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INTEGRATION OF THE SCIENTIFIC METHOD IN CHESS TEACHING**

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Abstract

The article evaluated the incorporation of the scientific method in educational chess videos on Lichess, identifying the application of fundamental principles such as observation, hypothesis formulation, experimentation, and analysis. The study highlighted the diversity of educational content, addressing various interests and skill levels within the chess community and balancing theory and practice to promote cognitive and strategic development. It analyzed how integrating the scientific method could revolutionize chess learning, improving specific game skills and analytical competencies transferable to other areas. The analysis of educational videos focused on active experimentation and meticulous analysis of games, especially from elite players. The software was used for transcription and data analysis tools to identify effective pedagogical patterns. Applying the scientific method in chess videos promoted significant cognitive development, emphasizing experimentation and critical analysis. The diversity of content reflected a comprehensive and effective educational ecosystem. Future research should explore the deeper integration of the scientific method in chess teaching, evaluate the effectiveness of these approaches, and adapt them to other disciplines. The importance of rigorous and accessible educational methods was emphasized to enhance techniques and strategies in chess, establishing a standard applicable to various fields.

Keywords: *chess teaching, scientific method, pedagogical strategies, educational technology, cognitive skills development, problem-solving in chess, educational videos, lichens platform, analytical competencies, game-based learning.*

INTRODUCTION

Studies validate chess for promoting cognitive and strategic skills, highlighting benefits such as improved memory, concentration, and creativity (Trinchero & Sala, 2016; Sala, Foley, & Gobet, 2017). Various traditional approaches exist in chess teaching, including the highly analytical

methodology of masters like Dvoretsky (2013). Dvoretsky's work, which resembles the scientific method in its rigorous and systematic approach, is complemented by the perspective of de Bruin, Kok, Leppink, and Camp (2014). These authors assert that the systematic implementation of evidence-based instructional strategies can significantly optimize learning outcomes. Additionally, Opheusden et al. (2023) discuss how expertise in complex games like chess increases the depth of planning and strategic decision-making. Applying this principle to chess teaching can enhance both students' cognitive skills and game strategies.

The effectiveness of chess teaching lies in the application of the scientific method, which uses rigorous principles to guide empirical exploration through observation, hypothesis formulation, controlled experimentation, and critical analysis. In this context, the hypothesis is that the systematic incorporation of the scientific method principles in educational chess videos on the Lichess platform significantly improves players' ability to develop cognitive skills and game strategies. This hypothesis directs the research to evaluate whether the structured use of the scientific method in the videos results in measurable improvements in players' skills, providing a clear focus for the study and helping to guide the methodology and data analysis.

Based on the established contextual relevance, this article aims to evaluate the chess teaching methods in educational videos on Lichess in light of the Scientific Method (SM) principles. The focus is to understand how these videos reflect the stages of the SM, from introducing fundamentals to novices to promoting strategic analysis and questioning in advanced players. The objective is to highlight pedagogical practices that, in addition to improving chess skills, encourage the development of critical thinking, problem-solving, and learning autonomy (Mefoh & Ugwu, 2013; Postoni & Vandenkieboom, 2019).

The analysis focuses on the practice of the SM applied to chess teaching, aiming to identify and evaluate innovative pedagogical strategies in Lichess videos. These strategies should reflect the principles of the SM, seeking to improve pedagogical effectiveness. The investigation of observation, hypotheses, experimentation, and analysis in chess aims to elevate players' performance and foster critical skills such as analysis and problem-solving. By emphasizing a reflective and investigative approach to chess challenges, the aim is to enrich its pedagogy and propose an educational model replicable in other areas. Combining scientific rigour with playful engagement, it is intended for educators, coaches, and content developers, promoting a harmonization between theory and practice, meticulous investigation, and creativity.

Chess Teaching

Chess education has evolved significantly and has been shaped by cognitive psychology and educational methods. This section discusses effective pedagogical practices that unite educational theories with the practice of chess. Academics recognize chess as a complex tool for enhancing decision-making. It challenges the intellect and fosters the development of essential skills such as strategic analysis, future planning, and problem-solving. Szczepanska and Kazmierczak (2022) demonstrate how chess improves decision-making, suggesting benefits beyond the game.

Decision-making in chess, involving analysis, anticipation, and evaluation of risks and benefits, is crucial for game mastery. This aspect has been studied by notable researchers like Gobet and Simon (1996a; 1996b) and De Groot and Gobet (1996), who developed cognitive models detailing information processing, pattern recognition, and working memory use by chess players. Gigerenzer (2023) highlights the effectiveness of algorithms based on simple heuristics for decision-making in uncertain environments, suggesting that such approaches can be equally applicable in developing chess teaching strategies, where quick adaptation and decision-making under pressure are essential.

Martinez Solis and Valdés (2021) describe chess as an intricate problem-solving activity, highlighting the crucial role of meticulous board evaluation. According to them, decision-making in this game transcends simple logical analysis and encompasses emotional management. This underscores the challenge of harmonizing cognitive abilities and mental resilience.

Kasparov (2007), a former world champion, and Gelfand (2016), renowned chess players, emphasize meticulous analysis and strategic move selection as fundamental. They demonstrate how experience and pattern recognition shape game decisions, enriching academic research with their practices. Such integration of theory and experience provides a broad and detailed understanding of decision-making in chess. Grève (2023) highlights the relevance of intuition in decision-making skills in chess, emphasizing that developing this intuitive competence is crucial for performance at advanced competition levels, where quick and precise decisions are often necessary under time pressure.

