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# Technological Innovations and Pedagogical Advancements in Basketball Skill Learning: A Systematic Review of High School Physical Education

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## ABSTRACT

**Purpose of The Study.** This systematic review investigates technological and pedagogical innovations in high school basketball skill education. The study evaluates theoretical frameworks, identifies effective strategies for varied learners, establishes a skill acquisition framework, and offers practical insights for educators and curriculum designers.

**Material and methods**. The research employed a systematic review methodology adhering to the PRISMA framework. The study searched multiple academic databases, primarily Scopus, targeting English publications from 2015-2024. The search applied Boolean logic and controlled vocabulary to examine basketball skill learning, technological interventions, and educational methodologies. Inclusion criteria included peer-reviewed articles relevant to high school basketball skill development with technological or pedagogical innovations. The analysis concentrated on three analytical dimensions: technological interventions, pedagogical approaches, and performance metrics.

**Results.** The systematic review indicated notable advancements in basketball skill acquisition influenced by technological and pedagogical innovations. Intelligent sensor technologies offer high precision in movement evaluation, while cognitive science integration fosters novel skill development avenues. Artificial intelligence and machine learning demonstrate significant improvements in tactical skills, with enhancements ranging from 9.655 to 13.989 through generative AI instructional models. Motion analysis technologies are essential advancements, notably improving free throw accuracy by up to 13%. These findings signify a transformative evolution in basketball training, where advanced technologies and cognitive methodologies are fundamentally reshaping athletes' skill acquisition processes, exceeding traditional training paradigms.

**Conclusions.** The landscape of basketball skill learning is undergoing a profound transformation driven by technological innovation and advanced pedagogical approaches. The emerging paradigm suggests a move towards more personalized, technology-enhanced, and cognitively informed training strategies. While promising, significant research gaps remain, particularly in developing comprehensive, integrated approaches to basketball skill learning. The study emphasizes the need for robust longitudinal designs to definitively demonstrate the long-term efficacy of innovative teaching methods.

**Keywords:** Basketball Skills; Technological Interventions; High School Students; Pedagogical Innovations; Cognitive Science; Teaching Methods.

## ARTICLE INFO

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## INTRODUCTION

Basketball is a multifaceted sport that requires a comprehensive approach to skill development (Schelling & Torres-Ronda, 2024). The game demands a diverse array of physical, cognitive, and technical capabilities from players, making it a challenging yet rewarding endeavor for high school students to master (Zhu, 2022). Effective teaching methods must account for the multidimensional nature of basketball skill acquisition, fostering holistic development that transcends the mere repetition of isolated techniques (Smith, 2017). Traditionally, physical education models have predominantly relied on direct instruction methods, which often limit student engagement and motor skill progression (Carlson, 1935; Konukman et al., 2010). The rapid evolution of educational pedagogies necessitates a comprehensive examination of teaching methodologies specific to basketball skill learning.

[abcde]Authors'Contribution: a-Study design; b-Data collection; c-Statistical analysis; d-Manuscript preparation; e-Funds collection.
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The landscape of physical education has undergone significant transformation in recent decades, with increasing emphasis on student-centered learning and holistic skill development (Physical Education Position Statements, 2024; Cipriano et al., 2024). Basketball, as a complex sport requiring intricate motor skills, cognitive strategy, and physical coordination, exemplifies the multifaceted challenges facing contemporary physical education programs (Vázquez-Guerrero et al., 2020; Yudho & Nugroho, 2021). High school physical education curricula must navigate the delicate balance between technical skill instruction and engaging pedagogical approaches that motivate adolescent learners (Yudho & Nugroho, 2021).

Basketball skill acquisition represents a nuanced intersection of motor learning theory, educational psychology, and sport-specific performance development. The effective acquisition of basketball skills involves a complex interplay between the theoretical foundations of motor learning, the psychological factors that influence student engagement and motivation, and the specific performance demands of the sport (Winkelman, 2023; Gutiérrez-Capote et al., 2023; Amato et al., 2023). This multifaceted nature of basketball skill development necessitates a comprehensive and integrated approach to pedagogy, moving beyond traditional direct instruction models. Traditional instructional models have predominantly relied on direct, teacher-centered approaches that often marginalize individual student differences in learning styles, physical capabilities, and cognitive processing (Shammas, 2023; Watson, 2023; Siregar et al., 2025) These models typically prioritize standardized instruction, overlooking the unique needs and learning preferences of each student (Vaughn & Fletcher, 2021; Pane et al., 2017). Consequently, they can fail to engage and motivate a diverse range of learners, limiting the potential for holistic skill development in basketball (Gurvitch & Metzler, 2010; Shi & Yang, 2019). To address these limitations, a shift towards more student-centered and differentiated teaching methods is necessary to foster a inclusive and empowering learning environment for high school basketball students. This pedagogical paradigm fails to account for the diverse neuromotor and psychological factors that influence skill development during the critical adolescent developmental stage.

The existing body of research presents a fragmented and often contradictory landscape of basketball skill instruction methodologies. Empirical studies have predominantly focused on isolated aspects of skill learning, such as shooting techniques, defensive positioning, or tactical understanding, without providing a comprehensive framework for holistic skill development (Smith, 2017; Chang, 2013). Previous systematic reviews have been constrained by narrow methodological approaches, typically examining either cognitive or psychomotor dimensions in isolation (Slimani et al., 2016; Fels et al., 2014).

