitive and non-cognitive skills is as yet incipient and inconclusive (Blanch, 2022; Sala & Gobet, 2016). Some researchers, including Hong and Bart (2007), Islam et al. (2021), Jerrim et al. (2018), Sala et al. (2015), Sala and Gobet (2017) and Trincherio and Sala (2016), have analyzed this causal relationship for primary education students by conducting randomized controlled trials (RCT) measuring the same outcomes before and after the chess instruction intervention through pre- and post-tests in a treated and a control group.

Hong and Bart (2007) examined the effects of chess instruction on 38 at-risk Korean students in three primary schools. The results of the test on cognitive abilities were no different from control group performance. Sala et al. (2015) found that face-to-face chess classes significantly improved mathematics performance in primary education in Northern Italy. Trincherio and Sala (2016) conducted a RCT to examine whether chess training influenced mathematical problem-solving abilities. To do this, they took data on 931 third-, fourth- and fifth-graders from 20 schools that were divided into three groups: two treatment groups and one control group. One treatment group received chess training from chess experts based on heuristics for solving chess problems, while the other treatment group received chess training from schoolteachers. Results showed that chess training can enhance problem-solving abilities in children but only when the chess training incorporates the problem-solving heuristics.

More recently, Sala and Gobet (2017) found that chess instruction had no impact on the ability of 233 third and fourth graders from eight Italian schools to solve mathematical problems. Jerrim et al. (2018) evaluated the influence of chess classes on mathematics, reading and science skills in primary school children in England, without finding significant effects. Finally, Islam et al. (2021) assessed the impact of educational chess on cognitive (mathematics, reading and science, attention/concentration) and non-cognitive (risk aversion, patience, creativity) skills in 569 fifth-grade primary school pupils in Southern Bangladesh. Their findings indicated that chess practice has a weak significant effect on reducing the level of risk aversion, positively influences mathematics scores, and decreases the incidence of time inconsistency in decision-making. However, no significant effects of chess on other academic outcomes (reading and science), creativity or attention were observed.

In Spain, Aciego et al. (2012, 2016) and Fernández-Amigo (2008) reported a positive correlation of chess as an educational resource with different outcomes, such as mathematical competence, memory, cognitive skills, and problem-solving in primary school students. However, these conclusions should be approached with caution since the selection of the treated and control groups was not randomized.

1.3. Research objectives and key questions

The purpose of this study is to examine whether incorporating educational chess as a teaching method for primary school students leads to improvements in cognitive (critical thinking and attention) and non-cognitive (patience and risk aversion) skills relative to a comparison group. We also measure and compare the chess-playing ability of both groups after the intervention. To do this, we take advantage of a phase-in design to introduce educational chess in a set of publicly funded private schools run by a private foundation in the Autonomous Community of Catalonia (Spain).

This aim can be formulated as three research questions:

1. Are there statistically significant differences in the cognitive and non-cognitive skills and the characteristics of the sample of students exposed and not exposed to the intervention before it took place?

Given these cognitive and non-cognitive skills, we first analyze whether there are statistical differences in baseline socioeconomic characteristics and skills before the intervention between the treated group and the control group in our sample of students. The motivation for conducting these tests is to check whether, apart from chess playing ability, both groups have similar characteristics.

2. Do the students who participated in the educational chess program significantly outperform those who were not engaged in the program for the outcomes of interest, including chess-playing ability?

We assess the impact of practicing educational chess by comparing the outcomes of students who received the chess intervention throughout the 2021–22 academic year with students in the control group who did not participate in the program.

3. From a qualitative perspective, do the teaching staff perceive any improvement in the students' cognitive and non-cognitive skills following the implementation of the program?

Finally, we qualitatively analyze teachers' and students' perceptions of the educational chess program during and after the intervention to complement the quantitative results. Previous results have shown that quantitative results and subjective perceptions may not match. For example, [Jerrim et al. \(2016\)](#) analyzed teachers' perceptions when implementing chess in their classrooms. Teachers observed a very positive improvement in competencies such as thinking/cognitive skills, confidence/self-esteem, ability to cope with winning/losing, concentration, and the ability to play chess. Similarly, [Chitiyo et al. \(2021\)](#) also gathered teachers' perceptions regarding the implementation of chess. Teachers reported that the use of chess greatly benefited their students, enhancing their problem-solving abilities, strategic thinking, critical thinking, decision-making, and increasing their interest in school.

1.4. Outcomes of interest

The choice of cognitive and non-cognitive skills to be assessed was made based on a literature review and validated by a panel of experts specializing in the educational application of chess. Regarding cognitive skills, critical thinking is intrinsically linked to the ability to analyze, infer, deduce, evaluate, judge, make decisions and solve problems ([Lai, 2011](#)). Theoretically, all these skills could be developed through chess, as this game requires a logical and in-depth analysis of the moves made, a meticulous evaluation of each piece and its movement, consideration of different options, and anticipation of the consequences of each decision. In recent years, great importance has been attached to the development of critical thinking in the field of education because of the important role it plays in preparing students to face future challenges ([Alsaleh, 2020](#); [Marques et al., 2011](#); [Rott et al., 2024](#)). Besides, it is considered to be a key educational competency with respect to sustainable development ([Felix, 2023](#); [Taimur & Sattar, 2019](#)).

Chess playing requires focused attention ([Bart, 2014](#)), a skill that is also involved in other learning processes, ([Stevens & Bavelier, 2012](#)). Thus, chess playing might be a vehicle for enhancing attention, leading to better academic performance. However, existing evidence of whether chess plays a role in increasing attention is still inconclusive. While [Scholz et al. \(2008\)](#) showed that chess can help to improve attention for children with learning disabilities, [Islam et al. \(2021\)](#) found no evidence of a link between learning chess and attention.

We also assess the impact on two non-cognitive skills, patience and risk aversion. Children have high discount rates, i.e., they are impatient decision-makers, which leads some of them to make irrational inter-temporal choices in search of immediate rewards ([Bettinger & Slonim, 2007](#)). This can affect several aspects of life, including their time management and future educational choices ([Belzil & Leonardi, 2013](#)). The game of chess might help them to develop strategic planning skills and improve their ability to forsake short-term gains in favor of problem-solving perseverance and patience ([Islam et al., 2021](#); [Jankovic & Novak, 2019](#)).

Chess also involves risk calculation. Depending on our willingness to take risks, given the expected returns, a movement may lead to either winning or losing the game ([Islam et al., 2021](#)). The willingness to take risks in some situations or to be cautious in others could have an impact on the future of young people, as various studies have examined the influence of risk preferences in different walks of life, such as academic success in high school ([Castillo et al., 2018](#)) or the likelihood of attending university ([Obermeier & Schneider, 2015](#)). Although these studies are not entirely conclusive, [Eckel et al. \(2012\)](#) suggest that, given the expected gains, risk preferences are determined not only by the environment, but also by the individual, and can be developed over time. Therefore, it is worthwhile assessing the influence of educational chess on this competence ([Islam et al., 2021](#)).

Lastly, we also measure and compare the chess-playing ability of both groups after the intervention. Should chess playing have a causal impact on the abovementioned skills, learning how to play the game and then practicing educational chess regularly is an intermediate necessary condition to achieve the desired outcomes.

1.5. Contribution of the paper

The contribution of the paper to the existing literature on the effects of chess as an educational tool is twofold. First, we provide causal evidence of the impact of chess on cognitive and non-cognitive competencies for a country (Spain) where chess has become increasingly popular as a teaching tool. It is noteworthy that, while most of the previous work focused on analyzing mathematics and problem-solving skills, other cognitive and non-cognitive competencies have been less analyzed. Some exceptions to this rule include [Islam et al. \(2021\)](#), who used risk preferences, patience and attention as outcomes, or [Berkley \(2012\)](#) and [Kazemi \(2022\)](#), who analyzed the role of chess in boosting critical thinking skills. Unlike previous work, we also check whether the practice of educational chess helps students in the treatment group to learn and play chess better than pupils in the control group. Learning to solve chess problems should be a necessary condition for improving the skills assessed in this research. Second, we conducted a qualitative evaluation, which rounds out the quantitative results, providing an understanding of the perceptions of the agents involved in the intervention.