Plaat, Kosters, and Preuss (2021) and Krakowski, Luger, and Raisch (2022) investigate the use of emerging technologies, especially artificial intelligence, in chess strategic analysis. They emphasize the potential of these technologies to significantly improve players' forecasting and strategic planning skills.

Combining practice and theory in chess is essential for developing advanced skills. Strategies that unite cognitive psychology, experience, and technology improve the strategic evolution of players. According to a detailed analysis by Chowdhary, Iacopini, and Battiston (2023), diversification and specialization in chess openings are critical factors influencing chess players' careers, highlighting the importance of adaptive strategies throughout a chess player's development. Thus, the theoretical basis of chess, highlighting its complexity and history, underscores the importance of educational methods that promote technical, cognitive, and emotional development.

The Scientific Method

The Scientific Method (SM), essential for research and education, offers a methodical approach to discovering and validating knowledge, applicable in areas like chess that demand critical analysis and evidence-based decisions (Lakatos & Marconi, 2003).

Observation, fundamental in the SM, requires meticulous data collection and pattern analysis to identify areas of investigation. This practice is evident in chess when players and coaches review previous games, identifying both effective strategies and failures (Gobet & Sala, 2023). This process is vital in formulating hypotheses about aspects of the game, such as the viability of specific openings or optimal responses to opponents' moves.

After observation, the hypothesis formulation stage occurs, where theories or solutions are proposed for the identified patterns and challenges. In chess, this may mean postulating that a specific opening results in a strategically superior position or that a particular move increases the likelihood of success (Dvoretsky, 2003). Chess players test such conjectures through practical experimentation.

Experimentation, essential in the SM, tests hypotheses under defined conditions. In chess, it manifests when players implement innovative strategies during games, adjust their tactics according to established hypotheses, and analyze the outcomes (Botvinnik, 1942). This phase is crucial for verifying the accuracy of hypotheses through tangible evidence collected during the game.

The concluding phase of the SM requires a detailed analysis of the data obtained during experimentation to verify conformity or divergence with the proposed hypothesis. In the chess universe, this process may involve a careful review of games where new strategies were applied, aiming to measure the success of these approaches (Gelfand, 2015). This evaluation guides players and coaches in choosing, refining, or discarding strategies, thus fostering a continuous process of

evolution and adjustment.

Prodanov and Freitas (2013) point out that the relevance of the SM in research and education is evidenced by its effectiveness in teaching chess, establishing a foundation for strategic investigation and continuous performance improvement. Besides enhancing learning, this method prepares players to face complexities in chess and beyond, cultivating crucial skills such as critical thinking, problem-solving, and evidence-based decision-making. Cowley and Byrne (2004), Szczepanska and Kazmierczak (2022), and Hélie and Pizlo (2021) highlight these skills.

METHODS AND METHODOLOGY

This research developed a methodology to improve chess teaching by analyzing educational videos on the Lichess platform, with 1536 videos, of which 150 were thoroughly analyzed. Data saturation was achieved with this analysis, a concept investigated by Guest, Bunce, and Johnson (2006), who demonstrated that saturation can be reached after a relatively small number of interviews. Similarly, the analysis revealed a saturation pattern, indicating that the analyses were sufficient to understand how the Scientific Method (SM) is incorporated into chess teaching, confirming the robustness of the sample according to guidelines on the importance of saturation to ensure the quality of qualitative research.

The selection of videos focused on those with diverse and effective pedagogical approaches, highlighting the importance of choosing high-quality materials, as Gobet and Sala (2023) discussed. To ensure a detailed qualitative analysis, the YTScribe software was used to transcribe the content of the educational videos. The transcriptions were carefully archived in documents, allowing methodical organization and individualized analysis. This process facilitated the precise identification of SM principles applied in chess teaching, subsequently allowing the creation of clear graphs that illustrate the data and highlight effective pedagogical patterns identified during the research. The videos analyzed in this study, available on the Lichess platform, were used with the authors' permission or under licenses that allow such use. Additionally, we ensured that the names and specific details of the content creators are not directly cited in this article, thus respecting the intellectual property and privacy of those involved.

Excel was used to initially organize data collected from YouTube, and later, Google Colab was employed to perform more complex data analyses. Google Colab, a cloud-based notebook platform that supports Python code execution, was chosen for its ability to process large datasets

and its ease of integration with data science libraries such as Pandas and Matplotlib. These tools were essential for conducting detailed statistical analyses and generating interactive visualizations that explore engagement patterns and pedagogical effectiveness in videos collected from YouTube and released to Lichess (2024). This empirical analysis process was crucial to validate the pedagogical methods, providing quantitative data that reflect viewers' satisfaction and engagement to reinforce empirical evidence in educational research. Thus, it was possible not only to understand the acceptance and effectiveness of teaching strategies but also to reinforce the validity and reliability of the conclusions.

Additionally, the Iramuteq software was used for qualitative data analysis, categorizing and visualizing the thematic structures present in the transcribed videos. This software facilitated the identification of key concepts and relationships within the data, enhancing the depth of analysis and ensuring a systematic approach to understanding how scientific principles are applied in chess teaching.