Moreover, a critical gap exists in understanding how different teaching methods interact with individual student characteristics, including prior athletic experience, cognitive processing capabilities, and motivational orientations. The complexity of basketball skill acquisition demands a more nuanced approach that transcends simplistic, one-size-fits-all instructional strategies.This systematic review aims to examine the critical need for evidence-based recommendations regarding basketball skill instruction in high school physical education. The review will comprehensively analyze current pedagogical approaches to accomplish four key objectives: 1) critically evaluate the theoretical and empirical foundations of basketball skill learning methodologies; 2) identify the most effective pedagogical strategies for diverse student populations; 3) establish a comprehensive framework for understanding the multidimensional nature of basketball skill acquisition; and 4) provide actionable insights for physical education practitioners and curriculum developers. Furthermore, the study will systematically address four specific research objectives: 1) thoroughly review and synthesize existing literature on basketball skill learning teaching methods; 2) analyze the differential effectiveness of various pedagogical approaches across diverse high school student populations; 3) identify best practices and innovative instructional strategies for basketball skill development; and 4) evaluate the methodological strengths and limitations of existing research in the field.

## MATERIALS AND ANALYSIS

This systematic review employed a rigorous and comprehensive search strategy to maximize the breadth and depth of literature retrieval on technological innovations and pedagogical advancements in basketball skill learning for high school physical education. Multiple academic databases, primarily scopus, were systematically explored, focusing on English-language publications from 2015-2024. The search utilized advanced Boolean logic and controlled vocabulary, carefully constructing search terms to capture the nuanced intersection of basketball skill learning, technological interventions, and educational methodologies.

### Inclusion and Exclusion Criteria

The methodological approach followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) framework, ensuring a structured and transparent approach to literature selection and analysis. Inclusion criteria encompassed peer-reviewed research articles directly related to high school basketball skill development, incorporating technological or pedagogical innovations. Exclusion criteria eliminated non-empirical studies, publications without clear methodological descriptions, and research lacking quantitative or qualitative performance assessments.

### Data Extraction and Analysis

The comprehensive analysis focused on three key analytical dimensions: technological interventions, pedagogical approaches, and performance metrics. Technological interventions examined intelligent sensor technologies, motion analysis systems, artificial intelligence applications, and virtual reality tools. Pedagogical approaches explored cognitive science integration, skill acquisition models, learning strategy effectiveness, and student engagement techniques. Performance metrics evaluated skill improvement quantification, tactical understanding development, and physical and cognitive performance enhancement.

### Methodological Approach

Researchers systematically extracted and analyzed data, comparing intervention outcomes and critically assessing various approaches to basketball skill learning. The review methodology acknowledged potential limitations, including possible publication bias, variability in study design, limited longitudinal research, and the diverse contexts of technological and pedagogical innovations.

This meticulous approach provided a comprehensive examination of contemporary basketball skill learning methodologies, offering valuable insights into emerging technological and pedagogical innovations in high school physical education.

The systematic review revealed significant advancements in basketball skill learning, highlighting the critical role of technological interventions and innovative pedagogical approaches. By synthesizing research from multiple studies, the analysis demonstrated the potential of integrating cognitive science, artificial intelligence, and advanced motion analysis technologies to enhance basketball skill development among high school students.

Furthermore, the dataset was subjected to analysis within the Scopus database utilizing Harzing's Publish or Perish, specifically version 8.17.4863.9118, and subsequently refined through the application of Microsoft Excel. The flowchart delineates the methodical procedure involved in the selection and screening of literature pertinent to the systematic review concerning technological innovations in the acquisition of basketball skills. Below is a comprehensive elucidation of each phase:

