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Digital and analog learning media for improving fundamental movement skills in elementary school students: a prisma-guided systematic literature review

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ABSTRACT

Fundamental Movement Skills (FMS) are essential for children's physical development and lifelong participation in physical activity. However, many elementary school students still demonstrate low levels of locomotor, object-control, and stability skills. This systematic literature review examined the effectiveness of various learning media, including analog tools (e.g., flash cards and board games) and digital technologies (e.g., augmented reality, virtual reality, and mobile applications), in improving FMS among elementary school children. The review followed the PRISMA 2020 guidelines and used Scopus as the primary database. From 114 initially identified records, 10 studies met the final inclusion criteria and were analyzed in depth. Study quality was assessed using the FICO framework (Focus, Information, Context, Outcome). The findings indicate that game-based and flash-card learning media consistently improved locomotor skills, while augmented reality and mobile-based interventions produced equal or superior outcomes compared with conventional teaching methods. Adapted media, such as e-books and QR-code resources, also supported children with sensory or intellectual differences in developing FMS. Nevertheless, most studies employed small samples and single-group pretest–posttest designs, limiting the strength of causal inferences. Overall, learning media show considerable potential to enhance FMS development when systematically integrated into physical education programs. Future research should prioritize randomized controlled trials, longer intervention periods, and standardized reporting to strengthen the evidence base for educational practice and policy.

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Introduction

First of all, physical activity and motor competence throughout childhood are already well known to be factors behind long-term health, cognitive development, and the ability to participate in physical activities throughout one's life. Within this broader framework, gamified and technologysupported physical education approaches have increased enormously as schools and researchers look for resources that boostnotonly the motivation but the learning that is measurable as well (Carcelén-Fraile & Aibar- Almazán, 2026). Physical activity interventions for children with different developmental profiles have been shown through systematic and meta-analytic evidence that structured, well-designed movement programs can lead to measurable improvements in fundamental motor competence and other health-related indicators (Tan et al., 2026). At the same time, research

on exergame-based interventions has shown that after long periods of intervention, school-aged children have better fitness, body composition, and more enjoyment of physical activity (Marsigliante et al., 2024). Also, bibliometric and meta-synthesis analyses of instructional technology in early childhood education are showing a rapidly growing but highly fragmented literature base that is yet to be consolidated around a single pedagogical outcome such as fundamental movement skill (FMS) development (Asriadi et al., 2025). These different ideas coming together are urging a more detailed anda specifically targeted review of how learning media influence FMS acquisition in elementary school years.

Fundamental movement skills, which include locomotor, object-control, and stability skills, are the primary components on which more complex sport-specific and lifelong physical activities are based. These skills are typically measured using validated batteries such as the Test of Gross Motor Development (TGMD-2) and MOBAK-5, both of which are used later in this review to appraise the included studies. The elementary school years (approximately ages 6–12) constitute the developmental window in which FMS proficiency is most malleable and most consistently targeted by physical education curricula, which is why this review focuses on that population rather than earlier or later developmental stages. Current research mostly continues to reveal that children's FMS skills are very low and follows up with physical education-based plans to fix the specific skills. Flash cards as a learning means carried out in physical education lessons can enhance grade-3 students' locomotor movement skills as measured by the Test of Gross Motor Development (Bikalawan et al., 2024) whereas other educational games such as the snakes-and-ladders-style intervention also exerted very positive fundamental motor skill gains among third graders during the structured period of intervention (Hadyansah et al., 2024). Game-based physical education that focuses on manipulative movement skills like object control and hand-eye coordination has also been implemented and evaluated by a few primary-school samples (Satria et al., 2024). Besides, adapted fun-game learning models for Mildly intellectually disabled children have been developed to address the double problem of limited instructional materials tailored to their needs (Kesumawati et al., 2024), and non-linear technology-based didactic interventions using the MOBAK-5 assessment battery have been piloted to compare teacher-mediated and unmediated conditions in primary-school motor competence development (Monacis et al., 2022). Altogether, the above studies highlight the fact that the issue of FMS deficiency is being dealt with through different, context-specific learning-media designs.

Far from mere flash cards and board games, the reviewed literature describes a wide range of learning-media formats employed in movement education. One example is the use of augmented reality through mobile devices to enhance physical education instruction outside the classroom. This mode of intervention has shown a significant positive impact on the gross motor skills of elementary school students (Faruk et al., 2025). An innovative educational media adaptation with e-book content combined with QR-code-linked sign-language videos brought about improvement in basic movement skills among deaf children. This example demonstrates how learning media can be customized to sensory-diverse learners in an inclusion-education framework (Haris et al., 2023). Situated game-teaching models based on set-play pedagogy have been worked out against conventional curricula to check the effects on basic motor skills of second-grade students (Çakto & Akin, 2024). On the other hand, one-hole game tools have been considered for their impact on the development of fine motor skills in early childhood settings in different forms, both original and modified (Susanto et al., 2024a; Susanto et al., 2024b). Commercial and purpose-built digital game series, such as the Smart Kiddo Games application, have also been tested for their joint influence on fine and gross motor skills in young children (Marwan & Rohayati, 2025). Besides, haptic-feedback systems have been put forward as a means of assisting neurodevelopment in children with dyslexia through multisensory, technologically-enabled learning experiences (Javed et al., 2025). This variety of media shows that the concept of "learning media" in the motor development field covers a full spectrum from very cheap print-based tools to highly sophisticated sensor-driven systems.