2. Method

2.1. Participants

To carry out this research, we used a sample of primary education teachers and sixth grade pupils, typically aged between 11 and 12 years old, attending four publicly funded private schools run by FEDAC (a private foundation in Catalonia, Spain) during the 2021–2022 academic year. The sample included 210 students that were assigned to participate in the experiment: 109 were from the two treated schools and 101 from the two control schools. We received 204 valid responses to the baseline questionnaire administered to this sample, distributed as 105 girls and 99 boys, with an average age of 11.02 years. In terms of their socio-economic background, 94 % of the surveyed students were native (born in Spain), and 38 % claimed to have >100 books at home. The study also included seven teachers, three of whom were from the treated school group and four from the control school group.

2.2. Procedure

The educational chess intervention, known as the EsKcs program, was divided into two phases (for a detailed description of the intervention, see [Appendix A](#)). In the first phase, three teachers in charge of developing the educational chess activity in the treated classrooms were trained. This specialized training, organized as five two-hour online sessions and ten hours of independent work, took place during the months of October and November 2021.

Following this training, the second phase involved the implementation of educational chess by the trained teachers during school hours throughout the academic year. The program was introduced exclusively for four groups of sixth grade students at the two treated schools.

The educational chess intervention consisted of 30 sessions of a weekly one-hour educational chess class. Additionally, teachers were allowed to incorporate educational chess into other classes apart from the specific chess lessons. In parallel, four sixth-grade classes at the other two schools that were to introduce educational chess during the 2022–2023 academic year were used as control groups. The four teachers associated with the control groups did not participate in the 2021–2022 training courses. While the teachers in the control group would have heard of chess as an educational methodology because it is part of the FEDAC project, they would not know how to apply the program. Note that FEDAC schools share the same syllabus, contents, and methodological approaches. They all participate in the same educational projects and have similar material resources. Teachers also have similar educational backgrounds.

Taking advantage of a pre-defined phase-in plan to extend educational chess across all FEDAC schools, the aim of this research is to compare the cognitive and non-cognitive outcomes of the four schools. The findings for the first-time EsKcs program participants during the 2021–2022 academic year are compared with the results of the students in the other two remaining schools that were to introduce the educational chess program during the 2022–2023 academic year. To implement this research, we combine quantitative and qualitative analyses.

2.3. Instruments

Regarding cognitive skills, we focused on critical thinking and attention. To evaluate students' critical thinking, we adapted several questions of similar difficulty from the Madrid Region (year 2017) and Canary Islands (academic year 2017–2018) Diagnostic Assessments; the 2019 Trends in International Mathematics and Science Study (TIMSS) program, and the Cornell Conditional-Reasoning Test ([Ennis et al., 1964](#)).¹ In total, seven items (questions) of similar difficulty to the sample shown in [Fig. 1](#), were included in the baseline and endline questionnaires.

The reliability of critical thinking was calculated using average inter-item correlation. The score was 0.15 in both the baseline and the endline sample, where the ideal range of average inter-item correlations is between 0.15 and 0.5 ([Clark & Watson, 1995](#)).

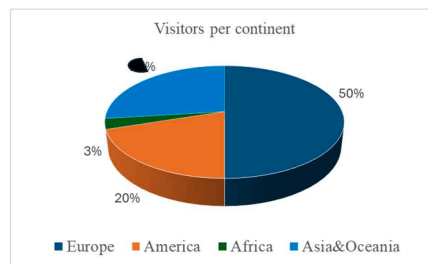
To assess students' attention, we employed a test inspired by the Groffman Visual Tracing Test ([Groffman, 1966](#)) and the Visual Pursuit Test ([Biehl, 2011](#)). Both tests are standardized methods for assessing an individual's attention and orientation in visual tasks ([Cui et al., 2017](#); [Deng & Wu, 2020](#); [Mikicin, 2021](#); [Facchin et al., 2022](#)). As illustrated in [Fig. 2](#), this is a single-item test, in which the student must select the appropriate path for letters.

Of the non-cognitive skills, we selected patience and risk aversion. To measure patience, we administered a time-preference test ([Islam et al., 2021](#)). In this single-item test, students were required to make eight decisions, each involving a choice between immediate or delayed gratification. We obtained two indicators: the patience indicator and the time inconsistency indicator. A sample of the test is presented in [Fig. 3](#).

In this activity you will have to make eight decisions. Each decision involves choosing whether you would prefer to get a number of stickers 'sooner' (in one week) or 'later' (in two weeks). This is an example of the stickers that you will receive.

There are no right or wrong answers, just decide how many stickers you prefer to receive. When the whole class has finished, the teacher will draw lots to choose one of the eight options and will do what you decided for that option. In other words, you will not collect the stickers for all

¹ For a comprehensive review of the released questions, the following websites can be consulted: <https://www.comunidad.madrid/servicios/educacion/evaluacion-6o-primaria>; <https://www3.gobiernodecanarias.org/educacion/accuee/nouniversitario/evadiag>; <https://timssandpirls.bc.edu/timss2019/index.html>.



Unfortunately, a stain has covered the data corresponding to the visitors from Asia and Oceania. What is the missing data? If you wish, you can use paper and pen to complete the exercise. Please write your answer here: _____

Fig. 1. Critical-thinking sample item.

For one month, visitors to the Eiffel Tower were surveyed about their nationality. The visitors were categorized by continent and the results are shown in this graph.

Unfortunately, a stain has covered the data corresponding to the visitors from Asia and Oceania. What is the missing data? If you wish, you can use paper and pen to complete the exercise. Please write your answer here: _____.

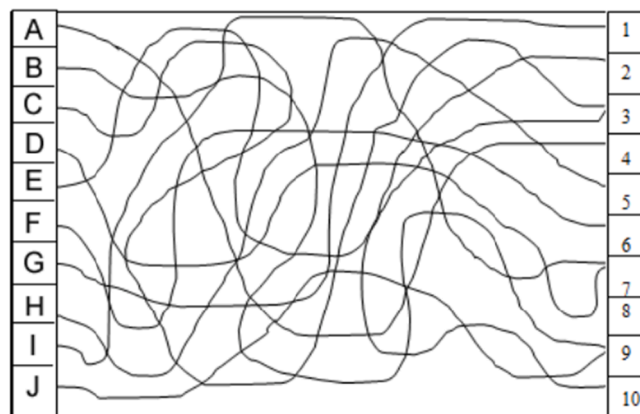


Fig. 2. Tangled paths sample test.

In this activity you will have to make eight decisions. Each decision involves choosing whether you would prefer to get a number of stickers 'sooner' (in one week) or 'later' (in two weeks). This is an example of the stickers that you will receive.



Fig. 3. Sample time-preferences test.

eight decisions, you will only collect the stickers for one of the eight options, the one that is drawn by lot.

Select your preference for each of the following eight options. Remember that you will receive your stickers within one or two weeks depending on your choice for the option selected in the draw.

Option	Sooner	Later
1	4 stickers	4 stickers
2	4 stickers	5 stickers
3	4 stickers	6 stickers
4	4 stickers	7 stickers
5	4 stickers	8 stickers
6	4 stickers	9 stickers
7	4 stickers	10 stickers
8	4 stickers	12 stickers

A risk-preferences test (Islam et al., 2021) is used to assess risk aversion. It is a single-item test in which students must choose between five available lottery options, where the reward increases in proportion to the level of risk. A sample of the test is provided in Fig. 4.

In this activity you have five different options. There are no right or wrong answers, just choose the lottery that you like best. For each lottery, there are two possible outcomes: 'heads' and 'tails'. Once you have all marked your choices, the teacher will flip a coin. If it comes up 'heads', you will receive the stickers that correspond to the 'heads' column of the lottery that you have selected. If it comes up 'tails', you will receive the stickers that appear in the 'tails' column of the lottery that you have marked. Please select **only one** of the following lotteries:

Lottery	If HEADS, you win:	If TAILS, you win:
1	4 stickers	4 stickers
2	6 stickers	3 stickers
3	8 stickers	2 stickers
4	10 stickers	1 sticker
5	12 stickers	0 stickers

Besides, we examined whether participation in the program enhanced students' knowledge of chess. To assess this, three chess exercises were randomly selected from a set of exercises provided by the coordinator of the educational chess program (see Fig. 5 for an example).