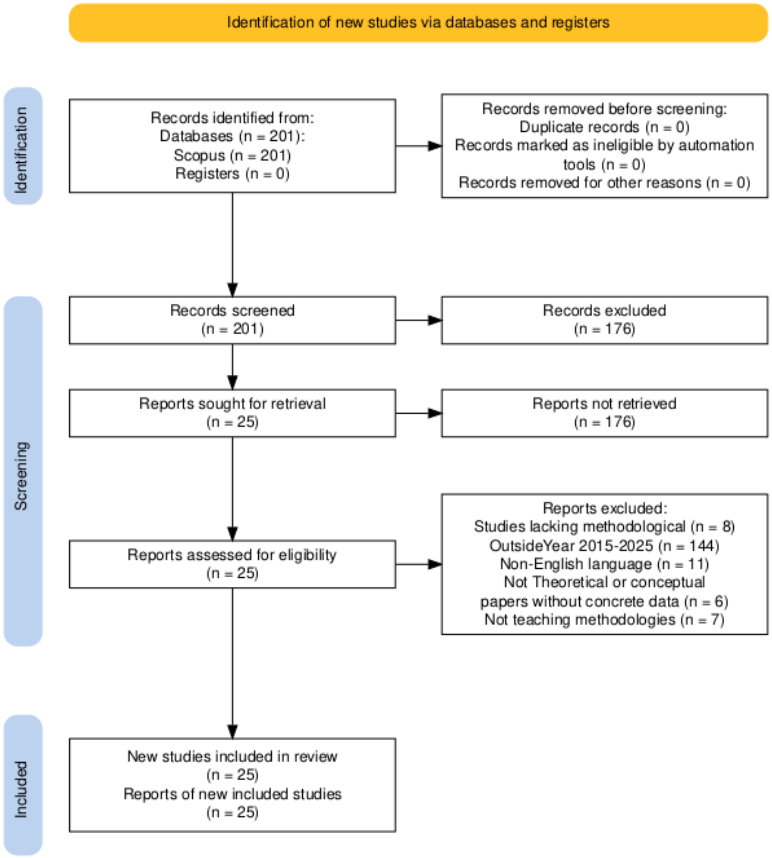


Figure 1. Flowchart utilizing the PRISMA methodology for the inclusion and exclusion flow diagram technique.

## RESULTS

Table 1. The results of the relevant research were taken after going through the stages of the prisma methodology

| Authors | Methods Used | Results |
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| Duoduo Yan, 2023. | - The paper utilizes intelligent sensors to collect basketball sports data, which is then processed and segmented using Kalman filtering. This method allows for accurate data analysis and enhances the understanding of basketball movements.<br><br>- A feature extraction method based on unit division is designed for analyzing basketball sports gestures, and the Support Vector Machine (SVM) method is employed to analyze the features of these gestures, facilitating intelligent SPOC hybrid basketball teaching. | - The experiments conducted on data collection and motion attitude resolution in basketball showed that the deviations of the collected acceleration and angular velocity were within 10−2 orders of magnitude and 1.8°/s deviation, respectively, indicating effective data accuracy in basketball motion recognition.<br><br>- The implementation of the intelligent SPOC hybrid basketball teaching resulted in an average improvement of roughly seven in physical quality for experimental class 1, with a P-value for the improvement of different basketball sports being less than 0.05, demonstrating a significant enhancement in students' physical quality and basketball abilities. |
| Yong Bai, Guanghui Yang, 2024. | - The paper integrates cognitive science and educational psychology into the PEDAGOGY model to reform and innovate the current basketball education methodology, aiming to enhance the theoretical system of basketball education.<br><br>- To investigate the impact of the innovative | - The study found that the integration of cognitive science and educational psychology into the PEDAGOGY model significantly affects the quality of basketball teaching, with the basketball course teaching factor contributing the largest rate of 25.632%. This indicates that the innovative approach has a substantial impact on teaching effectiveness. |

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| | PEDAGOGY model on basketball teaching quality, the study employs factor analysis and the EM algorithm to screen the main factors affecting teaching quality, identifying that embodied cognition and psychological counseling significantly contribute to the effectiveness of basketball teaching. | - Empirical analysis revealed that the loadings for embodied cognition and psychological counseling were notably high, at 0.865 and 0.875 respectively, suggesting that these elements are critical components of the newly designed basketball teaching mode and play a key role in enhancing the overall quality of basketball education. |
| Zhuoxiao Liu, 2024. | - The paper utilized a comprehensive research approach that included a questionnaire survey method to gather data on the effectiveness of the basketball tactics teaching model among students.<br>- Statistical analysis methods such as paired-sample t-test and one-way ANOVA were employed to compare the improvements in individual and team tactics between the experimental group using the generative AI model and the control group using traditional training methods. | - The study found that both individual offensive and defensive tactics, as well as local and team-wide tactics, showed significant improvement in students from the experimental group who used the generative AI-based teaching model, with improvements ranging from 9.655 to 13.989, compared to the control group which showed improvements of 4.844 to 6.515.<br><br>- The effectiveness of the generative AI-assisted basketball tactics teaching model was demonstrated to be superior to the traditional tactics training method used by the control group, indicating a more effective approach to teaching basketball tactics. |
| Bin Li, 2024. | - The paper integrates motion vector field transformation to enhance the teaching quality of the free throw action in basketball courses, focusing on optimizing player motion vectors through smoothing processing and compensation models to reduce interference from random noise during video analysis.<br><br>- A comparative study was conducted between an experimental group using the motion vector field transformation method and a control group using traditional teaching methods, revealing a significant improvement in the ball-hitting rate for the experimental group, with differences of 7.8% and 13% noted in the seventh and eighth weeks, respectively. | - The integration of motion vector field transformation in teaching free throw action resulted in a significant improvement in the ball-hitting rate of athletes, with differences of 7.8% and 13% observed between the experimental group and the control group during the seventh and eighth weeks, respectively.<br><br>- The study concluded that the teaching method incorporating motion vector field transformation outperformed the traditional teaching mode, as indicated by a significant difference in performance (<0.05) between the two methods, demonstrating its effectiveness in enhancing free throw shooting skills. |
| Xinquan Xu, Hao Wu, 2024. | - A Mediapipe-based 3D human posture domain adaptive detection method is proposed, which combines statistics and human limb proportion simulation to effectively analyze basketball training techniques.<br>- The modified SVM classification algorithm is utilized to compare and classify the newly acquired key point data information of the system against the standard basketball action key point data, allowing for the assessment of whether the basketball actions meet the established standards. | - The experimental group showed an improvement in total basketball scores with an average of 86.26±2.228, compared to the control group's average of 81.34±9.672, although the difference was not statistically significant (P>0.05).<br><br>- The experimental group demonstrated greater proficiency in basketball techniques, as evidenced by faster overall times in cross-step breakout and same-side step breakout with the ball, being 0.64 seconds and 0.77 seconds quicker than the control group, respectively. |
| Gaetano Altavilla, Alfredo Pio Di Tore, Tiziana D'Isanto, Gaetano Raiola, 2017. | - The paper clarifies the fundamental elements of the basketball dribble from various perspectives, including technical, tactical, and biomechanical viewpoints, to enhance understanding and application in game situations.<br>- It advocates for the optimization of specific preparation and training methods in basketball, moving away from generic training approaches that are deemed unsustainable in modern competitive sports. | - The paper clarifies the fundamental elements of the basketball dribble from technical, tactical, and biomechanical perspectives, aiming to optimize training and preparation for various game situations.<br>- It advocates for the application of specific technical elements in sports practice, moving away from generic training methods that are deemed unsustainable in modern competitive sports. |
| Yingjing Qian, 2024. | - The study designed a new smart teaching mode for physical training science by utilizing blended learning theory and artificial intelligence technology.<br>- A comparison analysis was conducted to evaluate the differences in students' physical education performance, participation, and satisfaction between the traditional teaching mode and the intelligent teaching mode. | - The study found that students who utilized the innovative intelligent teaching methods showed a significant improvement in their physical education performance, specifically in the 100-meter sprint and basketball shooting accuracy, with an average improvement rate of 15% compared to those using traditional teaching methods.<br><br>- The intelligent teaching mode was shown to effectively enhance students' learning efficiency and mastery of movement skills in physical education, indicating a promising new direction for college physical education programs. |