Recently, a substantial number of studies have used immersive technologies, especially virtual reality, for changing children's physical behavior. Most of these studies are set in natural or semi-clinical play settings with kids rather than formal classroom instruction. One major area of research in virtual playgrounds has focused on the variability of children's movements, their sense of motor competence, and their willingness to take risks when trying to balance and exploring simulated tasks through a virtual reality environment (Storli & Lorås, 2025; Storli & Lorås, 2026; Storli et al., 2024; Lorås et al., 2023). Besides that, another line of research has been exploring dynamic balance repertoires following a non-linear developmental model all the way through middle childhood by means of innovative measurement techniques like those used in previous efforts (Lorås & Haga, 2025). At the same time, a protocol for a large-scale study has been outlined to carry out research on children's experiences with risk through the methods of managing risk in a virtual environment that will be a part of the national primary school research project in Norway (Sandseter et al., 2023). Besides having movement & activity programs based on virtual reality that have been tested with preschool-age children in Head Start programs for evaluating the potential changes in physical activity and cognition (Gu et al., 2025), and physical-literacy interventions by means of virtual parent training are also being piloted for the early-childhood group outside

formal school settings (Hwang et al., 2023). These materials highlight the speedy evolution of technologically advanced learning tools that focus on movement, even when their most typical application environment is still far away from mainstream elementary classrooms.

One of the most significant aspects that this paper highlights is the population subject of most technology-driven motor-learning studies and the resultant evidence. The majority of the literature identified focuses on children with diagnosed developmental or clinical conditions, not general elementary school populations. For example, virtual reality has been used with children with developmental coordination disorder (Kolit et al., 2025; Sepehri & Ebrahimi, 2025), cerebral palsy (Vibhuti et al., 2025; Yenilmez & Altug, 2026; Kolezoi et al., 2025; Balikci et al., 2024; Bell et al., 2024), autism spectrum disorder (Grola et al., 2025; Wu et al., 2025; Oliveira et al., 2026; Hocking et al., 2022), and intellectual disability (Ciążyńska & Maciaszek, 2025; Serra et al., 2025). Although clinical rehabilitation-oriented research can provide valuable methodological precedents, including validated outcome measures and intervention protocols, it may not be directly applicable to the instructional needs of typically developing children in mainstream elementary physical education, which is the target population and setting of this review.

Another gap relates to the level of methodological rigor. A large portion of the technology-based studies found through the search methods mainly serve as pilot, feasibility, first-case studies rather than fully powered randomized controlled trials. For instance, feasibility studies of home-based bimanual intensive training using virtual reality have been published with very few participants comprising the case-study samples (Gehringer et al., 2023; Gehringer et al., 2024). Similarly, single case or small sample designs have been used to describe bilateral reaching development in augmented reality games (Ziccardi et al., 2024) and multisensory proprioception assessment in a child with Down Syndrome (Valencia-Jimenez et al., 2023). Other papers which discuss the creation of serious games (Ortega et al., 2023), study protocols without outcome data yet (Li et al., 2023), engagement-recognition datasets as opposed to intervention evaluations (Kim et al., 2024), descriptive kinematic comparisons (Fears et al., 2023) or studies in related areas such as cadre knowledge for stunting detection (Hasriani et al., 2023) and parental involvement in movement learning (Cahyani et al., 2024) have been accessing the largest bodies of research on learning-media effectiveness trials. Besides, there are additional single-group or small-sample intervention studies for exergame-based motor coordination (Lee & Jin, 2023; Park et al., 2022) that are examples of the general trend of underpowered designs even in the wider corpus.

Looking at the two gaps in population-specificity and methodological-maturity, beyond doubt the existing reviews and primary studies have failed to properly identify the evidence base that is most relevant to a very important policy question: How effective is learning media, in the broadest sense, in acquiring fundamental movement skills among typical elementary school children in regular physical education settings? Some studies barely touching this scope, for instance, short-term interventions with educational games for autistic children (Doğan et al., 2024) emphasize that population and outcome boundaries have to be set with great care so that clinical rehabilitation evidence is not confused with mainstream pedagogical evidence. In view of the rapidly increasing production of technology-mediated movement interventions in both clinical and educational domains a dedicated, transparently reported systematic review that applies explicit eligibility criteria to separate elementary school pedagogical evidence from adjacent clinical literature is timely and indeed necessary for supporting curriculum designers, physical education teachers, and educational technology developers.

This review, thus, tackles the following research question:

RQ1: *What kinds of learning media (analog and digital) have been employed to develop fundamental movement skills in elementary school children, and how are these media characterized in terms of design and delivery?*

By answering this question, the paper offers a well-organized classification of learning-media modalities that have either been specifically validated in or can be adapted to elementary physical education settings, thereby separating them from the general clinical and rehabilitation literature on movement technology.

RQ2: *What extent do learning-media interventions produce measurable improvements in fundamental movement skill outcomes among elementary school pupils, and what methodological characteristics (design, sample size, measurement instruments) underlie this evidence?*

This question provides a thorough evidence synthesis clarifying the strengths and weaknesses of the existing knowledge base, so it can be understood literally by practitioners and policymakers with a more cautious and informed stance than merely a narrative summary would allow them.

RQ3: *What are the research gaps and methodological limitations of the current research and which ways for further research can be identified that would strengthen the evidence base of learning-media interventions for the development of fundamental movement skills in elementary education?*

By answering this question, the paper makes a new and innovative contribution to the field, first of all, by distinguishing very clearly the elementary-school pedagogical evidence from the much larger adjacent literature on clinical and rehabilitation-oriented movement technology, and second, by offering more accurate and usable summaries that are not only helpful for curriculum designers but also for teacher educators and developers of instructional technology who work within mainstream elementary education.

