



Project-Based E-Modules for Teaching the Human Movement System in Secondary Schools

Eka Liana^{1*}, Paidi²

Universitas Negeri Yogyakarta

Corresponding Author: Eka Liana: eka0067fmipa.2023@student.uny.ac.id

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ABSTRACT

This study synthesises empirical evidence on the design and implementation of project-based e-modules for teaching the human movement system in secondary schools. The review is motivated by persistent fragmentation in students' understanding of the relationships between structure, function, and biomechanics, and by the under-use of digital technologies and culturally grounded movement contexts in biology and physical education. A systematic literature review was conducted using Scopus, targeting articles published between 2020 and 2025 in English, open access, and reporting primary data. From 163 initial records, a PRISMA-based multi-stage screening process yielded 15 eligible studies. Data on context, samples, designs, interventions, media, and learning outcomes were extracted and synthesised thematically. The findings show that projects using 3D models, makerspaces, local martial arts, high-intensity interval training, web-based dance learning, artificial-intelligence-supported exercise monitoring, and computer interfaces can improve conceptual understanding, motor skills, motivation, and movement and science literacy.

INTRODUCTION

Teaching the human movement system in secondary schools is strategically important because it underpins students' biology literacy, health awareness, and active lifestyles. However, research indicates that students often view body systems in isolation and struggle to see how bones, muscles, and nerves form an integrated system (Snapir et al., 2017). A systems-thinking perspective on body systems helps learners link structure, function, and physiological dynamics more meaningfully (Raved & Yarden, 2014). In science classrooms, systems-oriented instruction can strengthen students' ability to explain complex biological phenomena and avoid fragmented misconceptions (Gilissen et al., 2020; Momsen et al., 2022). Taken together, these findings suggest that strengthening understanding of the human movement system requires learning designs that go beyond factual presentation and support students to model relationships among body components and connect them to everyday motor activities in reflective and contextual ways.

Another emerging challenge concerns the need for instructional strategies that combine conceptual understanding with twenty-first-century skills such as critical thinking, collaboration, and creativity. Synthesis studies show that project-based learning (PjBL) has positive effects on achievement and engagement because it positions students as designers of authentic solutions through extended projects (Kingston, 2018). In Indonesian contexts, PjBL has been reported to enhance creativity and independence when students are tasked with designing tangible products and presenting their findings (Ummah et al., 2019). In science education, PjBL can foster higher-order thinking through structured investigative and problem-solving activities (Kardoyo et al., 2020). Classroom practice in biology also suggests that differentiated project tasks and teacher scaffolding can accommodate diverse abilities within the same group of learners (Fajrina et al., 2024). The human movement system is therefore well-suited to PjBL so that structure, function, and mechanics are learned through designing and testing projects that are directly relevant to students' real lives.

Developments in educational technology have driven the use of e-modules as flexible, interactive media in science learning. Well-designed e-modules have been shown to be valid, practical, and effective in improving lower-secondary students' scientific explanation skills in integrated science (Mardhiyyah et al., 2022). Integrating multimedia features and interactive activities into organ-system topics can also enhance motivation and engagement in biology learning (Kale et al., 2021). Digital flipbook-based e-modules further support self-regulated learning and align well with the characteristics of the digital generation (Humairah & Wahyuni, 2024). When e-modules are integrated with local socio-cultural contexts, they can effectively strengthen science literacy and students' sense of connection to their environment (Utari et al., 2024). Thus, e-modules offer a robust pedagogical and technological foundation for packaging human movement content so that it is more accessible, personalisable, and suitable for both independent and collaborative study.

A growing body of work on digital media development indicates that the quality of instructional design in e-modules strongly determines their impact on

science literacy and higher-order thinking. Biology e-modules that integrate unity-of-sciences perspectives with science literacy, for example, have been found feasible and effective for deepening conceptual understanding of biodiversity (Octaviani et al., 2023). Digital teaching materials explicitly grounded in science literacy frameworks also produce significant gains in secondary-level students' critical-thinking skills (Tiara & Mubarok, 2023). In higher education, e-modules based on Google Sites have improved biology students' creative-thinking skills through open-ended tasks that demand exploration and idea generation (Lativa et al., 2024). At upper-secondary level, biology e-modules built with Flip PDF Professional have been shown to improve learning outcomes and critical thinking simultaneously (Purnamasari et al., 2024). These findings underscore the importance of e-modules that not only present content but also orchestrate projects, data exploration, and conceptual reflection in a structured manner.