In order to quantify the impact of the educational chess program on both cognitive and non-cognitive skills, students and teachers from the four participating schools completed an online questionnaire at two points in time: before (baseline) and after (endline) the program's implementation.

The validity and reliability of the above questionnaires were assessed by a pilot group of 20 students with similar profiles who did not participate in the study, together with an advisory board composed of two economists with expertise in educational evaluation and one economist and one psychologist who were both academics and experts in the implementation of educational chess. On the one hand, the advisory board validated the questionnaire items and confirmed that the tests used would measure the intended dimensions to ensure validity. On the other hand, the pilot group of students filled in the questionnaires and indicated any difficulties they had with their completion. The questions that all students answered correctly or incorrectly were discarded and replaced by other questions with similar content, as they did not help to discriminate between high- or low-scoring students for the defined outcomes.

To assess reliability, a test-retest was carried out by asking the pilot group of students to complete the same questionnaire again 20 days later. The results of the two test administrations were highly correlated, yielding a correlation coefficient of 0.890 for the baseline.

*In this activity you have five different options. There are no right or wrong answers, just choose the lottery that you like best. For each lottery, there are two possible outcomes: 'heads' and 'tails'. Once you have all marked your choices, the teacher will flip a coin. If it comes up 'heads', you will receive the stickers that correspond to the 'heads' column of the lottery that you have selected. If it comes up 'tails', you will receive the stickers that appear in the 'tails' column of the lottery that you have marked. Please select **only one** of the following lotteries:*

Lottery	If HEADS, you win:	If TAILS, you win:
1	4 stickers	4 stickers
2	6 stickers	3 stickers
3	8 stickers	2 stickers
4	10 stickers	1 sticker
5	12 stickers	0 stickers

Fig. 4. Sample risk-preferences test.



The options for all the puzzles are the same, as summarized below. Please select only one of the following options:

- a) Checkmate
- b) Stalemate
- c) Black can move
- d) I don't know

Fig. 5. Chess puzzles.

Black to move. Solve the positions by indicating whether the position is checkmate, stalemate (draw) or if black can move.

The options for all the puzzles are the same, as summarized below. Please select only one of the following options:

Checkmate

Stalemate

Black can move

I don't know.

The same procedure was also carried out with the endline questionnaire using the same pilot group of students resulting in a correlation coefficient of 0.829.

Additionally, we conducted a qualitative evaluation using a range of instruments. This included baseline and endline teacher surveys, follow-up surveys, a structured in-depth interview with one of the program promoters, a focus group with participating pupils and teaching staff, and satisfaction surveys for both students and teaching staff. For a detailed account of the instruments see [Appendix B](#).

2.4. Statistical analysis

To answer the first research question —are there statistically significant differences in the cognitive and non-cognitive skills and characteristics of students exposed and not exposed to the intervention before it took place?—, we checked whether the sample was balanced. When analyzing data from a RCT or any other research design, a balance test formally checks whether there are differences in observable characteristics between the treatment and control groups. When average characteristics in both groups are statistically similar, we can conclude that data come from an experiment ([Angrist & Pischke, 2015](#), p. 16).

For this purpose, we examined whether there were statistically significant differences between the characteristics, and cognitive and non-cognitive skills of students in the treatment and control groups before the implementation of the program. To do this, we used the well-known *t*-test to examine mean differences and the Kolmogorov-Smirnov test to analyze the similarity of the distribution functions.

Second, to address the second research question —do the students who participated in the educational chess program significantly outperform pupils who were not engaged in the program for the outcomes of interest?—, we estimated the following regression model:

$$y_{ik} = \alpha_i + \delta T_{ik} + \tau X_{ik} + \varepsilon_{ik} \quad (1)$$

The assessed outcomes of interest (denoted by y_{ik}) included critical thinking, attention, decision-making efficiency (measured by the hits-per-second indicator), patience along with a related time consistency indicator, risk aversion, and chess knowledge. The variable y_{ik} corresponds to the outcome of interest of student i at school k at the end of the program. Given the presence of multiple outcomes, [Eq. \(1\)](#) was estimated separately for each outcome, resulting in a separate estimation for each case. The treatment is indicated by T_{ik} , which takes values 1 or 0 depending on whether student i participated in the program or belongs to the control group, respectively. Consequently, the coefficient δ captures the impact of the educational chess program on the student's outcome of interest.

The predictors are denoted as X_{ik} , a vector comprising student control variables, which account for contextual characteristics, as well as baseline student outcomes, included to increase the precision of our results. The selected control variables include: student gender, coded as 1 for girls and 0 for boys; age, treated as a continuous variable; immigrant status, indicated by a value of 1 for first-generation immigrant students and 0 for native students; the number of books at home, categorized as fewer than 25, between 25 and 100, between 100 and 200, or >200 books, based on student self-reports; and a specific question regarding chess knowledge, scored 1 if the student responded affirmatively to the question "Have you ever played chess?" and 0 otherwise. Lastly, ε_{ik} captures the residual

term of the model. Standard errors were calculated clustered at the school level.

To address these research questions, we used STATA 17® statistical software. Data and code to replicate these results are available upon request.

3. Results

3.1. Response rate

We collected a total of 204 valid responses to the baseline questionnaire from the 210 students recruited in September 2021 and assigned to participate in the experiment. Under standard hypothesis and parameters (95 % confidence test, 80 % statistical power and assuming that the standard deviation in outcomes for the population is 1), the minimum detectable effect is about 40 % of a standard-deviation of the outcome.

Regarding the endline questionnaires, we got 194 observations. This represents a slightly smaller number of valid responses than for the baseline questionnaire. The non-response rate in the endline questionnaire with respect to the sample of valid observations for the baseline questionnaire, as well as the difference in this rate between treated and control schools can be found in Table C1. In total, there were about 5 % fewer valid responses, non-response being higher in the case of students enrolled in the treated schools.

3.2. Research question (1): are there significant differences in skills and characteristics between exposed and non-exposed students before the intervention?

To assess the balance of the sample and answer the first research question, the baseline questionnaire data were used. Tables 1 and 2 report the balancing checks for student outcomes and control variables, respectively. There are no significant differences between pupils in either group for any of the outcomes considered. As for the contextual variables, once again, both groups seem to be evenly matched for all the dimensions considered, since no significant differences were identified. This confirms that the pre-defined phase-in design established in 2013 behaves like a natural experiment (descriptive statistics for the student outcomes and control variables are reported in Tables C2 and C3, respectively).

3.3. Research question (2): do students in the chess program significantly outperform those not engaged in it for the outcomes of interest, including chess ability?

The second research question is addressed in Tables 3 and 4. Table 3 shows the mean differences in the outcomes of interest before and after the implementation of educational chess for each group. The main results indicate that the scores for critical thinking (treated and control) significantly improve for all students, students are more patient, and their responses to the patience test are less inconsistent. On the other hand, risk aversion decreases and attention increases. However, the differences are not statistically significant in either case. In terms of hits per second, a significant increase is observed in both groups, mainly influenced by control group student responses. Therefore, we observed that, on the whole, the competencies of all students improved at the end of the academic year, possibly because of both their greater maturity and the education received in the different subjects.

To analyze the differences in outcomes between the treatment and control groups after the intervention, we estimated the regression model (Eq. (1)) for all the considered outcomes. Table 4 shows that no significant differences are observed in any of the relevant outcomes.

Significant differences were observed for the outcome related to the level of chess knowledge. Students were asked “Do you know how to play chess?” before starting the chess problems. Students who answered “Yes” were asked to solve three problems similar to the example shown in Fig. 5, while students who considered that they did not know the game well and answered “No”, skipped these questions. The responses by students from the treated and control groups were notably different. Nearly all students in the treated group, with the exception of two, answered “Yes”, giving a response rate of 98 %. In the control group, 52 of the 94 respondents answered “No”, which means that only 45 % knew how to play chess and had learned the game outside school (Table C4).