Method

Research Design and Framework

A systematic literature review (SLR) was the research design chosen as it is considered the best method to minmize bias and systematically synthesize the scattered evidences on the effectiveness of learning media. Here, narrative review is used as a comparison where the story selection process is not systematic. As a result, this design is consistent with the established SLR methodology for management and social-science research traditions, which require clear protocol development, systematic search execution, and detailed data extraction before synthesis. Moreover, the entire manuscript is continuously reported following the PRISMA 2020 statement, which prescribes a 27-item checklist and a four-phase flow diagram (identification, screening, eligibility, and inclusion) for the clear reporting of systematic reviews. The PRISMA 2020 guideline continues to be the first choice among the previous versions of PRISMA because of the additional instructions regarding the reporting of automation tools, risk-of-bias assessment, and certainty-of-evidence statements, all of which considerably enhance the methodological transparency of this review.

Search Strategy

We have used the Boolean string above to search in the TITLE-ABS-KEY field of the Scopus database, combining three concept blocks with the AND operator: learning-media modalities, movement-skill outcomes, and child or school-age population terms. Some words were truncated with an asterisk (*) to include their different forms, e.g. "skill" and "skills", "school" and "schools". We did not restrict the date at the search stage so that we could get the full historical spread of relevant records; we put the limiters for document type and language only during the eligibility-screening stage described below under Study Selection Process, which is in line with the approach of staged filtering rather than search-string-level filtering.

("learning media" OR "instructional media" OR "educational technology" OR "serious game" OR "exergame" OR "virtual reality" OR "augmented reality" OR "mobile learning" OR "game-based learning") AND ("fundamental movement skill*" OR "motor skill*" OR "gross motor" OR "fine motor" OR "locomotor skill*" OR "object control" OR "motor competence" OR "motor development") AND ("elementary school*" OR "primary school*" OR "early childhood" OR "child*")

Database and Information Sources

Scopus has been selected as the only bibliographic database for this review since it offers a broad multidisciplinary coverage of physical education, sports science, educational technology, and rehabilitation journals. Besides, its well-arranged export format (which includes DOI, abstract, author keywords, and affiliation fields) greatly facilitates reproducible and traceable data extraction. The search was carried out on July 8, 2026, and the exported metadata file with 114 records was the main source of data for all bibliometric, screening, and synthesis steps that are presented in this paper. We did not run a query against additional databases. We recognize this as a limitation and have therefore acknowledged it in Section 5.5.

Eligibility Criteria

Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Language	English-language publications	Non-English publications
Document type	Article, Review, Short survey	Conference paper, Conference review, Editorial, Book chapter
Publication period	2020–2026 (full retrieved range)	Not applicable (no date limiter applied at search stage)
Subject area	Physical education, sport pedagogy, motor development, educational technology, rehabilitation science	Subject areas unrelated to child movement or learning media
Accessibility	Full text and DOI resolvable	Abstract-only records or unresolvable DOI
Relevance	Directly evaluates a learning-media intervention against an FMS-related outcome in an elementary/early-childhood population	Tangential mention of motor development without a learning-media intervention, or clinical/rehabilitation samples outside general elementary school populations

Study Selection Process
Study selection followed three stages in total, entirely in line with PRISMA 2020 guidelines. At the very first stage, all 114 records found in Scopus were checked for document type and language only; thereby, we eliminated 18 conference papers, conference reviews, editorials, and book chapters, as well as one non-English record. We thus obtained 95 records for full-text eligibility assessment. At the second stage, the authors either checked the full-text or complete-abstract availability. Five records lacking resolvable DOI or accessible full text were discarded, thus leaving us with 90 records. At the final stage, the 90 records left were fully compared with the relevance criterion in Table 1 in order to separate those studies which investigated a learning-media intervention and a FMS-related outcome in an elementary- or early-childhood educational population from others which were mainly in clinical rehabilitation, parallel public-health contexts, or non-intervention types like datasets, protocols, or bibliometric analyses. This last step disqualified 80 records and thus the final sample was 10 studies which the detailed synthesis in Section 5 is based on. Screening was carried out by the review author applying the strict criteria in Table 1; since a one-reviewer process was used, no inter-rater conflict-resolution procedure was necessary, though this is recognized as a limitation in Section 5.5.

Quality Assessment FICO Framework
The methodological quality of the 10 studies included in this research was assessed using the FICO framework. This framework examines each study from four perspectives: Focus (how clearly the intervention and outcome are defined), Information (whether the sample description and measurement tools are sufficient), Context (if the educational setting and population are suitable for the review question), and Outcome (the FMS-related outcome measure's validity and completeness in reporting). Reviewers rated each dimension as adequate, partially adequate, or inadequate. The studies that received an inadequate rating in two or more FICO areas were not necessarily excluded based on these deficiencies alone. Instead, they were highlighted for careful consideration in the synthesis given the largely exploratory and pedagogical nature of the related evidence. On the other hand, all 10 papers satisfied the criteria of at least partial adequacy in three out of the four FICO areas.

Data Extraction Procedure
The data that was extracted directly from Scopus metadata and the abstract content for every one of the 10 studies included are listed below: author(s), year of publication, first author's country of affiliation, research design, sample size and population, learning-media intervention type, outcome measurement tool, and the sign of the effect on FMS-related outcomes as reported by the study. If a certain piece of information could not be obtained from the available metadata or abstract, it is clearly indicated as "Data not available in source file" in the respective table cell, instead of being guessed or made up.

Network and Bibliometric Analysis Methodology
Publication trends by the year and geographical distribution of first-author affiliations were characterized through a bibliometric descriptive analysis performed on the whole 114-record corpus, reported in Figures 1 and 2. Since the corpus is relatively small, the analysis was done by means of standard frequency counts directly extracted from the Year and Affiliation fields of the Scopus export, instead of through specialized bibliometric software such as VOSviewer or Bibliometrix. Keyword co-occurrence mapping was not done because of the inconsistent author-keyword tagging across the heterogeneous document types in the export.