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| Avelino Silva, Ricardo Manuel Pires Ferraz, Luis C. Branquinho, Tatiana Dias, José E. Teixeira, Daniel A Marinho, 2023. | | - The study utilized the FITescola® test battery to assess physical fitness, which included various exercises such as sit-ups, push-ups, horizontal impulse, shuttle test, 40 m sprint, and agility 4 × 10 m. This comprehensive assessment allowed for a thorough evaluation of the students' physical conditioning levels.<br><br>- For evaluating tactical performance, the Game Performance Assessment Instrument (GPAI) was employed, which measured players' game performance during a 20-minute 3 vs. 3 match. The GPAI focused on several indices, including decision making index (DMI), skill execution index (SEI), support actions index (SI), and adaptability index (AI), providing a detailed analysis of the students' tactical skills. | - The application of a multivariate training program over 6 weeks significantly improved both physical fitness and tactical performance among students, as evidenced by the results of the FITescola® test battery and the Game Performance Assessment Instrument (GPAI). The pre- and post-assessment comparisons showed significant differences in all indexes, indicating enhanced physical conditioning and tactical skills.<br><br>- The study found that there were small effects in the performance improvements between basic and secondary school students, with statistical significance in the changes observed ($p<0.05$–$p<0.001$), suggesting that a structured training program can effectively cater to different educational levels in enhancing students' overall performance in team sports. |
| Chengjian Sheng, Chenxin Lian, Haolin Pang, 2023. | | - The paper utilizes a human body posture estimation algorithm to locate key points of the human body in RGB screens, along with two human body multi-objective algorithms to predict posture trajectories, which help mitigate errors from sensor data.<br><br>- A spatio-temporal graph convolutional neural network is employed to identify human behavior and extract behavioral action features, enabling an analysis of students' basketball skill levels and informing the proposed reform strategies for college basketball teaching. | - The reform of basketball teaching based on big data led to an increase in the average scores of students in specific skills: spot-up shooting improved by 1.80 points, half-court folding dribbling by 1.08 points, and marching one-handed over-the-shoulder shooting by 1.85 points after the reform.<br><br>- The study indicates that the implementation of big data strategies in basketball teaching not only enhanced students' training scores but also increased their interest in learning and improved their overall basketball skill level. |
| Cláudio Farias, Isabel Mesquita, Peter A. Hastie, Toni M. O'Donovan, 2018. | | - The study employed an action research methodology that included three cycles, one for each season of sport education, which involved the processes of planning, acting and monitoring, reflecting, and fact finding. This structured approach allowed for continuous improvement and adaptation of teaching strategies across the seasons.<br><br>- Data collection methods included videotape and audiotape records of all 47 lessons, a reflective field diary maintained by the teacher-researcher, and 24 semi-structured focus-group interviews with participants. This comprehensive data collection aimed to ensure trustworthiness through extensive triangulation and collaborative interpretational analysis. | - The study provided an integrated analysis of a teacher's peer-teaching mediation strategies, the instruction from student-coaches, and the development of students' gameplay across three consecutive seasons of sport education, indicating a systematic approach to enhancing learning in invasion games.<br><br>- Data collection included extensive methods such as videotape and audiotape records of all lessons, a reflective field diary maintained by the teacher-researcher, and 24 semi-structured focus-group interviews, which contributed to the trustworthiness of the research findings through data triangulation and collaborative interpretational analysis. |
| Stephen C. Harvey, Alexander Gil-Arias, Megan Smith, Lindsey Rachel Smith | 2017 | - Data on teacher behavior were collected using the West Virginia Teaching Evaluation System (WVUTES), which includes 11 behavior categories such as general observation, specific observation, encouragement, and management. Observers recorded model benchmarks in 59 of the 65 lessons, and inter-observer reliability checks were conducted to ensure accuracy in the data collection process.<br><br>- Need satisfaction and self-determined motivation data were gathered using a validated questionnaire developed by Standage et al., which measured aspects of self-determination theory (SDT) within a sport and physical education context. This questionnaire assessed students' perceptions of autonomy, competence, and relatedness, as well as their levels of intrinsic motivation, through a Likert scale ranging from 1 (strongly disagree) to 7 (strongly agree). | - The study revealed a significant main effect for time in need satisfaction for both middle and elementary school students, with middle school students experiencing an increase in relatedness, while elementary school students showed a decrease in autonomy. Additionally, middle school students exhibited a significant increase in self-determined motivation, specifically in introjected regulation, external regulation, and amotivation.<br><br>- Approximately 48% of lesson time for middle school students and 42% for elementary school students was spent on game play, with both groups spending equal amounts of time (22%) on skill practice. The remaining lesson time was allocated to management (17% for middle school and 17% for elementary school) and knowledge (13% for middle school and 19% for elementary school), indicating a structured approach to the Tactical Games Model (TGM) implementation. |