Excel was also used for rigorous quantitative analysis, organizing videos by themes and quantifying the presence of SM elements. This analysis was crucial to identify educational patterns and trends. Additionally, teaching strategies from the videos were tested in real games, and feedback was collected from players for evaluation and adjustment, a practice recommended by de Bruin et al. (2014) and Dvoretsky (2013). This process validated the identified strategies and contributed to the development of more effective online teaching practices. The integration of player feedback emphasizes the importance of a practical and evaluative approach, which is essential for pedagogical improvement and cultivating a deeper understanding of chess through the SM.

RESULTS

The analysis of 150 educational chess videos on the Lichess platform, conducted between 2016 and 2024, revealed valuable information about the pedagogical strategies' popularity, engagement, and effectiveness. This section details the results obtained through quantitative and qualitative analyses, including evaluations of likes, views, comments, and the frequency of specific terms related to the Scientific Method (SM). The absence of dislikes in the analyzed videos suggests that the content is predominantly sought after by individuals already interested and engaged in learning chess, which may indicate a pre-selection of the audience accessing these materials. These

indicators were correlated with the perceived effectiveness of the videos, allowing for a rigorous evaluation of how different pedagogical approaches impact chess learning.

The thematic selection of the videos reflects the priorities of the chess community. Focusing on openings and learning from masters indicates an effort towards comprehensive and detailed teaching to develop skills. The diversity of content evidences a commitment to educational inclusion and quality. The emphasis on feedback and iterative learning, practices highlighted by de Bruin et al. (2014) as crucial for effective pedagogy, mirrors the application of the SM in improving chess teaching.

Investigating the dichotomy between "Quantity versus Depth," the volume of videos per theme highlights the priority areas for the chess community, indicating the main interests and educational directions.

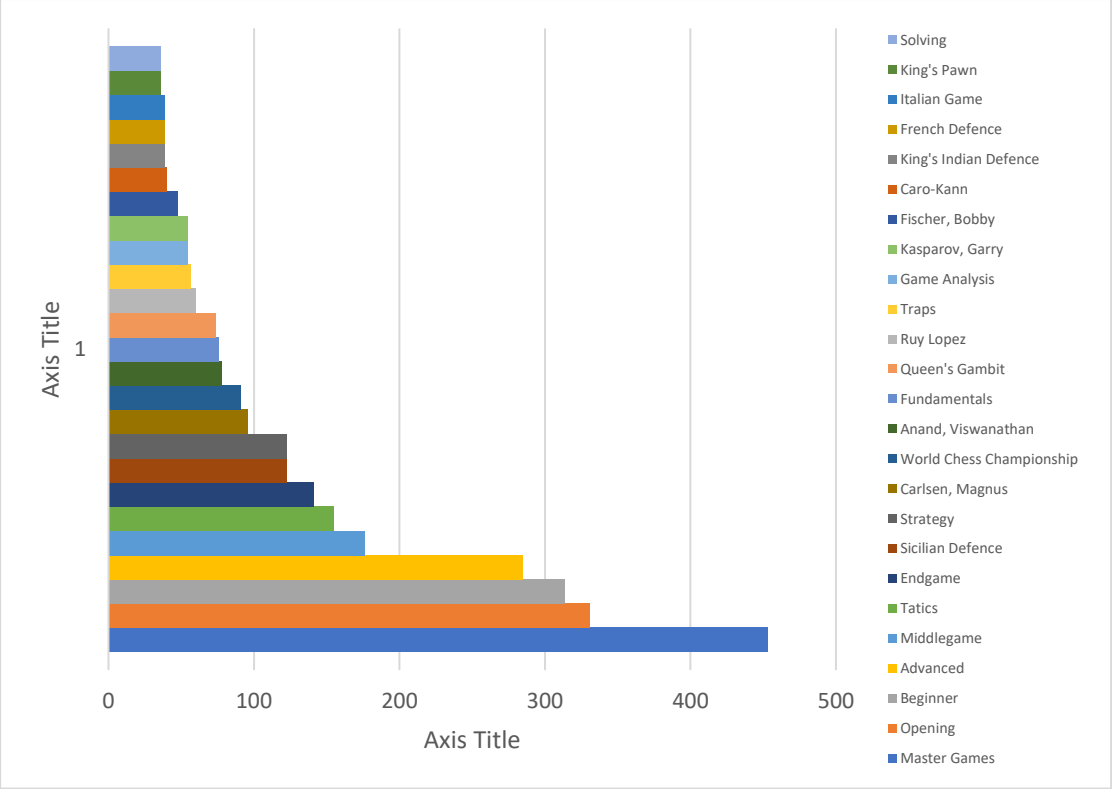

Diagram 1. Quantity by Themes in the Videos

Investigating the dichotomy between "Quantity versus Depth," the number of videos per theme highlights the priority areas for the chess community, indicating the main interests and educational directions. Diagram 1, which shows the number of videos by theme, illustrates this

analysis.

The predominance of videos on openings, with 546 videos, including specific defences such as the Sicilian (165) and the Ruy Lopez (91), highlights the importance attributed to the initial stages of chess, reflecting a focus on specialization and in-depth understanding of strategies. This trend, which favours the study of openings and learning from grandmasters, is corroborated by Sala, Foley, and Gobet's (2017) findings on teaching effectiveness based on high-level examples to develop cognitive and strategic capacities in chess.