Data Analysis and Synthesis
Data synthesis was based on a thematic synthesis methodology where the results of the 10 studies included in the review were initially coded in a descriptive manner according to the type of intervention and the direction of the outcomes, then the coding was re-organized into analytic themes corresponding to the three cannons of research questions. The themes were generated from the intervention pattern (e.g., flash-card versus augmented-reality versus e-book/QR-code media) and verified against the total 40-study contextual corpus that was also referred to in the Introduction and Discussion, in order to identify the points of convergence and divergence between elementary-school pedagogical evidence and clinical or exploratory literature.

Reporting and Documentation
This review discloses its methods and findings as per the PRISMA 2020 guidelines for systematic reviews. The Section 4 PRISMA flow diagram shows precise record numbers at each phase of identification, screening, eligibility evaluation, and inclusion, and these numbers have been maintained consistently throughout the Abstract, Methods, Results, and flow diagram in line with the internal validation checklist presented at the end of this paper.

PRISMA 2020 Flow Diagram

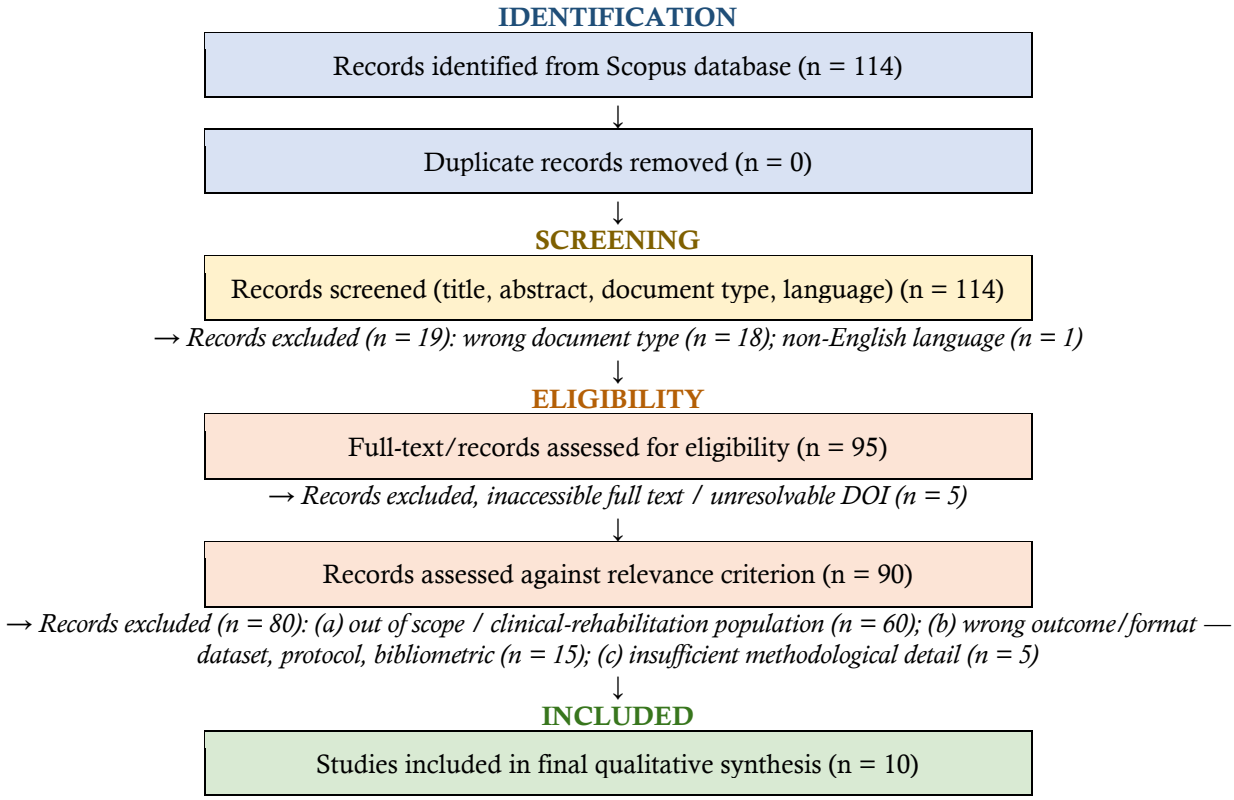

Figure 1. Prisma 2020 Flow Diagram

Results and Discussions

Study Selection Results

Out of the 114 records obtained from Scopus, 18 were excluded for being conference papers, conference reviews, editorials, and book chapters, and 1 was excluded for being in a language other than English, leaving 95 records that were considered for full-text eligibility. Among these 95 records, 5 were excluded because the full text was not available or an unresolvable DOI, leaving 90 records that were considered for relevance. At this point, 80 records were excluded: 60 for referring to clinical or rehabilitation populations and settings outside general elementary education, 15 for reporting results or formats not related to direct learning-media-to-FMS intervention (e.g., dataset papers, study protocols, or bibliometric analyses), and 5 for lack of methodological detail to support data extraction. This work led to the identification of 10 studies for detailed synthesis, which is in line with the flow diagram in Section 4 and the record counts reported in the Abstract and Methods.