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| Bryn Evans, Richard Fitzgerald 2017 | - The paper employs ethnomethodological and conversation analytic studies to examine the interactional practices involved in basketball training, particularly focusing on how instruction is accomplished through the correction of player performances during training sessions.<br><br>- It analyzes the visual-analytic work of coaches as they observe and organize basketball training activities, highlighting the sequential layering of membership categorization devices and spatial orientations that help identify players' errors and facilitate the organization of instructional interactions. | - The paper examines the visual-analytic work involved in organizing and observing basketball training activities, highlighting how coaches observe players' performances to identify competencies and correctable errors through their embodied displays within a dynamic environment.<br><br>- It argues that coaches utilize spatial orientations that function similarly to membership categorization devices, where players' bodily positions and their relationships to the surrounding material structure help establish rights, responsibilities, and sequential relevancies, which are essential for identifying errors and organizing instructional interactions. |
| Stephen C. Harvey, Megan Smith, Yang Song, David Robertson, Renee Brown, Lindsey Rachel Smith, 2016. | - The study utilized Actigraph GT3X triaxial accelerometers to objectively measure students' physical activity levels during the basketball lessons. These accelerometers recorded movement across three axes, and the data were converted to activity counts to determine the levels of moderate and vigorous physical activity.<br><br>- A non-experimental observational design was employed, where two teachers (one from middle school and one from elementary school) taught a series of Tactical Games Model basketball lessons. The lessons were observed and rated based on specific benchmarks, and data from paper records were transferred to an electronic coding form for analysis of lesson context and physical activity levels. | - Middle school boys exhibited significantly higher levels of moderate-vigorous physical activity (MVPA) and vigorous physical activity (VPA) compared to girls, with boys achieving 34.04% MVPA and 22.37% VPA, while girls reached 25.14% MVPA and 15.47% VPA. Similarly, elementary school boys also had higher MVPA (29.73%) and VPA (18.33%) than girls, who recorded 23.03% MVPA and 14.33% VPA.<br><br>- The study utilized Actigraph GT3X triaxial accelerometers to objectively measure physical activity levels during the Tactical Games Model (TGM) basketball lessons, confirming that boys, across both middle and elementary school levels, consistently accumulated higher levels of both MVPA and VPA compared to their female counterparts. |
| Jingran Wang, Wenyi Li, 2024. | - The study employs the 3DRS model to analyze the initial motion of free throw shooting, utilizing weighted bidirectional motion to fix and smooth the motion vectors, which enhances the accuracy of the shooting technique.<br>- The research incorporates adaptive motion compensation and introduces a method for reviewing training videos that is based on the transformation of the motion vector field, allowing for improved prediction and training outcomes in free throw shooting. | - The research demonstrated that the average PSNR and SSIM values for different video sequences using the motion vector field transform algorithm were higher than those of other algorithms by 6.16% to 7.00% and 4.50% to 5.00%, respectively, indicating improved video quality in the analysis of free throw shooting.<br><br>- Athletes trained using the motion vector field transformation algorithm showed a significant improvement in their performance, with a 19.23% increase in hitting free throws and a 16.07% enhancement in other technical measures, confirming the algorithm's effectiveness in teaching basketball free throw shooting techniques. |
| Cláudio Farias, Carla Valério, Isabel Mesquita, 2018. | - The study utilized the Game Performance Assessment Instrument to collect pre-test and post-test measures of students' Game Performance and Game Involvement during their participation in three consecutive Sport Education seasons, which included basketball, handball, and football units.<br><br>- Data analysis was conducted using 2 (time) x group (sport) repeated measures ANOVA tests to examine inter-group differences and improvements in Game Performance and Game Involvement from pre-test to post-test within each sport season. | - Significant improvements in Game Performance and Game Involvement were observed from pre-test to post-test during the second (handball) and third (football) seasons of Sport Education, while no significant improvements were found during the first season (basketball).<br><br>- Students' Game Performance and Involvement scores were significantly higher in handball and football compared to their scores in basketball, indicating that the extended engagement in game-play activities and consistent team membership across seasons positively influenced their development. |
| Wei Shi, Yang Lin, 2024. | - The study employs and refines the Kano model to better analyze and categorize student needs in PE classrooms, reducing ambiguity typically associated with classifying needs in the conventional model.<br>- Utilizing the Better-Worse coefficient, the study evaluates the influence of distinct educational needs on student satisfaction within courses, facilitating the identification of specific types of needs and their impact on student outcomes. | - The application of the refined Kano model in a controlled study on basketball training resulted in significant improvements in students' basketball skills, with scores for the 5-step backward shot increasing from 12.55 to 15.97 and scores for the marching shot rising from 8.64 to 11.04. Additionally, enhancements were noted in the marching pass and half-court folding dribble, improving by 2 and 4 points, respectively.<br><br>- Students in the experimental group, who benefited from the enhanced Kano model, achieved higher basketball theory scores than those in the control group by an average of 7.92 points, and their overall classroom satisfaction ratings were also 2.2 points higher, indicating a positive impact on both skill development and student satisfaction. |