The attention given to games of masters and iconic players such as Carlsen (98) and Kasparov (55) emphasizes the importance of learning through examples, reflecting an educational trend that values emulation of models of excellence and learning from the experience of the best in the field. Additionally, the distribution of videos across skill levels, with 414 for beginners and 256 for advanced players, suggests a solid inclination to welcome and educate new players, aiming to expand and make the chess community accessible to a broader audience.

Videos focused on the middle game (176), tactics (162), and endgames (136) are less numerous but still significant, indicating the recognition of the complexity and importance of these phases of the game. The focus on strategy and fundamentals, with 124 and 104 videos, respectively, is crucial for developing a deep understanding of the game, underscoring the need for a solid foundation in critical principles that can be applied in various game contexts. This thematic selection of videos reveals trends in the chess community, mainly the focus on openings, demonstrating the importance given to the initial stages of the game.

Active experimentation and hypothesis formulation are central in videos about openings and strategies. Instructors deeply discuss strategies using methods similar to scientific experimentation. This approach, evidenced in the analysis of the "Sicilian Defense," aligns with Dvoretsky's (2013) recommendations, highlighting the importance of analysis and hypothesis-based reasoning in learning chess.

The analysis of games highlights detailed observation and analysis, treating each game as a scientific experiment. Videos offer practical tips for applying strategies and theories, reinforcing the importance of feedback and iterative learning, and are aligned with Gobet and Sala (2023), who value the scientific approach in enriching chess teaching and strategic development.

The rigorous and systematic approach to the study and practice of chess reflected in these videos resembles scientific research. It is demonstrated that chess, like science, benefits from a

methodical and analytical approach.

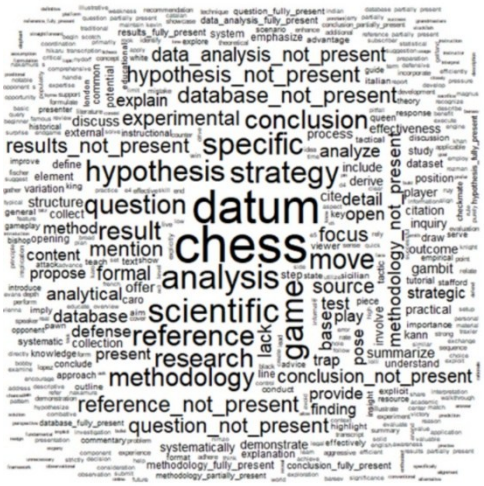

Diagram 2. Word Cloud Analysis of Scientific Method Terms in Educational Chess Videos Using Iramuteq

The word cloud illustrates the frequency of terms related to the Scientific Method (SM) in the analyzed educational chess videos. The predominance of words such as "hypotheses," "analysis," and "experimentation" evidences that although the videos do not formally follow all stages of the scientific method, many of its principles are present. This suggests that instructors use critical evaluation and analysis methods to teach chess, promoting a deep and systematic understanding of the game.

A similarity analysis was conducted to visually illustrate how SM principles are integrated into chess pedagogical practices. This qualitative analysis technique allows for mapping and visualizing the relationships between key concepts mentioned in the educational videos. Through this method, it is possible to identify patterns and connections that are not immediately obvious, offering a deeper perspective on how instructors apply scientific theories to enhance strategic chess teaching. The following Diagram presents a similarity graph that highlights these connections, demonstrating the interaction between observation, analysis, and experimentation in the studied content.

Diagram 3. Similarity Analysis of Key Scientific Method Concepts in Educational Chess Videos Using Iramuteq

The similarity analysis highlights the connections between key Scientific Method (SM) concepts and the content of educational chess videos. Although most videos do not formally follow all stages of the SM, they integrate essential components such as detailed observation and critical analysis. This approach emphasizes the importance of analytical techniques in chess teaching, using continuous evaluation and experimentation to enhance players' strategic understanding. Such methods engage students more effectively and foster more profound and more reflective learning.

The results highlight not only the chess community's acceptance of these educational materials but also how they encourage critical and in-depth thinking, reflecting the teaching practices that resonate most with viewers.

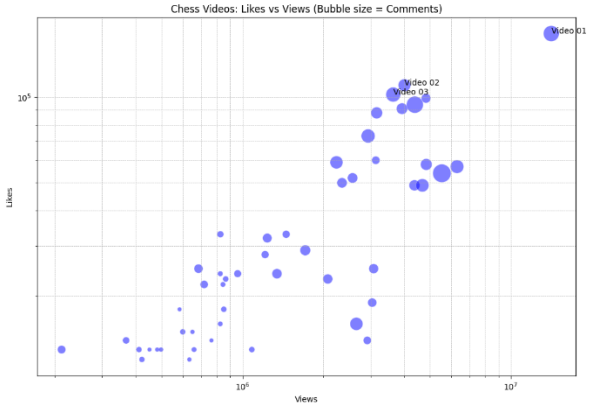

Diagram 4 - Bubble Scatter Plot showing likes, views, and interaction intensity (comments) using Google Colab

The analysis of videos in terms of likes, views, and positive comments provided a strong indication of the videos' popularity and acceptance among the audience. Videos with a high number of likes and views, such as "Video 01" and "Video 02," suggest that these materials are considered valid and effective by viewers. Additionally, the number of comments can indicate the level of viewer engagement, with frequent and detailed comments suggesting that the videos are stimulating discussions and reflections, promoting an active and collaborative learning environment.