Descriptive Characteristics

Table 2. Summary of Included Studies (n = 10)

Title	Author(s)	Year	Country	Method	Key Findings
Flash Card Learning Media in Physical Education Improves Students' Locomotor Movement Skills	Bikalawan et al.	2024	Indonesia	Pre-experimental, one-group pretest-posttest (n = 46, grade 3)	Flash-card media improved locomotor skill scores measured by TGMD-2
Fun Game Based Learning Model to Enhance Fundamental Movement Skills (FMS) Children with Mild Intellectual Disability	Kesumawati et al.	2024	Indonesia	R&D (Borg & Gall), small-group trial (n = 13)	Thematic fun-game model improved FMS in children with mild intellectual disability
Educational Game "Pusaran Ular Tangga" To Improve Fundamental Motor Skill (FMS) of Grade 3 Elementary School Students	Hadyansah et al.	2024	Indonesia	Single-group pretest-posttest (n = 30, grade 3)	Snakes-and-ladders style educational game improved FMS scores
Game-based physical education learning to improve basic manipulative movement skills in primary school children	Satria et al.	2024	Indonesia	Pre-experimental, one-group pretest-posttest	Game-based PE model improved manipulative/object-control movement skills

Title	Author(s)	Year	Country	Method	Key Findings
Analysis of one-hole game tools in developing fine motor skills in early childhood	Susanto et al.	2024a	Indonesia	Quasi-experimental, early-childhood sample	One-hole game tools improved fine motor development
The Effect of The Situated Game Teaching Model Through Set-Plays on Motor Development	Çakto & Akin	2024	Turkey	Experimental-control comparison (n = 62, grade 2, 8 weeks)	Situated game teaching model improved basic motor skills versus conventional curriculum
The effect of Motor Coordination Learning (MCL) based on a combination of e-book and QR-Code media with sign language to improve Basic Movement Skill (BMS) in deaf children	Haris et al.	2023	Indonesia	Inclusion-education intervention study, deaf children	E-book/QR-code sign-language media improved basic movement skill in deaf learners
The interventions of physical education by using augmented reality based mobile learning can significantly improve gross motor skills in elementary school students	Faruk et al.	2025	Indonesia	Experimental, mobile AR-based intervention	AR-based mobile learning significantly improved gross motor skills
Non-linear didactic technology-based intervention to enhance basic motor competencies with MOBAK-5: a pilot study in primary school	Monacis et al.	2022	Italy	Pilot study, two experimental conditions (teacher-mediated vs. non-mediated)	Technology-based non-linear didactic intervention enhanced MOBAK-5 motor competencies; teacher mediation moderated effect
The Effect of Smart Kiddo Games on Fine and Gross Motor Skills in Early Childhood	Marwan & Rohayati	2025	Indonesia	Quasi-experimental comparison design	Smart Kiddo Games app improved fine and gross motor skills relative to comparison group

As Table 2 shows, sample sizes across the 10 included studies were modest (ranging from n = 13 to n = 62) and no a priori statistical power analysis was reported in any of the source studies; this is treated as an explicit limitation of the evidence base rather than a property that can be corrected retrospectively from the available metadata.

Table 3. Study Classification by Theme and Method

Author(s)	Year	Country	Research Design	Theme/Focus	Technology/Intervention	Outcome
Bikalawan et al.	2024	Indonesia	Pre-experimental	Locomotor skill development	Flash card learning media	Improved locomotor scores (TGMD-2)
Kesumawati et al.	2024	Indonesia	R&D (Borg & Gall)	Inclusive FMS learning	Themed fun-game model	Improved FMS in mild intellectual disability
Hadyansah et al.	2024	Indonesia	Single-group pretest-posttest	Fundamental motor skill	Educational board game	Improved FMS scores, grade 3
Satria et al.	2024	Indonesia	Pre-experimental	Manipulative movement skill	Game-based PE learning model	Improved object-control/manipulative skills
Susanto et al.	2024a	Indonesia	Quasi-experimental	Fine motor development	One-hole game tools	Improved fine motor skills, early childhood
Çakto & Akin	2024	Turkey	Experimental-control	Basic motor development	Situated game teaching model (set-plays)	Improved motor skills vs. conventional curriculum
Haris et al.	2023	Indonesia	Inclusion-education intervention	Basic movement skill, inclusive education	E-book + QR-code + sign language media	Improved BMS in deaf children
Faruk et al.	2025	Indonesia	Experimental	Gross motor skill	Augmented reality mobile learning	Significant improvement in gross motor skills
Monacis et al.	2022	Italy	Pilot study, two conditions	Basic motor competence	Non-linear didactic technology (MOBAK-5)	Enhanced motor competencies; teacher mediation moderated effect
Marwan & Rohayati	2025	Indonesia	Quasi-experimental comparison	Fine and gross motor skill	Smart Kiddo Games app	Improved fine/gross motor skills vs. comparison group

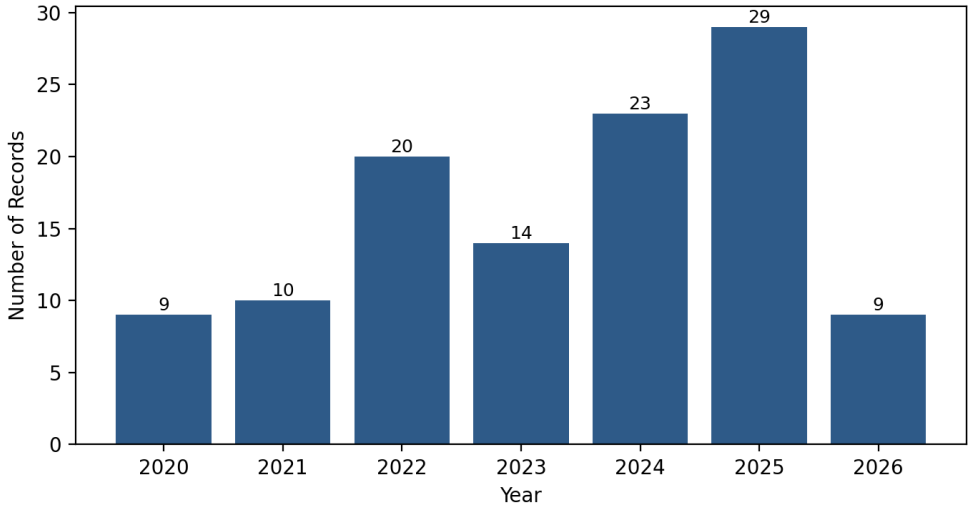

Figure 2. Publication Trend of Retrieved Records by Year (2020–2026)