Hence, the difference in “Chess knowledge” shown in Table 4 was calculated with respect to the 45 % of students in the control schools who claimed to know how to play chess. According to the solutions to the chess problems, however, students in the treated group have a significantly higher average knowledge of the game, by 0.60 standard deviations, than students in the control group.

Table 1
Student's *t*-test and Kolmogorov–Smirnov test of students' outcomes at baseline.

Test	Student's <i>t</i> -test*		Kolmogorov–Smirnov test	
Variable	<i>t</i>	p-value	D	p-value
Critical thinking	0.2755	0.7832	0.050	0.999
Patience	-0.4957	0.6207	0.069	0.975
Time inconsistency	0.2801	0.7797	0.020	1.000
Risk aversion	-1.3018	0.1945	0.133	0.330
Attention	0.9562	0.3402	0.050	1.000
Hits per second	-0.9132	0.3623	0.114	0.549

* Two-tailed test. Null hypothesis: different from 0.

Table 2Student's *t*-test and Kolmogorov–Smirnov test of students' control variables at baseline.

Test	Student's <i>t</i> -test*		Kolmogorov–Smirnov test	
Variable	t	p-value	D	p-value
Gender	-0.8180	0.414	0.057	0.996
Age	0.8679	0.387	0.031	1.000
Immigrant status	0.6978	0.486	0.023	1.000
< 25 books at home	0.3980	0.691	0.024	1.000
Between 25 and 100 books at home	-1.2609	0.209	0.086	0.848
Between 100 and 200 books at home	0.7255	0.469	0.044	1.000
> 200 books at home	0.3700	0.712	0.018	1.000
Chess playing	-1.3653	0.174	0.068	0.982

* Two-tailed test. Null hypothesis: different from 0.

Table 3

Average student outcomes of interest before and after the program by treatment group.

	Treated			Control			All		
	t ₀	t ₁	Diff.	t ₀	t ₁	Diff.	t ₀	t ₁	Diff.
Critical thinking	3.989 <i>0.152</i>	5.523 <i>0.144</i>	-1.534***	3.957 <i>0.139</i>	5.771 <i>0.131</i>	-1.814***	3.973 <i>0.103</i>	5.647 <i>0.097</i>	-1.674***
Patience	5.29 <i>0.175</i>	5.871 <i>0.176</i>	-0.581**	5.223 <i>0.156</i>	5.713 <i>0.154</i>	-0.489**	5.257 <i>0.117</i>	5.791 <i>0.117</i>	-0.535***
Time inconsistency	0.441 <i>0.052</i>	0.258 <i>0.046</i>	0.183***	0.479 <i>0.052</i>	0.309 <i>0.048</i>	0.17**	0.46 <i>0.037</i>	0.283 <i>0.033</i>	0.177***
Risk aversion	3.452 <i>0.157</i>	3.29 <i>0.147</i>	0.161	3.138 <i>0.148</i>	2.957 <i>0.15</i>	0.181	3.294 <i>0.108</i>	3.123 <i>0.105</i>	0.171
Attention	7.766 <i>0.245</i>	8.096 <i>0.199</i>	-0.330	7.989 <i>0.189</i>	8.298 <i>0.154</i>	-0.309	7.878 <i>0.155</i>	8.197 <i>0.126</i>	-0.319
Hits per second	0.037 <i>0.002</i>	0.04 <i>0.002</i>	-0.003	0.034 <i>0.002</i>	0.041 <i>0.002</i>	-0.006**	0.036 <i>0.001</i>	0.04 <i>0.001</i>	-0.005***
Observations	94			94			188		

Note: t₀ refers to the outcome in the pre-test (baseline) and t₁ refers to the outcome in the final questionnaire (endline). // Standard deviation in italics
 // The Diff. columns report the difference between columns t₀ and t₁, indicating whether the difference is statistically significant with respect to the mean at t₀ as follows: **p* < .10, ***p* < .05, ****p* < .01 denote that the difference is significant at 90 %, 95 % and 99 %, respectively.

Table 4

Estimated impact of the program on outcomes of interest at the end of the intervention (endline).

Variables	Coefficient	Standard error	p-value	N
Critical thinking	-0.250	0.177	0.253	188
Patience	0.174	0.493	0.747	187
Time inconsistency	-0.058	0.076	0.502	187
Risk aversion	0.299	0.157	0.154	187
Attention	-0.156	0.291	0.628	188
Hits per second	-0.002	0.001	0.216	187
Chess knowledge	0.616	0.231	0.076*	134

Note: The second column shows the estimated coefficient of the delta parameter of the ordinary least squares (OLS) model in Eq. (1), which indicates the causal effect of the program. Estimates were calculated using clustered errors at school level including the following individual variables as controls: gender, immigrant status, number of books at home, and value of the outcome in the initial questionnaire (except for the last outcome which were not included in the initial questionnaire). The third column shows the standard errors, whereas the fourth column shows the corresponding p-value. The last column lists sample size. // * *p*-value < 0.1.

Fig. 6 summarizes the impact of educational chess on the skills of treated students with respect to students in the control group. For each outcome, we plotted the point estimate of the policy, that is, the coefficient shown in Table 4, and its respective 90 % confidence interval. Except for chess knowledge, all confidence intervals overlap the zero-bar in Fig. 6, leading to the conclusion that there are no statistically significant differences between the cognitive and non-cognitive skills in the treated and control groups after the intervention. However, knowledge of chess is statistically greater in the treated group than among members of the control group who claimed to be able to play chess.

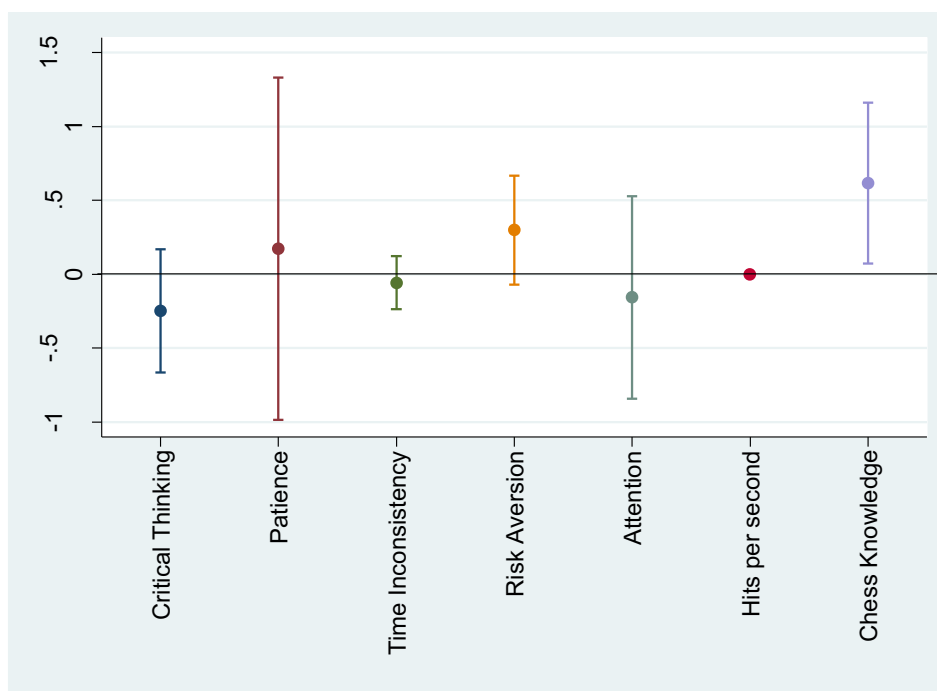


Fig. 6. Estimates of the impact of educational chess on treated students' skills in comparison with the control group.

Note: This figure shows the estimated coefficients of Eq. (1), reported in Table 4. The plot also shows 90 % confidence intervals for the point estimates of each outcome.

3.4. Research question (3): do teaching staff perceive improvements in students' cognitive and non-cognitive skills after the program's implementation?