The analysis of bubble scatter plots visually represents the relationship between likes, views, and comments, with videos showing large bubbles (indicating many comments) suggesting a higher level of interaction and engagement. This positive relationship between likes and views indicates that the videos are well-received by a large audience, reinforcing the effectiveness of the pedagogical approaches used. The qualitative analysis of the comments highlights popular and effective themes, such as videos that teach well-known openings, which receive praise for the clarity and usefulness of the explanations. These themes are particularly valued by viewers, indicating that focusing on clear strategies can be an effective pedagogical practice.

The comments also reveal that the videos are encouraging critical thinking among viewers. Detailed discussions about strategies, tactics, and personal experiences indicate that viewers are critically applying the lessons learned in their own games. Comments mentioning improvements in ELO or success in tournaments suggest that viewers are internalizing and effectively applying the information.

Video Group	Average Likes	Average Views	Average Comments	Highlighted Opinions
1-10	106k	4,342,275	2,259	Clarity, usefulness, personal experiences, cultural references, motivation, ELO improvements.
11-20	37k	2,734,527	1,583	Clarity, usefulness, effectiveness over time, humor, learning success, cultural references.
21-30	22k	1,259,312	972	Clarity, usefulness, learning success, ELO improvements, detailed and careful approach.
31-40	16k	1,548,362	627	Clarity, practical usefulness, learning success, engaging and educational style.
41-50	13k	1,230,073	583	Clarity, practical usefulness, inspiration, motivation, game improvements, scientific approach.

Table 1. Summary of Comments, Likes, and Views of Educational Chess Videos on Lichess

The summarized table presents an analysis of educational chess videos on Lichess, highlighting the application of the principles of the Scientific Method (SM) and audience receptivity. The data, grouped in sets of 10 videos each, provide a clear view of how viewers value clarity, usefulness, and practical application.

In the video group 1-10, the high numbers of likes (106k), views (4,342,275), and comments (2,259) indicate strong acceptance and engagement, especially in content that addresses openings, strategies, and personal experiences. This group reflects the effectiveness of clear explanations and the topics' relevance, aligning with the hypothesis that well-structured videos promote significant learning.

The video group 11-20 maintains a good level of engagement, with averages of 37k likes, 2,734,527 views, and 1,583 comments. The comments highlight effectiveness over time, humour, and success in learning, reinforcing that integrating the SM contributes to robust cognitive and strategic development.

Despite showing lower numbers compared to the first groups, the video groups 21-30, 31-40, and 41-50 continue to demonstrate a significant positive impact. The average likes range from 13k to 22k, with views between 1,230,073 and 1,548,362 and average comments from 583 to 972. These groups emphasize clarity, practical usefulness, and a detailed approach, confirming that the chess community values the systematic application of SM in chess teaching.

G	Avg L	Avg V	Avg C	σL	σV	CVL	CVV	ρ(L,V)
1-10	106k	4,342,275	2,259	30.4k	3,597,644	28.7%	82.8%	0.85
11-20	37k	2,734,527	1,583	17.2k	1,647,913	46.5%	60.3%	0.72
21-30	22k	1,259,312	972	4.8k	464,712	21.8%	36.9%	0.68
31-40	16k	1,548,362	627	1.7k	834,521	10.6%	53.9%	0.75
41-50	13k	1,230,073	583	1.2k	392,471	9.2%	31.9%	0.79

Table 2. Descriptive Statistics and Correlations of Educational Chess Videos on Lichess

Legend:

G: Video Group

Avg L: Average Likes

Avg V: Average Views

Avg C: Average Comments

σL: Standard Deviation of Likes

σV: Standard Deviation of Views

CVL: Coefficient of Variation of Likes

CVV: Coefficient of Variation of Views

ρ(L, V): Correlation between Likes and Views

The table presents a detailed analysis of educational chess videos on Lichess, divided into groups of 10 videos each. The data include averages, standard deviations, coefficients of variation, and correlations between likes and views.

The high average number of likes and views in Groups 1-10 indicates significant popularity and engagement. The high correlation (0.85) between likes and views suggests a strong positive relationship, where more viewed videos tend to receive more likes.

The averages for Group 11-20 are lower than those for Group 1-10, but engagement remains substantial. The positive correlation (0.72) indicates that videos with more views continue to receive more likes.

The averages decrease in Groups 21-30, indicating lower popularity. The correlation (0.68) shows that the relationship between views and likes is still positive, although less intense.

The averages in Groups 31-40 are lower, but the high correlation (0.75) indicates a consistent positive relationship between views and likes. The lower variability in likes suggests more uniform interactions from viewers.

Despite the lower averages in Groups 41-50, the high correlation (0.79) reinforces the positive relationship between views and likes. The low variability in likes indicates consistent interactions from viewers.

Statistical calculations reveal that educational chess videos on Lichess that utilize SM principles are popular and well-received. The strong correlation between views and likes suggests that well-viewed videos are generally more appreciated. The analysis of variability and averages demonstrates that clear, functional, and well-structured videos attract a larger and more engaged audience. These results indicate the effectiveness of rigorous educational methodologies and suggest that such approaches can be adapted and applied to other disciplines to promote effective and engaging learning.