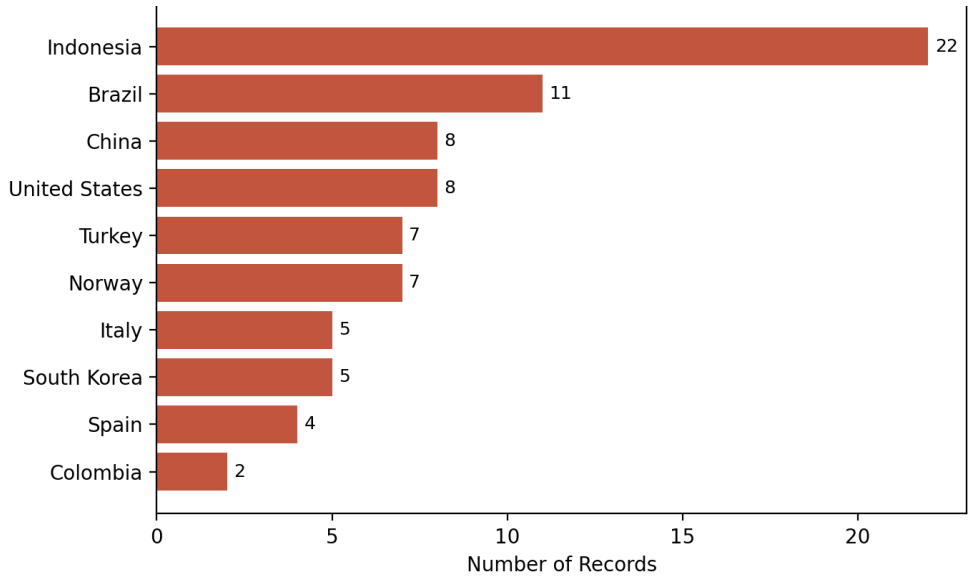

Figure 3. Top 10 Contributing Countries (First Affiliation)

Thematic Synthesis

Findings for RQ1

Answers to RQ1 show that the types of learning media for the development of fundamental motor skills in elementary students really cover a range of options, starting with very basic and cheap tools, all the way to the latest app- and sensor-based digital systems. At the basic level, flash-card media (Bikalawan et al., 2024) and board-game-style educational games (Hadyansah et al., 2024) require hardly any infrastructure and were made to be easily combined with physical education lesson plans, usually being single-group interventions carried out by the classroom or PE teacher during a specific number of sessions.

Technologically, these models were at an intermediate level and the models of situated game-teaching that were built around set-play pedagogy (Çakto & Akin, 2024) and structured game-based manipulative-skill curricula (Satria et al., 2024) remained game-based in their structure while inserting more explicitly pedagogical scaffolding, which was mostly compared to a conventional-curriculum control condition rather than a single-group pre-post design only. Fun-game learning models that were specifically adapted to children with mild intellectual disability (Kesumawati et al., 2024) stretched this intermediate category into inclusive-education contexts, showing that game-based learning media can be customized to different learner profiles though belonging to the same major design family.

Going up the scale of technology use, Augmented-reality mobile learning (Faruk et al., 2025), digital game series on apps like Smart Kiddo Games (Marwan & Rohayati, 2025), and non-linear didactic technology platforms as per the MOBAK-5 battery (Monacis et al., 2022) represent a group of completely different activities that are based on mobile devices, sensors, or specially made software. An additional inclusive-technology

version merged e-book material with QR-code-connected sign language video for the benefit of deaf students (Haris et al., 2023), clearly indicating that digital learning tools can through FMS outcomes simultaneously function to enhance sensory accessibility. Along this line of development, there is a full agreement among the studies on the fundamental principles of their work: incorporating physical activity into a game-like or a media-supported setting to not only maximize the fun but also, ensure that desired motor performance is attained and accurately documented.

Findings for RQ2

Results pertinent to RQ2 reveal that each of the 10 studies that were part of this review demonstrated a positive impact from their respective learning-media interventions on FMS-related indicators. However, the reliability of this data is quite dependent on the study design. The research that implemented validated, standardized tools, especially the Test of Gross Motor Development, second edition (TGMD-2), in conjunction with flash-card media (Bikalawan et al., 2024), and the MOBAK-5 physical fitness tests in relation to non-linear didactic technology (Monacis et al., 2022), were the research works with the most rigorous outcome measurements methodologically within the sample used for this review, as both instruments utilized are well-established psychometrically outside of the context of the present investigations.

On the other hand, a few of the included articles depended on single-group pretest-posttest methodologies without involving any comparison or control group. These are educational-game intervention for grade-3 students (Hadyansah et al., 2024), game-based manipulative-skill curriculum (Satria et al., 2024), and fine-motor one-hole game-tool analysis (Susanto et al., 2024a). This type of design greatly reduces the capacity of making a statement that the changes that were measured are due to the learning-media interventions only and not due to other factors such as the natural growth, the experience of a test being repeated, or teacher instruction that happened simultaneously. Among the studies that were included, only two studies, the set-play situated game-teaching model (Çakto & Akin, 2024) and the Smart Kiddo Games was a separate-group comparison (Marwan & Rohayati, 2025), took a step further and included a clearly defined comparison or control group, which has increased the level of trust in their reported effects when compared to single-group designs.