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| Mark David Williams, Andrew Hammond, Jason Moran, 2021 | - The study employed snowball and criterion-based sampling approaches to survey youth basketball coaches, gathering data on their beliefs and experiences regarding the implementation of fundamental movement skills (FMS) training.<br>- The analysis of the collected data utilized Realist Evaluation, which included descriptive statistics (means and frequencies) and reflexive qualitative thematic analysis to derive insights from the coaches' perceptions and practices. | - The study found that youth basketball coaches generally understood fundamental movement skills (FMS) and recognized their importance for the long-term development of young players. However, there was a noticeable variation in how these coaches implemented FMS training in their practices.<br><br>- The results indicated a need for governing bodies to create innovative strategies aimed at encouraging youth basketball coaches to incorporate non-sport specific movement skills into their training regimens to enhance their coaching effectiveness. |
| Alexander Gil-Arias, Luis García-González, Fernando del Villar Álvarez, Damián Iglesias Gallego, 2019. | - The study utilized a pre-test/intervention test/retention test quasi-experimental design, where eleven male basketball players aged 12 to 13 years were assigned to either an experimental group or a control group. The decision training program was implemented over a period of 11 weeks.<br><br>- Participants in the experimental group engaged in analyzing their decision-making processes through video feedback and questioning, which were used as cognitive tools to enhance their understanding of the causes and reasons behind their decisions in basketball. Decision-making and skill execution were assessed using the French & Thomas (1987) observation instrument, while procedural knowledge was evaluated through a validated questionnaire. | - The experimental group of basketball players who participated in the decision training program showed significant improvement in their intervention test scores for successful decisions and skill executions compared to the control group, indicating enhanced sport expertise as a result of the training.<br><br>- In the intra-group analysis, the experimental group demonstrated significant improvements in decision-making, skill execution, and procedural knowledge from the pre-test to the intervention test, highlighting the effectiveness of cognitive tools like video feedback and questioning in developing players' skills. |
| Ching-Hang Chen, Tyng-Luh Liu, Yu-Shuen Wang, Hung-Kuo Chu, Nick C. Tang, Hong-Yuan Mark Liao' 2015. | - The paper employs a dominant-set clustering approach to divide the dataset of basketball video clips into clusters, each corresponding to a specific offensive strategy. This method allows for the accommodation of situations where the exact number of clusters may not be known in advance.<br><br>- Gaussian mixture regression (GMR) is utilized to generate mean trajectories and variance matrices for each identified cluster, enabling the modeling of spatio-temporal variations among individual player trajectories within the same offensive strategy. This approach enhances the robustness of the learned discriminant functions for classifying basketball offensive strategies. | - The experiments conducted in the study involved modeling and classifying basketball offensive strategies using a dataset of 134 video clips from NBA games, which included ten different types of offensive strategies. The strategies were effectively represented and categorized through the application of unsupervised learning techniques, resulting in a systematic approach to analyzing group behaviors in basketball.<br><br>- The effectiveness of the proposed method was demonstrated through the generation of confusion matrices that compared the training procedures with and without the use of an EM-like iterative training procedure. The results indicated that the method successfully divided the dataset into meaningful clusters corresponding to specific offensive strategies, thereby enhancing the robustness of the learned discriminant functions. |
| Elisa De Stefani, Francesca Rodà, Elio Volta, Vincenzo Pincolini, Andrea Farnese, Stefano Rossetti, Federica Pedretti, Pier Francesco Ferrari, Pier Francesco Ferrari, 2020 | - The study utilized the **Observational-Imitative Method (OIM)**, where participants observed an expert athlete performing the sport actions before attempting them. This method aimed to facilitate early stages of skill learning by providing motion information essential for assembling novel motor sequences.<br><br>- The second method employed was the **Descriptive-Directive Method (DDM)**, which involved providing verbal explanations and static images of the sport actions. This method was particularly effective for teaching specific aspects of an exercise, such as how to grasp a tool, and showed that repetition of the exercise could enhance performance even in the absence of a model. | - The study found that the observational-imitative method (OIM) was more effective for teaching new sport actions to children with no prior experience, as it facilitated better understanding and execution of unfamiliar motor sequences compared to the descriptive-directive method (DDM). The OIM group demonstrated higher performance scores in actions such as the shoulder stand, soccer action, vortex howler throw, and step action.<br><br>- Conversely, the DDM was effective when children needed to learn specific aspects of an exercise, such as how to grasp a tool for the vortex throw. The results indicated that detailed verbal instructions could enhance performance, especially when the action was repeated multiple times, suggesting that repetition can improve the effectiveness of verbal instruction in the absence of a model. |
| Julius B Apidogo, Achraf Ammar, Atef Salem, Johannes Burdack, W. Schöllhorn., 2023 | - The study employed a pre–post–retention test design, which included a 6-week intervention program where participants engaged in three training sessions per week, each lasting approximately 80 minutes. During these sessions, participants executed ten attempts of basketball free-throw shooting, handball three-step goal throwing, and volleyball underarm passing in a blocked order.<br><br>- Three learning approaches were examined: contextual interference (CI), differential learning (DL), | - The differential learning (DL) group showed significant improvements in performance for both non-mastered basketball free-throw shooting ($p = 0.03$, ES = 1.58) and handball shooting tests ($p = 0.05$, ES = 0.9), with a trend towards improvement in the mastered volleyball underarm-pass skill (ES = 0.53) during the short-term (pre–post) assessment.<br><br>- In terms of relatively permanent gains, the contextual interference (CI) group improved significantly in the non-mastered basketball free-throw skill ($p = 0.018$, ES = 1.17), while the DL group showed significant improvements at |