DISCUSSION

The thematic selection of the videos indicates a strong emphasis on openings, such as the Sicilian and Ruy Lopez, reflecting the importance of establishing a solid foundation in the initial stages of the game. This shows an educational trend to focus on the initial development of players' strategic skills, a practice supported by the results highlighting the prevalence of videos on openings. Findings by Chowdhary et al. (2023) corroborate the observations on the importance of openings in player learning and development, suggesting that specialization in specific openings can lead to significant performance improvements, as periods of success (hot streaks) are often preceded by a focused application of well-defined strategies. Developing intuitive skills, as evidenced by chess grandmasters, requires dedicated training beyond regular practice, involving conscious efforts to enhance intuitive play using time-controlled exercises (Grève, 2023).

Diagram 1 clearly illustrates the predominance and value attributed to the initial stages of the chess game, especially in educational approaches to specific openings. With 546 videos focused on openings, highlighting the Sicilian Defense with 165 videos and the Ruy Lopez with 91 videos, a significant pedagogical inclination is evident to teach solid foundations from the beginning of the game. This pedagogical strategy, which prioritizes a deep understanding of the initial phases, is crucial for subsequent success in matches, equipping players with analytical and strategic skills applicable in various game situations.

As illustrated in the graph, this focus on openings underlines the educational goal of developing players who deeply understand chess and are well-prepared for competitions, enhancing their strategic decision-making abilities from the outset. In their analysis of expertise in complex games, Opheusden et al. (2023) demonstrate that higher levels of expertise correlate with greater planning depth in-game scenarios. This finding supports the discussion on pedagogical approaches in chess videos, where deep planning and anticipation of future scenarios are crucial skills for advanced players. Using computational models to validate planning depth offers a rigorous methodological framework that can be referenced to underline the scientific rigour in chess training.

Videos aimed at beginners are common, indicating a conscious effort to welcome and instruct new chess enthusiasts. This reflects a desire to expand the chess community and make the game accessible to a broader audience, highlighting the importance of providing educational resources that are understandable and engaging for all skill levels.

The wide range of videos aimed at beginners emphasizes a deliberate effort by the chess

community to welcome and educate new players. This effort reflects an inclusive pedagogical approach and highlights the importance of making chess accessible to everyone. The graphical analysis of the distribution of videos by skill level shows a predominance of resources for beginners, facilitating initial engagement with the game and contributing to the expansion of the player base.

This approach aligns with best practices in education, where accessibility and inclusion are fundamental to developing a learning community. By providing content that is both introductory and engaging, chess educators demonstrate a commitment to developing players who, although initially inexperienced, have the potential to develop complex skills as they advance. This helps cultivate a new generation of chess enthusiasts and contributes to greater diversity within the global chess community.

The videos demonstrate how the integration of the SM transforms chess teaching. Observation, experimentation, and rigorous analysis promote a deep understanding of the game and develop problem-solving skills, demonstrating that chess, like science, greatly benefits from a systematic and methodical approach.

Each topic discusses the results' implications in detail, connecting the collected data with effective pedagogical practices and contemporary educational theories. This structure helps emphasize how different aspects of educational chess videos contribute to effective and inclusive teaching while highlighting the research's practical utility for the chess community.

The application of the SM in chess teaching, as revealed by the analysis of educational videos, suggests an implicit rather than explicit approach to the scientific process. Diagram 2, a word cloud generated from the video transcripts, illustrates that while terms such as "hypotheses," "analysis," and "experimentation" frequently appear, there is no formal sequence of the SM. This indicates that while scientific principles are utilized, they are not necessarily applied systematically or recognized by instructors as part of a structured SM.

This observation is crucial to understanding how chess teaching can be improved. Although instructors employ essential techniques for scientific investigation, such as experimentation and critical analysis, the lack of explicit recognition of these approaches as part of a scientific process may suggest a missed opportunity. This could further deepen critical and methodological thinking among chess students.

Therefore, the discussion about transforming chess teaching through the SM should

acknowledge existing practices and consider how a more deliberate and recognized implementation could further enrich the educational experience. This would include explicitly introducing scientific steps, encouraging players to identify their hypotheses before testing them in matches, observing and documenting results in a more structured manner, and using these observations to refine theories and practices. Such an approach improves game ability and develops analytical and problem-solving skills transferable to many other fields and real-life situations.

The analysis revealed a notable focus on learning through games of masters and iconic players, such as Magnus Carlsen and Garry Kasparov. This underscores a valuation of learning through examples of excellence, a practice that inspires and guides players in applying complex and advanced strategies.

The similitude analysis in Diagram 3 revealed how crucial SM concepts are incorporated into chess pedagogy, deepening the understanding of the teaching methods employed in chess videos. The graphical representation of this analysis allows for visualization of the interrelationship between observation, analysis, and experimentation, highlighting the robustness of the educational approach adopted. This systematic and analytical focus, mirroring scientific processes, reflects a commitment to deep and strategic learning characterized by continuous evaluation and practical application of theories in real-game contexts.