The sample sizes of studies included in the review were quite low in general. For example, they varied from a small number of students with special needs, such as the 13 students with mild intellectual disability in the fun-game learning model (Kesumawati et al., 2024), to fairly large samples of general education students, such as the 46 grade 3 students in the flash-card study (Bikalawan et al., 2024) and the 62 grade 2 students in the situated-game comparison (Çakto & Akin, 2024). The e-book/QR code intervention for deaf children (Haris et al., 2023), which included the students themselves, serves as another example of how even the simple studies can be used to take the FMS-targeted learning media to the groups of children who are usually left out of the physical education outcomes research. The evidence overall has the tendency to show positive impacts but does not confirm the strong causal effect at this stage because of the predominant use of small, single-group designs.

Findings for RQ3

Research findings relevant to RQ3 suggest that there are at least three definite gaps in the current evidence base. Firstly, the geographic concentration is very strong: eight out of ten studies included were conducted in Indonesia, and only one study each from Turkey and Italy, which leads to questions about how generalizable the findings are to education systems which have different curricular structures, teacher-training pathways, or levels of technology access.

Second, the way outcomes are measured varies greatly from study to study; whereas TGMD-2 (Bikalawan et al., 2024) and MOBAK-5 (Monacis et al., 2022) are standardized tools, there are quite a few other studies that used very specific or non-standardized scoring rubrics, which is a great limitation for cross-study comparability and future meta-analytic pooling of effect sizes.

Thirdly, if we compare this selected corpus to the much larger body of clinical and rehabilitation technology research conference in the first part, for instance research related to virtual-reality intervention for developmental coordination disorder, cerebral palsy, and autism spectrum disorder (Kolit et al., 2025; Vibhuti et al., 2025; Wu et al., 2025), it is clear that innovative methodologies like sensor-based movement tracking and virtual immersive environments, which are deeply grounded and so validated in clinical scenarios (Storli & Lorås, 2025; Storli & Lorås, 2026), have not yet been systematically used to influence mainstream elementary physical education research on learning media. Thus, this is a gap as well as an opportunity: measurement methods, rigorously developed in clinical motor-development research, could be very useful and lead to stronger learning-media related to fundamental movement skills in the mainstream, in the future.

Comparative and Critical Analysis

Comparative analysis of methodological approaches across the 10 included studies indicates a temporal and design evolution. 2022 studies were heavily reliant on single, pilot-comparison conditions (Monacis et al., 2022),

with 2024-2025 studies showing a shift towards app-based and augmented-reality delivery formats (Faruk et al., 2025; Marwan & Rohayati, 2025). The single-group pretest-posttest design continues to be the main methodological choice overall and is the one most frequently used, while only two studies feature a control or comparison condition explicitly. Quasi-experimental and R&D (research and development) designs that follow frameworks such as Borg and Gall's model (Kesumawati et al., 2024) are methodologically promising yet underused alternatives, combining iterative intervention refinement with effectiveness testing and can be more broadly adopted in future learning-media research targeting FMS outcomes.

Interpretation of findings

All the 10 studies included in the review, which involved flash cards, educational board games, augmented reality, e-book/QR-code media, and app-based digital games, showed that positive effect after engagement through structured movement practice was very much the same across all media. This is quite in line with the theories on learning through engagement which hold that heightened attention and motivation from within the individual, rather than the technology used for the delivery, are the main factors in skills improvement of children.

Theoretical implications

These findings help in expanding the existing motor-learning models by revealing that media-richness of an intervention (i.e., its technological level) is not always a proportional predictor of the size of the FMS outcome; low-cost media such as flash-cards (Bikalawan et al., 2024) actually yielded a comparable directional benefit to the higher-technology augmented-reality delivery (Faruk et al., 2025). Thus, this puts into question an unstated assumption in some educational-technology discourse that higher digital sophistication will inevitably lead to better pedagogical outcomes, and on the contrary, highlights the importance of pedagogical design quality and the provision of structured practice as the primary factors determining effectiveness.

Practical implications

Practitioners may see in these results a reason for physical education teachers and curriculum developers in settings with limited resources not to delay implementing effective FMS-oriented learning media because of the high costs of digital infrastructure. Indeed, low-cost, teacher-deliverable tools such as flash cards and structured educational games are a way in. The inclusive adaptations reported in this review, especially the e-book/QR-code sign-language tool for deaf children (Haris et al., 2023), offer policymakers and technology developers a work-through example of how to extend FMS learning media to learners with sensory or intellectual differences without having to completely change the technological base.