Recent research trends reveal a shift from e-modules as mere "digital books" towards richer, multimodal, project-oriented learning ecosystems. Google Sites-based e-modules, for instance, have been shown to optimise critical-thinking skills through integrated exploration and reflection tasks (Susanti et al., 2023). A literature review of e-module research in Indonesian biology-education journals highlights the dominance of R&D designs, while also signalling the need for deeper examination of varied models, content, and implementation contexts (Almaas et al., 2025). Other innovations, such as STEM-based e-modules with virtual simulations and augmented-reality e-modules using problem-based learning, demonstrate strong potential for developing science and digital literacy simultaneously (Tyas & Sumiati, 2025; Nst & Ariyanti, 2025). Nonetheless, there remains a notable gap in systematic reviews on project-based e-modules that specifically target the human movement system in secondary education and link it explicitly to curriculum demands and twenty-first-century skills.

METHOD

Review design

This study employed a systematic literature review (SLR) focusing on project-based learning and digital media (including e-modules and web-based resources) used to teach the human movement system and movement-related activity in secondary-school contexts and their supporting ecosystems (physical education teachers, facilities, and learning environments). The review followed PRISMA stages of identification, screening, eligibility, and inclusion, with explicit reporting of inclusion–exclusion criteria and the selection process.

Search strategy

The search was conducted exclusively in the Scopus database using the following query: (project-based learning OR project based learning) AND (biology OR science education) AND (human body movement OR musculoskeletal system) AND (secondary school OR high school OR upper secondary)

The search was refined through successive filters:

1. Publication year: 2020–2025, yielding 116 records from an initial 163.

2. Document type: restricted to journal articles (excluding conference papers, book chapters, and editorials), resulting in 39 articles.
3. Language: limited to English, retaining 39 articles.
4. Access type: restricted to open-access articles, producing 28 articles for further screening.

Eligibility criteria

Inclusion and exclusion criteria were aligned with the review question on project-based e-modules for teaching the human movement system at secondary level.

Inclusion criteria

1. Articles published between 2020 and 2025, indexed in Scopus, and available in English as open-access.
2. Document type: original empirical research reporting primary data (experiments, quasi-experiments, research and development, design-based research, quantitative surveys, qualitative or mixed-methods studies).
3. Domain and context:
 - Science/biology education including human movement, anatomy, musculoskeletal system, or
 - Physical education and sport (physical activity, coordination, training, HIIT, inclusive movement, functional movement) involving secondary-school aged learners or teachers working with this group.
4. Use of:
 - Project-based, task-based, or authentic activities (e.g., HIIT programming, 3D modelling, integration of indigenous movement), and/or
 - Digital technology/e-learning/web-based tools that can inform project-based e-module design.
5. Participants:
 - Secondary-school students;
 - Teachers, student-teachers, athletes, or university students in contexts that can be meaningfully transferred to human movement teaching in secondary schools.

Exclusion criteria

1. Review, SLR, meta-analysis, bibliometric, or portfolio studies based on secondary data.
2. Purely conceptual or theoretical articles without empirical data collection.
3. Studies unrelated to science/biology or physical education; or with no substantive link to movement, project work, or educational technology.
4. Retracted or ethically problematic articles (none were identified in the dataset).
5. Studies focused solely on macro-level policy or SDG indicators without clear link to teaching practice or educational interventions.

Study selection and PRISMA flow

From the 28 open-access articles, screening followed PRISMA logic:

1. Identification
 - Initial records from Scopus: n = 163.
 - After restricting to 2020–2025: n = 116.
 - After filtering by article type, English language, and open access: n = 28.
2. Screening (titles and abstracts)
 - The 28 records were screened for relevance to movement, project-based approaches, and educational technology.
 - Thirteen articles were excluded, primarily because:
 - Five were SLR/review/meta-analysis/bibliometric studies.
 - Three focused on macro-level policy or SDG indicators with no clear link to classroom practice in movement education.
 - Five were in education but lacked substantive connection to movement, project work, or learnable digital media.
3. Eligibility (full-text assessment)
 - The remaining 15 articles were assessed using full texts and Scopus detail pages to confirm:
 - Use of primary data;
 - Relevance to physical activity, human movement systems, or the design of movement-related teaching/training;
 - Potential for informing project-based e-module design.
4. Included
 - All 15 articles met the inclusion criteria and were retained for qualitative synthesis.