This approach enriches the educational experience by providing students with tools for a more critical and in-depth understanding of chess strategies. It also highlights the effectiveness of integrating scientific research methods into pedagogical content development. By applying these methods, instructors can foster a learning environment that encourages the acquisition of knowledge and the development of critical thinking and problem-solving skills.

The analysis of the matches in the videos is treated as a scientific experiment, where each game is an opportunity to observe, analyze, and test strategies. This focus not only underscores the application of the SM in chess teaching but also encourages an analytical and critical approach, which is fundamental for the continuous development of chess skills. Gigerenzer (2023) emphasizes the importance of algorithms informed by human psychology, which could inspire chess teaching methods that mimic the brain's natural decision-making process, thus facilitating intuitive and strategic learning for players.

The "Similitude Analysis" graph plays a crucial role in highlighting how the concepts of the SM are integrated into chess teaching, emphasizing the adoption of a methodology that encourages

both critical analysis and experimentation in-game strategies. Through this graph, it is possible to visualize the connections between different educational concepts, such as detailed observation, critical analysis, and hypothesis testing, which are fundamental in chess education. This approach demonstrates the practical application of the SM as a pedagogical tool in chess and emphasizes the importance of an analytical and systematic approach. Thus, the analysis of the videos through this graph shows how instructors encourage players to develop critical thinking and problem-solving skills, which are essential for advancement in the game.

Feedback and iterative learning are emphasized, aligning with modern pedagogical practices that value continuous review and improvement. This feedback cycle after each game helps players evaluate and adjust their strategies, promoting more profound and more effective learning.

The analysis of 'likes' and comments on the chess videos, represented in Diagram 4, reveals a continuous feedback cycle vital for players' constant improvement. These data, illustrated in the "Engagement and Feedback" graph, show a positive correlation between the number of 'likes' and comments, indicating that well-received videos tend to generate more discussions. This phenomenon suggests that the videos capture viewers' interest and stimulate them to participate actively, asking questions, sharing experiences, and suggesting improvements. This interaction is fundamental for iterative learning, as it allows instructors to better understand the needs of students and refine their teaching methods. Continuous user feedback, therefore, not only validates the presented content but also promotes a collaborative and adaptive learning environment, which is essential for developing strategic skills in chess.

The results presented in Table 1 and Table 2 reveal deep insights into the effectiveness and impact of the educational chess videos on Lichess, especially in the context of the application of the SM. The statistical analysis of the data, grouped in averages, standard deviations, coefficients of variation, and correlations, illuminates the relationship between the quality of educational content and viewer engagement.

In the group of videos 1-10, the high average likes (106k) and views (4,342,275) indicate strong acceptance and popularity of this content. The high correlation (0.85) between likes and views suggests that more viewed videos are generally more appreciated, indicating that the audience values the clarity and utility of the videos. The high variability in views (CV of 82.8%) indicates that while some videos are viral, others may not reach the same level of engagement, reflecting the diversity of interests within the target audience.

The group of videos 11-20, although with lower average likes and views than the previous group, maintains significant engagement. The positive correlation (0.72) still suggests that videos with more views tend to receive more likes, indicating consistency in content appreciation. The lower variability in views (CV of 60.3%) compared to groups 1-10 may indicate that this group's audience is more homogeneous in terms of their preferences and interactions with the content.

For groups 21-30 and 31-40, the trend of decreasing average likes and views is accompanied by still significant correlations (0.68 and 0.75, respectively). This suggests that although the overall popularity of these videos is lower, the relationship between views and content appreciation remains robust. The lower variability in likes in groups 31-40 (CV of 10.6%) points to a viewer base that interacts more uniformly with the content, which may indicate a dedicated and loyal audience.

The group 41-50, despite showing the lowest averages of likes and views, presents a high correlation (0.79) between these metrics. The low variability in likes (CV of 9.2%) suggests that even with fewer viewers, those who interact with the videos consistently value the quality of the content. These results underscore the importance of a pedagogical approach that incorporates the principles of the SM. The high correlation between views and likes in all groups suggests that viewers appreciate clear, practical, and well-structured videos. The variability observed in views and likes, especially in the more popular groups, highlights the need to continue exploring and refining pedagogical approaches to maximize educational impact.

These findings show that integrating SM into chess teaching enhances engagement and promotes more profound and meaningful learning. Instructors can benefit from explicitly applying scientific steps such as hypothesis formulation, experimentation, and critical analysis to enrich video content (Dvoretsky, 2013; de Bruin, Kok, Leppink, & Camp, 2014; Gobet & Sala, 2023). Moreover, adapting these methodologies to other disciplines can open new possibilities for developing more effective and engaging educational strategies, expanding the positive impact of the SM in contemporary education.

The discussion highlights that continuing to investigate and validate these methodologies can provide additional insights on how to optimize teaching and promote the development of analytical and critical skills not only in chess but in various fields of knowledge (Trinchero & Sala, 2016; Sala et al., 2017; Opheusden et al., 2023; Gigerenzer, 2023).

Based on the analyzed data, it is clear that the systematic application of the SM principles in chess teaching significantly impacts the quality and effectiveness of learning. This study suggests

that by continuing to refine and adapt these methodologies, we can improve chess teaching and offer a robust framework that can be applied to other educational areas, promoting more critical, analytical, and engaging learning.