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| | and a free-play control condition (CO). The effectiveness of these approaches was assessed by measuring performance improvements in both mastered and non-mastered skills before and after the intervention, as well as at a retention test following the intervention period. | retention in both non-mastered basketball (p = 0.004, ES = 1.65) and handball (p = 0.003, ES = 2.15) skills, along with a trend towards improvement in the mastered volleyball test (ES = 0.4). |
| Wan-Lun Tsai, Min-Chun Hu, 2018. | - The proposed framework utilizes a tactic input device, such as a tablet, to allow users to input target tactics and modify players' offensive trajectories and orientations intuitively, enhancing the training process by providing a clear visual representation of the tactics to be executed.<br><br>- The system incorporates motion analysis through IMU-based human motion capture technology, which detects incorrect movements of the user and provides real-time action hints, such as reminders for performing fake actions or ball-passing, thereby improving the accuracy and effectiveness of tactic execution during training. | - The proposed VR-based framework enhances the effectiveness and experience of basketball tactic training by allowing players to practice in a high-fidelity environment, which includes features such as virtual teammate editing, motion analysis, and AI-generated virtual defenders. This leads to a more engaging and realistic training experience.<br><br>- By utilizing motion capture technology and providing real-time feedback on players' movements, the system helps trainees improve their execution of offensive tactics, including timing for running and ball-passing, ultimately strengthening their tactical nous and increasing the efficiency of their training sessions. |
| Weibo Liu, 2023 | - The main method for classifying basketball tactics used in this paper is cluster analysis, which is a branch of multivariate statistical methods. This approach helps in grouping similar tactics based on their characteristics and performance metrics.<br><br>- Nonlinear programming functions with constraints are constructed using mean square approximation theory, which aids in refining the classification of basketball tactics by minimizing the least square error sum, ensuring the classification results are reasonable and accurate. | - The analysis revealed that man-to-man defensive tactics were the most frequently employed strategy in basketball, with 72 instances, which accounted for 75.19% of all defensive strategies observed in the study.<br><br>- The study found that the most successful offensive tactic was dribbling with a fast break, achieving a success rate of 75%, as it resulted in 15 successful scores out of 20 attempts during the first half of the games analyzed. |
| Shane Pill, Brendan SueSee, Michael Drummond Davies, 2023. | - The paper contests the view that teaching styles are different from pedagogical models, providing a rationale for The Spectrum of Teaching Styles as a pedagogical model in physical education (PE).<br>- It highlights the central aspects of The Spectrum, explaining its fundamental characteristics and demonstrating how it helps teachers understand the 'how', 'when', and 'why' of their pedagogical decisions to align their teaching with desired educational outcomes. | - The paper argues that The Spectrum of Teaching Styles is a valuable pedagogical model for physical education teachers, as it helps them understand the 'how', 'when', and 'why' of their pedagogical decisions, ultimately leading to improved teaching and learning practices in PE.<br>- The paper contends that The Spectrum assists teachers in aligning their pedagogy with desired learning outcomes, thereby enhancing curriculum alignment and successful enactment of models-based practices in physical education. |
| Caleb Pagé, Pierre-Michel Bernier, Maxime Trempe, 2019. | - The paper discusses the use of video simulations as a method to enhance decision-making skills in basketball, highlighting its effectiveness in invasion sports.<br>- It also explores the application of virtual reality as a tool to further improve these decision-making skills, although the transferability of these improvements is questioned. | - The paper discusses the effectiveness of video simulations in enhancing decision-making skills specifically in invasion sports, indicating a positive correlation between the use of these simulations and improved performance in decision-making scenarios.<br>- It raises the question of whether the improvements gained from video simulations are transferable to real-game situations, suggesting that further research is needed to explore the extent of this transferability. |