Finally, we addressed the third research question by analyzing participant student and teacher perceptions and experience to explore the context in which the intervention was developed from a qualitative perspective (Ballestín & Fàbregues, 2018).

The information received in the qualitative evaluation indicates that, even though no significant differences were observed in the defined outcomes, all the stakeholders involved in the development of this activity perceived that educational chess facilitated the development of a wide variety of cognitive and non-cognitive skills. In particular, teachers emphasized an improvement in critical thinking ability, concentration, patience, taking the initiative and learning from mistakes. The teaching staff unanimously agreed that the impact of chess had to be observed on a personal and longer-term basis. Teachers also agreed that the benefit of educational chess is best perceived in the second cycle of primary school, preferably in the fourth grade. This is a stage when students are more able to understand the different dimensions introduced by chess and are more motivated by games.

Additionally, teachers and students highlighted that the educational chess experience promoted socialization among pupils. In particular, they explained that, at the end of the game, chess players engaged in a conversation with their opponent to discuss the moves made, the strategies employed during the game, the thought process behind them, and to share advice. This routine was underlined by teachers and pupils as mutually beneficial for improving socialization and learning from the feedback received, which is less common in other sports. All the students, even those who were initially ill-disposed towards this activity, were highly motivated and participative. By learning through play, they understood this activity as a way of disconnecting from their regular classes and having a fun time learning with their classmates. Interestingly, this was a more widespread perception during educational chess sessions than in the interaction with classmates during other subjects.

Finally, the teachers agreed that teaching staff really have to connect with educational chess and like the game, regardless of whether or not they are regular chess players. In other words, it is not enough to have completed the training courses and to know how to play chess. Unless teachers are motivated and interested in its application, the experience will not succeed.

4. Discussion

In relation to the main research question of the study —do the students who participated in the educational chess program significantly outperform those who were not engaged in the program for the outcomes of interest?—, our results do not support the view that educational chess significantly contributes to changing cognitive (critical thinking and attention) and non-cognitive (patience and risk aversion) outcomes in sixth-graders after one academic year.

Regarding critical thinking, our results contradict findings by Kazemi (2022) for 180 fifth-, eighth- and ninth-grade boys from Iran,

which showed that chess instruction improved this outcome. This inconsistent result could be explained by two facts. On one hand, Kazemi's research focused exclusively on boys, whereas our intervention included both boys and girls simultaneously. On the other hand, Kazemi (2022) combines the results of students of different ages, where about two-thirds of the total sample are high-school students, that is, older than the students included in our research. A future line of research is to explore whether educational chess might help to develop critical thinking among older students, since the students in our sample are entering the phase of cognitive development, primarily focused on the dimensions of critical thinking. Although this competency develops over time and its foundations are laid in earlier stages of development, maturity level can play an important role (Coleman, 2011).

The second cognitive outcome is attention, where our results are consistent with findings by Islam et al. (2021), who did not observe significant changes between the treated and the control group for a sample of fifth-graders in Bangladesh. Likewise, Gliga and Flesner (2014) used a sample of 38 students from Romania to evaluate attention. A randomly selected group of 20 students received 10 blended learning lessons about chess and participated in a final chess competition, whereas 18 students in the control group participated in 10 fun math lessons. They concluded that there were no significant differences with respect to the control group after one minute and five minutes of focused attention. Nevertheless, they found marginally positive significant results for resistance to monotony after 11 min-long calculations. These results suggest that, considering that our attention tests lasted <10 min, longer periods of attention should be explored in future educational chess research. In addition, as Scholz et al. (2008) pointed out, it would be interesting to analyze the impact of educational chess on the abilities of children with learning disabilities or learning difficulties. Unfortunately, in our setting we did not have access to this information. Finally, in the case of the development of attention in schools, other external factors, such as an encouraging learning environment, can have a significant impact on the development of these competencies (Coleman, 2011). Again, we do not have information about these contextual factors, but it would be worthwhile controlling them in future research.

It is worth noting here that other previous research (Velea & Cojocaru, 2018) found that chess training had positive results on attention and other outcomes. However, the results of research designs that do not use a random or quasi-random method to assign participants and non-participants are correlational, and no causal relationship can be established.

In relation to the non-cognitive outcomes, the findings by Islam et al. (2021) suggest that chess instruction does not have any effects on patience. For time inconsistency, Islam et al. (2021) found some evidence that students in the treatment group were less likely to make time-inconsistent decisions three weeks after the program, although these results were less robust 9 to 10 months later. Although our results did not show significant average treatment effects, two out of the three teachers that applied the program did get significant results in reducing time inconsistency. In general, our results support findings by Islam et al. (2021) with respect to there being no effect on patience and a weak relationship between educational chess and time inconsistency. Although other studies, such as Blanch (2022), have found more promising results, the effectiveness of these interventions can vary based on factors like the intensity of the instruction and the age of the students. In our setting, the low-intensity intervention (one hour per week) could explain the ineffectiveness. Another potential explanation lies in the fact that chess playing involves making quick tactical decisions, which, in some cases, may not foster the long-term reflection needed to cultivate patience. Finally, patience is a complex trait, and the instruments available to measure it might not capture subtle or gradual improvements.

Moreover, findings by Islam et al. (2021) show that chess training significantly reduces the treatment group's level of risk aversion, although this evidence is less conclusive after controlling for multiple hypothesis testing. These results, suggesting just a weak causal relationship between chess training and risk aversion, are consistent with the findings of our current research. Our results show a reduction in risk aversion in the treatment group compared to the control group, although the associated p-value (0.154) is not significant at standard levels. As Eckel et al. (2012) show, the school environment plays a key role in determining risk preferences. In our study, however, we did not have information about this contextual variable and did not control for it in the analysis. Therefore, any potentially positive effects of the intervention may be offset by the effect of the school environment.

One possible explanation for why our study, like other similar studies, shows no to low effects on students' cognitive and non-cognitive skills might be the difficulty in transferring skills acquired during training to other unrelated domains. In our study, this would involve transferring specific skills developed in chess to broader cognitive and non-cognitive domains that extend beyond the tasks for which students were explicitly trained. The transfer of knowledge across domains is a desirable goal in education, as it assumes that skills learned in school can be transferred to real-life situations (Barnett & Ceci, 2002). However, Barnett and Ceci (2002) explained that the success of this transfer depends largely on the shared characteristics between the source and target domains. If the domains share common characteristics, it is considered near transfer, whereas far transfer occurs when the domains are unrelated.

A meta-analysis conducted by Sala et al. (2019) on the effects of working-memory training shed light on this distinction. They found that near transfer, such as improved performance on memory tasks, occurs frequently but depends on the population studied, being more common in children with normalized cognitive development. In contrast, far transfer—such as improvements in fluid reasoning or language—does not occur when biases are controlled, regardless of the type of transfer, training, or population examined. This supports the conclusion that while mental capacities can be shaped by training, the benefits remain specific to the trained domain.

As far as the qualitative research question is concerned—do the teaching staff perceive any improvement in the students' cognitive and non-cognitive skills following the implementation of the program?—, our findings are consistent with those reported by Jerrim et al. (2016) and Chitiyo et al. (2021), who noted that teachers were very positive about the intervention and its impact on pupils' skills. Although our study did not find any statistically significant quantitative differences in the development of the competencies, all the stakeholders involved in the development of this activity perceived that educational chess facilitated the development of a wide range of cognitive, non-cognitive and social skills. Given that it takes significant time and practice to become a skilled chess player and that the assessed competencies are influenced by maturational development and other contextual factors, it is possible that, while teachers may already observe slight changes, these may not yet be strong enough to have a statistically significant impact as they

require a longer development period.

5. Limitations

Our results leave many questions, corresponding to different dimensions, open. For example, is one year enough to observe significant changes in students' skills? Given the complexity of the game of chess and the number of years and hours it takes to become a skilled chess player (Chang & Lane, 2018), it is likely that one year of educational chess is not long enough to observe impacts on these competencies. A related dimension is the matter of intensity. It is likely that training sessions of just one hour per week might not be enough to produce significant effects after only one academic year. Considering that the qualitative results are positive, a study involving a longer implementation period may, therefore, be necessary to explore significant changes in the assessed competencies.