Proposal for Practical Application

To enhance and expand the content on chess teaching strategy using the SM, it is essential to consider how this approach can not only facilitate the technical learning of the game but also encourage the development of transferable skills, such as analytical ability and strategic reasoning. The use of the SM in chess teaching offers a rigorous and systematic structure that can significantly improve how players learn and apply chess concepts in their games.

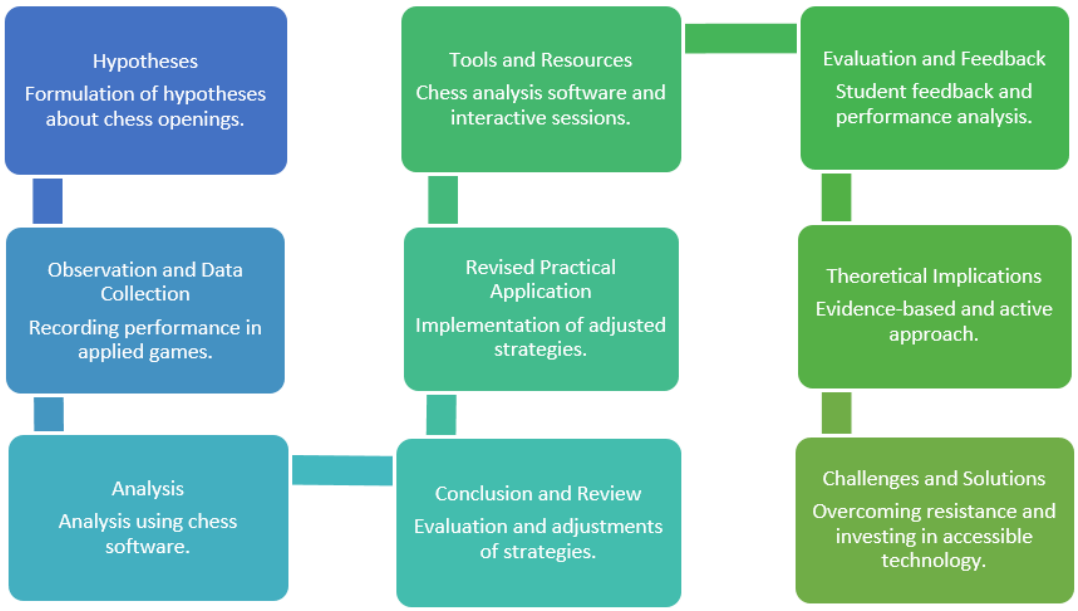

Diagram 5. Educational Model for Chess Teaching with the Scientific Method.

To implement the SM in chess teaching, the educational model, as shown in Diagram 5, proposes a structured learning system that follows a logical and ordered sequence, beginning with a clear definition of hypotheses about strategies and moves. Educators and students are encouraged to observe games and strategies in detail, collect data on the games, and then analyze this information to test the initially proposed hypotheses. This approach reinforces the understanding of chess techniques and teaches players to think scientifically, stimulating constant questioning and rigorous investigation of their strategies and those of their opponents.

By incorporating the SM, chess teaching aligns with pedagogical principles emphasizing

problem-solving and critical thinking. Active experimentation during games allows students to test different approaches and evaluate the results, facilitating deep and reflective learning. This methodology improves chess skills and develops essential competencies such as critical analysis, the ability to adapt strategies in real time, and the ability to anticipate and respond to opponents' moves.

Implementing this educational model involves several practical steps, from integrating educational technologies, such as chess analysis software, to conducting workshops and training sessions for educators. These actions ensure that instructors are well-equipped to apply the SM in chess teaching, promoting a culture of continuous and innovative learning.

By adopting this approach, chess teaching transcends the simple transmission of technical knowledge and becomes a platform for intellectual and personal development. Through the disciplined and conscious application of the SM, players learn to play chess more effectively and acquire an analytical and strategic mindset that can be applied to many other areas of their lives.

CONCLUSION AND FINDINGS

The analysis highlights the relevance of the Scientific Method in the pedagogical strategies of chess educational videos on Lichess, showing how a systematic and reflective approach can revolutionize the game's learning. Videos focusing on openings and strategies emphasize the importance of active experimentation and hypothesis formulation, while the meticulous analysis of games, especially by elite players, underscores the need for detailed observation and in-depth analysis.

The diversity of the analyzed content reveals a broad educational spectrum, addressing various interests and skill levels within the chess community. The emphasis on openings, strategies, and analysis of masters' games reflects an educational trend that values the establishment of a robust theoretical foundation and learning from the experiences of the best in the field.

The implications of this study are clear: integrating the SM into chess teaching not only equips players to face complex challenges on the board but also endows them with skills to solve problems in other areas of life. Therefore, it is suggested that these pedagogical practices continue and expand, aiming not only to improve specific chess skills but also to promote the development of broader analytical and strategic reasoning.

Moreover, this study fosters a discussion on effective educational practices and recommends

further investigation to integrate such principles into chess teaching and explore their applicability in other educational disciplines, leveraging approaches that are systematic and evidence-based.

In conclusion, it reiterates the importance of adopting teaching methods that are rigorous, accessible, and challenging, providing an educational experience that not only enriches but truly transforms. This analysis highlights the need for additional research to test and validate the effectiveness of the discussed methodologies, expanding the scope and depth of studies at the intersection of chess and scientific education.

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