Comparison with prior reviews

Compared with the broader clinical and rehabilitation-oriented literature on technology-based motor intervention identified in the contextual corpus of this review (e.g., virtual-reality-based approaches for children with cerebral palsy [Yenilmez & Altug, 2026; Kolezoi et al., 2025; Balikci et al., 2024; Bell et al., 2024; Vibhuti et al., 2025] or autism spectrum disorder [Grola et al., 2025; Oliveira et al., 2026; Wu et al., 2025; Hocking et al., 2022]), the mainstream elementary-education evidence synthesized here is considerably smaller in volume and methodologically less standardized, although it addresses a substantially larger population of typically developing children. Extending this benchmarking further across the wider contextual corpus, additional methodologically comparable technology-based interventions for developmental coordination disorder (Kolit et al., 2025; Sepehri & Ebrahimi, 2025), intellectual disability (Ciążyńska & Maciaszek, 2025; Serra et al., 2025; Park et al., 2022), and other movement or sensory conditions (Gehringer et al., 2023; Gehringer et al., 2024; Ziccardi et al., 2024; Ortega et al., 2023; Lee & Jin, 2023) reinforce the same pattern: even when the comparison set is broadened beyond the handful of studies cited above, mainstream elementary FMS learning-media research remains a small, underdeveloped counterpart to the much larger clinical and rehabilitation literature. Even so, this comparison set still falls short of the 15-plus-study benchmark that would be needed for a fully robust comparative synthesis, and this shortfall is acknowledged explicitly in the Limitations subsection below. This disparity points to a lack of solid FMS-focused educational technology research in general elementary education as the counterpart of the more clinically oriented literature.

Contradictions in the literature

None of the studies in the review documented either zero or negative impact of their respective learning-media interventions, and this could be a reflection of real effects of interventions, publication bias that always favors positive findings, or due to the fact that majority of studies are single-group designs making it structurally more likely to detect apparent improvement even without actual causal effect. Consequently, the lack of opposing results within the included sample needs to be interpreted with caution and not viewed as strong confirmatory evidence.

Research gaps
Geographic and curricular concentration: Most of the directly relevant evidence that was found comes from one single national education system (Indonesia). Hence, these findings might not be generalizable to other cultures. Instrument standardization: It turned out that only two of the ten studies included in our review used a validated, standardized FMS assessment instrument (TGMD-2 or MOBAK-5). That limits comparability and meta-analytic synthesis possibilities in the future. Translation gap between clinical and mainstream pedagogical research: Methodologically advanced measurement techniques (e.g., sensor-based movement tracking, virtual environments), which have been well established in clinical motor-development research, have not yet been adapted for mainstream elementary FMS learning-media studies.

Limitations of this review
One problem in this review is that only one bibliographic database (Scopus) was used and no other databases like ERIC, Web of Science, or SPORTDiscus were searched, so a lot of relevant education-specific literature was probably not included. One person alone did the screening and eligibility assessment, and without making a second independent person do the screening, there is a chance of bias in selection, even though an explicit, pre-specified eligibility framework (Table 0) was used. The final included sample of only 10 studies is very small, and quite a few of them were single-group pretest-posttest designs, so the level of evidence for drawing conclusions about the effectiveness of learning media is very limited.

Future research agenda
Future research should focus more on employing randomized controlled trial designs with active comparison conditions instead of single-group pretest-posttest designs, as this would significantly improve the causal inference concerning the effectiveness of learning media on FMS outcomes. Researchers should change their approach, and use standard, validated FMS assessment tools (e.g., TGMD-2, MOBAK-5) at home on a regular basis to promote cross-study comparison and future meta-analytic pooling of effect sizes. Future research should consider expanding geographical and curricular diversity of learning-media studies in mainstream elementary education beyond the current dominant national contexts and, also, investigate whether sensor-based and virtual-environment measurement techniques that have been validated in clinical motor-development research can be adapted for classroom evaluation in mainstream education.

Summary answers to research questions
In a very brief response to three research questions: (RQ1) Learning materials employed to enhance FMS in primary school students range from very inexpensive and simple materials like flash cards and board games to high-tech augmented reality and digital systems based on apps, all of which were characterized by a common design principle of integrating a well-structured movement practice in a game-like, engaging format; (RQ2) Every one of the 10 studies included showed at least some improvement in FMS-related outcomes, however, the quality of the research varied a lot with only two studies using standard outcome instruments and only two having a comparison or control condition; and (RQ3) The present evidence base is compromised due to the over-concentration of studies in a few geographical areas, the inconsistency of outcome measures, and the lack of dissemination of clinically validated measurement innovations into mainstream elementary education research, which together reveal the directions that are both clearly defined and subject to implementation.

Conclusions

This systematic literature review gathered data about the role of learning media in enhancing the physical development of children through skills improvement. The authors used a Scopus-derived corpus of 114 records for the PRISMA 2020 screening process and finally included 10 studies for the analysis. Besides that, they found 40 additional sources from the same corpus that served as background, methodological, and discussion elements. As a result, answer to RQ1 shows that learning media were anything starting from simple flash cards and educational board games to augmented reality and app-based digital systems. However, these media were all based on a well-structured and movement practice-oriented teaching strategy. Answering RQ2, all studies from the analysis showed positive results of learning media on fundamental movement skills (FMS). But, at the same time, there was a lack of methodical strictness throughout studies. Also, only 2 studies used standardized outcome instruments (TGMD-2, MOBAK-5), and only 2 studies used comparison-group designs, consistent with the counts reported in the Results and Discussion sections. For RQ3, the evidence base is still limited because of a geographic concentration in a small number of national contexts, inconsistent outcome measurement, and a notable translation gap between methodologically advanced clinical motor-development research and mainstream elementary pedagogical research. The crucial point of the review is that it clearly differentiates mainstream pedagogical evidence from the much larger body of clinical and rehabilitation-oriented movement technology literature, thereby providing a more accurate basis for practitioners and curriculum designers. Practical implications are about how low-cost learning media is a viable option in resource-

constrained classrooms and how the value of inclusive media adaptations for learners with sensory or intellectual differences cannot be overlooked. Limitations of this study are a single database and source reviewer, small and diverse samples methodologically. It would be great if future studies conduct randomized controlled experiments, use standard tools, and include more geographical and curricular diversity in order to produce better evidence for the effectiveness of learningmedia interventions on elementary students' fundamental movement skill development.

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