Another key issue is the age of the participants. Does the effectiveness of the program vary according to the students' age? The chosen grade, sixth year of primary education, might not be the most suitable for observing short-term effects on student outcomes. Since the development of abilities and skills is cumulative over life (Cunha & Heckman, 2007), it might be more effective to implement the program in younger students so that they can develop these skills at earlier ages (Blanch, 2022). This idea has been further supported by the teachers in the qualitative analysis, who also emphasized the potential benefits of implementing the program at earlier ages.

Thirdly, could chess training exercises be improved to foster skill transfer? An additional limitation regarding the design of the intervention is the possibility that the activities and exercises used for chess training may not effectively foster the targeted skills. For instance, incorporating exercises that focus on the reasoning behind students' decisions, such as discussions about strategies, decision-making processes, and reflective thinking, could help them develop critical thinking skills. Similarly, exercises that introduce plausible distractions or misleading moves could train resilience and focus, thereby enhancing attention. Additionally, leveraging technology and gamification, such as augmented reality platforms to simulate over-the-board scenarios, might effectively teach players how to manage stress and maintain focus in live settings. Incorporating Artificial Intelligence and adaptive learning systems to personalize and dynamically adjust training could significantly boost student engagement. Trinchero and Sala (2016) demonstrated that chess training enhances problem-solving abilities in children, but only when it integrates problem-solving heuristics rather than being delivered by schoolteachers without specialized methods.

Another methodological concern pertains to the limitations with respect to the reliability of the instruments employed, which may complicate the replicability of the findings in the future. General reliability was assessed using the test-retest method, which was deemed the most appropriate approach for the type of test utilized. Given the age of the students, we were unable to administer a very long test without risking a loss of validity due to fatigue, disinterest, and declining attention levels while completing the test (Pérez-Juste et al., 2009). As a result, the number of items used to measure each competency in both the baseline and endline questionnaires was limited. This may have constrained the precision and internal consistency of our measurements. Consequently, inter-item reliability methods were not employed, except for calculating item difficulty and removing unsuitable items. Although inter-item reliability generally provides greater accuracy when a larger number of items assessing the same construct are included, the limited number of items per competency likely reduced the robustness of our reliability estimates. The only competency for which we could calculate reliability using the average inter-item correlation method was critical thinking, as it was the only one assessed with more than one item. Future research should consider employing extensive and diversified assessment tools to enhance reliability and ensure a more comprehensive evaluation of the targeted competencies.

A further constraint is the issue of experience as this was the teachers' very first experience in applying educational chess at the treated schools. Teacher inexperience and unfamiliarity with the development of the classes may have affected the effective use of class time. We suggest that further research be developed to evaluate the change in the range of student skills after interacting with experienced teachers. In terms of other teacher characteristics, we cannot conclude that any of the three teachers in the treatment group achieved better results, as a preliminary analysis revealed no clear pattern. However, future research should place more emphasis on investigating the most successful learning practices developed by the participating teachers.

Finally, this research only explores the results of a limited number of cognitive and non-cognitive skills. However, educational chess could have clearer effects on other skills, such as mathematics, science or reading, which are not addressed in this work. Note that the conclusions that we draw cannot be generalized to the whole population, as we worked with a small sample of around two hundred students at four schools. However, this research does pinpoint some insights about possible key variables for a subsequent large-scale experimental study.

6. Conclusions

In this study, we exploited a phase-in design to introduce educational chess in Catalan schools (Spain) comparing the cognitive (critical thinking and attention) and non-cognitive (patience and risk aversion) outcomes from 204 sixth-year primary education students from two treated and two control schools. Our results indicate that no statistically significant differences are observed between the students in the treated and control group for the main outcomes considered.

However, significant differences were found for the chess-playing knowledge level indicator. While after one academic year of educational chess, 98 % of students in the treated group stated that they knew how to play chess, this percentage was only 45 % in the control group. Furthermore, when comparing chess puzzle performance, the average knowledge of the game was significantly higher (by 0.60 standard deviations) among the students in the treated group than among students within the control group claiming to know how to play chess.

This finding could suggest that the practice of educational chess makes the students learn and play chess significantly better, but this knowledge does not translate, at least in the short term after one academic year, into an improvement in the skills assessed in this research.

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Álvaro Choi: Writing – review & editing, Writing – original draft, Validation, Supervision, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Marta Hurtado:** Writing – review & editing, Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Daniel Santín:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Gabriela Sicilia:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Rosa Simancas:** Writing – review & editing, Writing – original draft, Validation, Supervision, Software, Resources, Methodology, Investigation, Formal analysis, Data curation, Conceptualization.

Declarations of interest

None.

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Appendix A. the intervention: the EsKcs program

The EsKcs program

The Interdisciplinary Educational Chess at School in Lesson Time (EsKcs) program is an educational project implemented by the schools run by FEDAC, a group of 24 publicly funded private schools located in the Autonomous Community of Catalonia (Spain). The EsKcs program introduces chess as a complementary activity to regular classroom activities within school hours. Since 2013, the program has been gradually phased in at different educational levels at all FEDAC schools according to a pre-defined plan.

Far from producing expert chess players, the main objective of this program is to employ chess as a pedagogical tool to facilitate the learning process and develop a set of skills, abilities and values. Specifically, educational chess aims to foster critical thinking and mental skills by developing the capabilities of organization, forecasting, conjecturing, hypothesis formation, and decision-making. Additionally, educational chess also aspires to improve socio-affective skills, such as knowing how to lose, patience, respect for others, empathy, and personal improvement, stimulating attention and concentration, and increasing student motivation. In fact, educational chess is part of the family of educational innovations linked to the gamification of the learning process, which seeks to increase student motivation through games (Malvasi et al., 2022).

The contents of the chess program are structured differently based on the educational level. During primary education (ages 6 to 12), children move from intuitive and imaginary thinking to logical and rational thinking, and the contents and objectives of EsKcs are much more structured by courses. The contents focusing specifically on chess playing are clearly differentiated from the curricular or cross-curricular cognitive or non-cognitive competency objectives to be worked on. The general objectives of the EsKcs program at this level are to help students acquire the different skills listed in the curriculum; exercise different types of memory, and especially visual memory; accept their mistakes and learn positive lessons from them; identify causal relationships with reference to problem-solving models; accept the consequences of their decisions; learn to win and to lose; promote the integration of diverse classmates; or acquire the ability to solve problems and make decisions as a team.

The program is overseen by a coordination board, which, in the 2021–2022 academic year, was composed of seven teachers from different schools with previous experience developing the chess program training. Simultaneously, each school appointed a teacher as the person in charge of supervising the implementation of the EsKcs program. Teachers involved in implementing the program must receive 20 h of specific training from Chess in School program trainers. This course is funded by the Regional Government of Catalonia. During the 2021–2022 academic year, these courses were held during the months of October and November 2021. The twenty-hour

courses are divided into five two-hour online sessions and ten hours of independent work. To successfully complete the course, attendees must correctly complete a questionnaire at the end of the five online sessions.

In addition to physical boards and chess pieces, teachers participating in the EsKcs program have access, through a website (esckmat.cat), to a wide range of contents and activities that are adapted to the syllabus and classified by educational level and subjects or contents. This teaching material includes presentations, songs, videos, textbooks, online games and problems, head-to-head online chess games and research papers on the relationship between chess and academic performance. Students work on these materials using physical boards, digital blackboards, tablets and laptops. Teachers have also suggested activities for each session and are provided with assessment rubrics to facilitate the learning process.

The schools in this intervention were selected taking advantage of a pre-defined phase-in design. As already mentioned, the EsKcs program has been progressively introduced at different levels in the 24 different FEDAC schools since 2013. At the beginning of the 2021–2022 academic year, the program had been implemented at different levels in all FEDAC schools, save four that had never used educational chess. The two schools implementing the EsKcs program for the first time in 2021–2022 constituted the treatment group, whereas the remaining two schools (which were to implement the program in the following 2022–2023 academic year) became the control group.