## DISCUSSION

The landscape of basketball skill learning has undergone a significant transformation, driven by the convergence of technological the landscape of basketball skill learning has undergone a significant transformation, driven by the convergence of technological innovation and advanced pedagogical approaches. Contemporary research increasingly recognizes skill acquisition as a complex, multidimensional process that extends beyond traditional physical repetition (Wang et al., 2024; Sullivan et al., 2021). Technological interventions have emerged as a critical catalyst in this educational paradigm shift. Intelligent sensor technologies, such as those explored by (Yan, 2023), now enable unprecedented precision in movement analysis. These systems utilize sophisticated techniques like Kalman filtering and Support Vector Machine (SVM) methods to capture and interpret basketball movements with remarkable accuracy, providing coaches and athletes with granular insights into biomechanical performance (Akbaş et al., 2019; Akbaş et al., 2019; Pustišek et al., 2019)).

The integration of cognitive science into basketball skill learning represents another significant advancement. Yong Bai and Guanghui Yang's (Bai & Yang, 2024) innovative Pedagogy model demonstrates how psychological and cognitive principles can be systematically incorporated into training methodologies. Their research revealed that embodied cognition and psychological counseling contribute substantially to teaching effectiveness, with empirical loadings of 0.865 and 0.875 respectively (Gagnon et al., 2020; Ray &

Pani, 2021)).

Artificial intelligence and machine learning are proving particularly transformative in tactical skill development. Zhuoxiao Liu's (Liu, 2024) generative AI-based teaching model showed remarkable improvements in individual and team tactics, with performance enhancements ranging from 9.655 to 13.989 compared to traditional training methods. This aligns with broader trends in sports science that emphasize technology's potential to personalize and optimize learning experiences (Wood et al., 2022; Schelling & Torres-Ronda, 2016). Motion analysis technologies have also demonstrated significant potential in skill enhancement. Bin Li's (Li & He, 2024)research on motion vector field transformation revealed improvements in free throw accuracy of 7.8% to 13%, highlighting the precision possible through advanced technological interventions. Similarly, Xinquan Xu and Hao Wu's (Xu & Wu, 2024) Mediapipe-based 3D human posture detection showed promising results in performance optimization (Düking et al., 2018; Appelbaum & Erickson 2016).

The methodological diversity in recent studies challenges traditional linear models of skill acquisition. Researchers like Julius B Apidogo et al. (Apidogo et al., 2023) have explored various learning approaches, including observational-imitative methods and differential learning strategies, revealing the complex interactions between learning techniques, individual capabilities, and skill development(Wood et al., 2022; Foster et al., 2024). Despite these promising advances, significant research limitations persist. Most studies continue to focus on isolated skill components rather than comprehensive, integrated approaches to basketball skill learning. There remains a critical need for robust longitudinal designs that can definitively demonstrate the long-term efficacy of these innovative teaching methods (Bower et al., 2014; Poirier et al., 2019).

The practical implications for coaches and educators are profound. The emerging paradigm suggests a move towards more personalized, technology-enhanced, and cognitively informed training strategies. This approach goes beyond traditional drill-based learning, emphasizing the dynamic interaction between technological tools, cognitive processes, and physical skill development (Song, 2022; Listiana & Jaharadak, 2019)).Looking forward, researchers and practitioners must continue to explore the intricate relationships between technological interventions, pedagogical approaches, and skill acquisition. The most promising path lies in developing holistic, adaptive learning systems that leverage advanced technologies while maintaining the fundamental human elements of coaching and skill development (Hegi et al., 2023; Rittenberg et al., 2022).

In conclusion, the field of basketball skill learning stands at a critical juncture. The exponential advancement of educational technologies, coupled with increasingly sophisticated understanding of motor learning principles, creates unprecedented opportunities for innovation. As research continues to evolve, the potential to personalize training, provide immediate performance feedback, and optimize skill acquisition represents a significant paradigm shift in athletic development strategies.

## CONCLUSION

The landscape of basketball skill learning has undergone a profound transformation, driven by the convergence of technological innovation and advanced pedagogical approaches. Our systematic review reveals critical insights into this evolution, highlighting significant technological advancements such as intelligent sensor technologies, artificial intelligence, and motion analysis systems that enable unprecedented precision in movement analysis and skill development. Cognitive science is now being systematically integrated into training methodologies, with embodied cognition and psychological counseling substantially enhancing teaching effectiveness. Performance improvements are remarkable, with generative AI-based teaching models showing skill enhancements ranging from 9.655 to 13.989, and motion vector field transformations improving free throw accuracy by up to 13%. However, despite these promising advances, significant research gaps remain. Most studies continue to focus on isolated skill components rather than comprehensive, integrated approaches, underscoring the need for robust longitudinal designs that can definitively demonstrate long-term teaching method efficacy. The emerging paradigm suggests a move towards more personalized, technology-enhanced, and cognitively informed training strategies that balance advanced technological interventions with fundamental human coaching elements. As educational technologies and motor learning principles continue to advance, unprecedented opportunities for innovation in basketball skill development are emerging, challenging traditional approaches and promising more effective, nuanced learning experiences for athletes.

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## CONFLICT OF INTEREST

The investigators assert that their research and results are devoid of any conceivable conflicts of interest.

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