Appendix B. quantitative and qualitative instruments

B.1. Instruments for the quantitative evaluation

Although the skills associated with learning and playing chess are extremely broad, this research analyzes a number of specific cognitive and non-cognitive skills. Within the category of cognitive skills, we selected critical thinking and attention, while we chose patience and risk aversion for non-cognitive skills. Besides, we analyzed whether participation in the educational chess program increased the students' level of chess knowledge, understood as the necessary intermediate output to achieve the above outcomes. As we mentioned, we focused on sixth-grade students (11- and 12-year-old students), because, according to [Anderson \(2002\)](#), attentional control domains develop during infancy and middle childhood reaching relative maturity by the age of 12 years.²

According to [Duplass and Ziedler \(2002\)](#), critical thinking is a process whereby reasoning, problem-solving and decision-making skills are applied in search of knowledge, enabling us to achieve the desired results most effectively. To assess this dimension, we previously adapted, tested and calibrated questions from different sources: (i) the Madrid (year 2017) and Canary Islands (academic year 2017–2018) Diagnostic Assessments; (ii) the 2019 Trends in International Mathematics and Science Study (TIMSS) program, and (iii) the Cornell Conditional-Reasoning Test ([Ennis et al., 1964](#)). In total, seven questions of similar difficulty were included in the baseline and endline questionnaires. Each question was assigned a score of 1 for correct answers and 0 otherwise. Therefore, the minimum and maximum score for the critical thinking indicator in both questionnaires is 0 and 7, respectively.

The second cognitive skill assessed was attention. Attention is a cognitive process whereby we focus on relevant stimuli, which are given priority over others that are not applicable. To measure students' attention, we employed a test inspired by the Groffman Visual Tracing Test ([Groffman, 1966](#)) and the Visual Pursuit Test ([Biehl, 2011](#)). Both tests are standardized methods for assessing an individual's attention and orientation in visual tasks ([Cui et al., 2017](#); [Deng & Wu, 2020](#); [Mikicin, 2021](#); [Facchin et al., 2022](#)). In this test, the student must select the appropriate path for letters. The main advantage of this test is that it measures attention directly, as it does not use possible distracters, such as words or language elements ([Facchin et al., 2020](#)). The attention indicator was assessed according to the responses to the 10 paths, assigning a score of 1 if the student selected the correct number and 0 otherwise. Additionally, this test allowed us to calculate a hits-per-second indicator as the ratio between the number of correct answers and the time taken. Therefore, we were able to measure decision-making efficiency, a skill also related to critical thinking.

To measure non-cognitive skills (patience and risk aversion), we adapted two of the experimental tests proposed in [Islam et al. \(2021\)](#). In these tests, the students were required to make several decisions, which allowed us to observe how well developed both their patience and their risk aversion are (for a discussion of the characteristics of the patience and risk aversion measures, see [Andersen et al., 2003](#); [Andersen et al., 2008](#); [Charness et al., 2013](#)). In order to make the decision-making process more realistic, we used a reward in the form of stickers to be used on smartphones and other electronic devices.

First, we administered the time preferences test to assess patience, defined as the ability to delay gratification. In this test, students had to make eight decisions, which involved choosing between immediate or time-delayed gratification (the reward increasing progressively). From this test, we obtained two indicators. On the one hand, the patience indicator, where a value of 0 was assigned if the decision was "before" and a value of 1 was assigned if the student selected "after" in each of the options. Thus, the minimum score of the variable is equal to 0 and corresponds to the least patient students and the maximum score is equal to 8 and corresponds to the most patient students. In parallel, we defined the time inconsistency indicator, which is a binary variable whose value is 1 if student responses were consistent throughout the decision-making process and 0 otherwise.

Secondly, risk aversion is measured using the risk preferences test. In this test, students had to choose between five available lottery options, each consisting of flipping a coin with two possible outcomes: heads or tails. The only difference was the reward that the student received in each lottery, where the reward increases in proportion to risk. In the first lottery, the risk is zero, as the reward is the same regardless of the result (heads or tails). The risk is put up in each lottery, increasing the reward for the heads result by 2 units and reducing the reward for the tails result by 1. Risk-loving students will choose the latter option, while risk-averse students will

² The selection of the age group was validated by a group of experts in the implementation of educational chess.

choose the former. The risk aversion indicator was approximated by assigning values from 1 to 5 to each lottery in descending order. A higher indicator value reflected a higher level of risk aversion.

Lastly, we evaluated whether program participation improved the students' level of chess knowledge. To assess this, three randomly selected exercises were included in the final questionnaire. The score was 1 if the answer was correct and 0 otherwise. Therefore, the values for the chess knowledge indicator ranged from 0 to 3.

To quantify the impact of the educational chess program on cognitive and non-cognitive skills, students and teachers participating at the four schools completed an online questionnaire before and after the program's implementation (baseline and endline, respectively).

We also carried out a qualitative evaluation to gather detailed information on the implementation of educational chess from the perspective of the participating teachers, pupils and the board promoting the program. Four different instruments were used for the qualitative evaluation. One instrument, composed of two teacher surveys completed at the end of the first and second term of the 2021–22 academic year, was applied during the intervention. The other three were administered once the intervention was completed. These included: monitoring surveys, a structured in-depth interview conducted with one of the program promoters and a focus group with participating pupils and teaching staff. The quarterly follow-up form, as well as the scripts for the in-depth interview and the focus group, are available in the following section. Additionally, satisfaction surveys for both teaching staff and students were included at the end of the endline questionnaires.

B.2 Instruments for the qualitative evaluation

Quarterly Follow-up Form

Teacher(s)/School:

Please indicate the number of sessions in the quarter:

What have you done in the educational chess sessions this quarter? (Specify content, activities, methodology, grouping...)

What was the reception from the students?

- Very good, the students liked educational chess.
- Good, most of the students liked educational chess, but there were some problems.
- Bad, most of the students did not like educational chess.
- Very bad, the students did not like educational chess and did not complete the proposed activities.

Please add any comments you would like to make about the students' reception of the project.

If you had difficulty with any student, what type of difficulty was it? How did you overcome the problem?

How would you rate student participation in the educational chess project?

- Very good, students participate in class.
- Good, most students participate in class, although some do not.
- Bad, most students do not participate in class, although some do.
- Very bad, none of the students participate.

Please add any comments you would like to make about student participation.

If you have students with special educational needs, have you noticed any differences in the participation of these students? If so, please specify.

What benefits do you perceive your students are getting from educational chess? Please check all that apply:

- Students are more motivated.
- Students participate more in class.
- Students improve their basic skills (mathematics, language...).
- Students improve their personal skills (self-awareness, emotional management, resilience, initiative, patience...).
- Students improve their social skills (communication, respect, empathy...).
- I have not observed any benefits for students.
- Others (Please specify): _____

Observations: Please specify any observations that you consider necessary or relevant for evaluating educational chess.

Script for In-depth Interview

Estimated time: 1 h - 1 hour and a half.

- Brief introduction of the group moderator, the research project, and the purpose of qualitative analysis: finding information not available in the quantitative data.
- Thank the participants.
- Ask permission to record (voice recorder) the session, explaining the importance and purpose of the recording for properly analyzing the gathered information. Clarify that the recording will not be shared with anyone other than the research team.
- Clarify that the information gathered during the session will be anonymized and will not be able to be traced to the respondent.

- Emphasize that there are no right or wrong answers: their responses will not be assessed for correctness and the aim is to get the educational chess experts' opinions and understand their reasoning.

QUESTION SCRIPT

Category 1: Sociodemographic Profile

- Name, age, education, and personal and professional career.

Category 2: Educational Chess Training

- What is your experience/level of knowledge of chess?
- How long have you been working in educational chess?
- How long have you been a trainer? At which levels (1, 2, and 3) have you provided training?
- Can any preschool, primary, or secondary education teacher receive training in educational chess?
- In your experience, is there a prototype of a successful educational chess teacher? (age, years of experience, liking for chess, etc.)
- In your opinion, is prior knowledge of how to play chess an advantage, disadvantage or neither for a teacher who is going to be trained in educational chess?
- Three levels and 20 h. Is the training sufficient (more or fewer hours)?
- What would be the best way to deliver educational chess training? Intensive, spaced over time, continuous training throughout the course...
- What are the main difficulties encountered in educational chess training?
- Do you think that educational chess training is beneficial for teachers themselves (organization of classes, having more patience themselves, etc.)?
- Do you know of other successful experiences of educational chess?
- Do you think there are areas for improvement? If so, what would you change?

Category 3: Educational Chess in the Classroom

Speaking of primary education (6th grade):

- In your opinion, what do you think are the main strengths of educational chess compared to other learning methodologies?
- In your opinion, what competencies do students participating in educational chess acquire?
- In general, do they enjoy it? Do they get bored?
- "Piece touched - piece moved" Do you think it can also improve other types of competencies (patience, respect, learning to win and lose, reasoning...)?
- If any, what are the main difficulties during an educational chess class?
- In your experience, if you could only choose a couple of grades in which to teach educational chess, which are the grades at which students can benefit most?
- Would you like to add anything else about the development of educational chess classes?

Category 4: The Future of Educational Chess

- Institutionally, socially, and educationally, what actions do you think can be taken to promote educational chess?
- Personally, do you think this program can be evaluated? Do you think it is difficult to evaluate? Do you think the evaluation will serve any purpose? If so, which?
- Do you think it was a good idea to carry out this evaluation project?
- Would you like to have tools to evaluate educational chess by yourself?
- Would you like to add any other comments?

Thank respondents for their time and emphasize the importance of the genuine feedback that they have given, which will be key to the research.

Focus group script

Estimated time: 1 h and a half.

- Brief introduction of the group moderator, the research project, and the purpose of qualitative analysis: finding information not available in the quantitative data.
- Thank the participants.
- Ask permission to record (voice recorder) the session, explaining the importance and purpose of the recording for properly analyzing the gathered information. Clarify that the recording will not be shared with anyone other than the research team.
- Clarify that the information gathered during the session will be anonymized and will not be able to be traced to the respondent.
- To facilitate information analysis, it is important to ask the group to respect their turn.
- Start the question rounds with the children, who are perhaps more likely to be influenced or conditioned by adult responses.
- Emphasize that there are no right or wrong answers: their responses will not be assessed for correctness and the aim is to get the educational chess experts' opinions and understand their reasoning.

QUESTION SCRIPT

Initial Category: Sociodemographic profile of participants

-Name, age, education, and personal and professional career (experience).

Category 1: Implementation, perceived advantages in students of working with educational chess, difficulties in class development

• Questions for students:

- Do you think you have improved by playing chess in class? How?
- Did you enjoy it?
- What did you like most and least about these classes?
- At what educational levels (early childhood, primary, secondary) did you participate in educational chess?
- In your opinion, what skills have you acquired through educational chess?
 - Teaching staff questions:
- At which educational levels (early childhood, primary, secondary) have you taught educational chess?

Speaking of primary education (6th grade)

- In your opinion, what skills have students acquired through educational chess?
- In general, do they enjoy it? Do they get bored?
- "Touched piece - moved piece" Do you think they can also improve other types of skills (patience, respect, learning to win and lose, reasoning...)?
- If any, what are the main difficulties during an educational chess class?
- In your experience, if you could only choose a couple of grades in which to teach educational chess, which are the grades in which students can benefit most?
- Would you like to add anything else about the development of educational chess classes?
- Now that the academic year has ended, what would you change?

Category 2: Teacher training in educational chess

- What was your previous experience with chess and with educational chess? Were you a chess enthusiast?
- What is your current training in educational chess?
- Do you think it is sufficient? Would you like to receive more training?
- Should there be continuous training (more materials, content, etc.) or is the preparatory training received sufficient?
- Do you think it is necessary for teachers to have a minimum knowledge of chess before teaching it in the classroom?
- Do you think that teachers themselves benefit from using educational chess in the classroom?
- Was there anything you missed in the training that you would like to include? Are the online format, contents, activities, and duration appropriate?
- Would you like to add anything else about educational chess?

Category 3: The future of educational chess

- At the institutional, social, and educational level, what actions do you think can be taken to promote educational chess?
- Personally, do you think this program can be evaluated? Do you think it is difficult to evaluate?
- Do you think it was a good idea that we conducted this evaluation project?
- Would you like to have tools to evaluate educational chess yourselves?
- Would you like to add any other comment?

Thank respondents for their time and emphasize the importance of the genuine feedback that they have given, which will be key to the research.

Appendix C: tables

Tables C1, C2, C3, C4

Table C1

. Response rate for the endline questionnaire compared to the baseline questionnaire.

Students participating in the experiment (September, 2021)	Baseline questionnaire responses (October, 2021)	Endline questionnaire responses (May, 2022)	Non-response rate for the endline questionnaire compared to the baseline questionnaire
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(continued on next page)

Table C1 (continued)

	Students participating in the experiment (September, 2021)	Baseline questionnaire responses (October, 2021)	Endline questionnaire responses (May, 2022)	Non-response rate for the endline questionnaire compared to the baseline questionnaire
Treatment group	109	105	97	7.6 %
Control group	101	99	97	2.0 %
Total sample	210	204	194	4.9 %

Table C2

. Descriptive statistics of student outcomes at baseline.

Variable	Treatment	Valid	Mean	Stand. Error	SD	[95 % CI]	
Critical thinking	Control	99	3.970	0.154	1.528	3.665	4.275
	Treated	105	3.904	0.177	1.816	3.553	4.256
Patience	Control	83	4.976	0.160	1.456	4.658	5.294
	Treated	84	5.095	0.180	1.647	4.738	5.453
Time inconsistency	Control	95	0.484	0.052	0.502	0.382	0.587
	Treated	97	0.464	0.051	0.501	0.363	0.565
Risk aversion	Control	99	3.141	0.143	1.421	2.858	3.425
	Treated	104	3.413	0.152	1.549	3.112	3.715
Attention	Control	95	8.284	0.157	1.534	7.972	8.597
	Treated	100	8.050	0.186	1.861	7.681	8.419
Hits per second	Control	95	0.036	0.002	0.016	0.032	0.039
	Treated	100	0.038	0.002	0.016	0.035	0.041

Table C3

. Descriptive statistics of students' control variables at baseline.

Variable	Treatment	Valid	Mean	Stand. Error	SD	[95 % CI]	
Gender	Control	99	0.495	0.051	0.503	0.395	0.595
	Treated	105	0.552	0.049	0.500	0.456	0.649
Age	Control	99	11.03	0.022	0.224	10.986	11.075
	Treated	105	11.01	0.010	0.098	10.991	11.028
Immigrant status	Control	99	0.071	0.026	0.258	0.019	0.122
	Treated	105	0.048	0.021	0.214	0.006	0.089
< 25 books at home	Control	99	0.253	0.044	0.437	0.165	0.340
	Treated	105	0.229	0.041	0.422	0.147	0.310
Between 25 and 100 books at home	Control	99	0.333	0.048	0.474	0.239	0.428
	Treated	105	0.419	0.048	0.496	0.323	0.515
Between 100 and 200 books at home	Control	99	0.263	0.044	0.442	0.174	0.351
	Treated	105	0.219	0.041	0.416	0.139	0.299
> 200 books at home	Control	99	0.152	0.036	0.360	0.080	0.223
	Treated	105	0.133	0.033	0.342	0.067	0.199
Chess playing	Control	88	0.830	0.040	0.378	0.749	0.910
	Treated	98	0.898	0.031	0.304	0.837	0.959

Table C4

. Response rate to the question "Do you know how to play chess?".

	Yes	No	Total	Mean*	Standard deviation*	% of "Yes" over the total
Treated group	92	2	94	1.695	1.080	97.9 %
Control group	42	52	94	1.167	1.024	44.7 %

* The mean and the standard deviation in the control group is for students who stated that they did know how to play chess.

Data availability

Data will be made available on request.

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