In the final manuscript, this process can be visualised as a PRISMA flow diagram showing records identified, screened, excluded with reasons, and included in the synthesis.

Data extraction and synthesis

For each of the 15 included studies, data were systematically extracted on:

1. Authors and year;
2. Country and research context;
3. Sample characteristics (size, level, and role);
4. Research design (e.g., quasi-experiment, R&D, DBR, survey, ethnography);
5. Nature of intervention or project (e.g., HIIT programming, makerspace STEM, indigenous martial arts, web-based dance, AI-supported monitoring);
6. Technologies or media used (e.g., 3D printing, web platforms, AI systems, computer interfaces);
7. Main cognitive, affective, and motor outcomes;
8. Key implications for movement-system teaching.

A narrative thematic synthesis was conducted, grouping findings into four clusters:

1. Project-based and digital approaches in science/biology;
2. Design of training programmes and physical activity projects;

3. Teacher capacity and learning environments;
4. Movement data and coordination as content and assessment sources.

RESULTS

Overview of included studies

The 15 included studies were published between 2020 and 2025, with the largest concentration in 2021 and 2024. They span biology education, physical education, sport science, and movement-related learning environments. Designs include quasi-experiments, R&D/DBR, cluster-randomised protocols, surveys, and qualitative or mixed-methods studies. Interventions and contexts range from AI-supported training systems and 3D-printed models to indigenous martial arts, inclusive swimming programmes, and school-based professional development.

Summary of individual studies

Table 1. Summary of the 15 included studies

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
1	Gul & Yalinkilic (2025)	61 Grade 9 students in a Turkish secondary school	Quasi-experimental design with experimental and control groups; the experimental group learned "Biomolecules in Living Organisms" using 3D-printed models over nine weeks, while the control group used conventional materials.	3D-printed models significantly improved students' achievement and retention compared with traditional instruction. Students reported that the models were engaging and helped them concretise abstract concepts, suggesting strong potential for project-based modelling tasks in biology e-modules.
2	Oshanova et al. (2025)	80 third-year physical education and fitness students divided into experimental	Controlled experiment; the experimental group trained using an AI-driven real-time	The AI-supported system increased engagement, motivation, satisfaction, and reduced injury

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
		and control groups	exercise monitoring system within a computer-supported collaborative learning environment, while the control group followed traditional training.	risk relative to conventional training. The study demonstrates that AI-based monitoring can be integrated into digital learning projects and assessment of movement quality.
3	Wang et al. (2025)	75 junior high-school STEM teachers in Taiwan receiving government STEM funding	Quantitative survey with descriptive statistics and logistic regression examining decisions on STEM equipment procurement and classroom space.	Teachers preferred equipment that is simple, safe, practical, and versatile; procurement decisions were strongly influenced by perceived usefulness. The study provides guidance on facilities and tools that can realistically support project-based STEM and movement-related activities in schools.
4	Kusmiyati et al. (2024)	40 primary-school physical education teachers in Cilacap, Indonesia	Descriptive quantitative survey using a self-efficacy questionnaire related to the National Sports	Teachers' self-efficacy was in the moderate-to-high range and positively associated with participation in DBON

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
			Grand Design (DBON).	programmes. Strengthening self-efficacy through training and institutional support is recommended to improve teachers' readiness to manage physical-activity projects and utilise e-modules.
5	Hardiansyah et al. (2024)	105 primary-school physical education teachers (certified and non-certified) in West Sumatra	Comparative survey measuring attitudes towards stimulating higher-order thinking skills (HOTS) in PE; Mann-Whitney U and Kruskal-Wallis tests were applied.	Certified teachers showed significantly more positive attitudes towards HOTS than non-certified teachers, whereas no differences were found by gender, age, or years of service. The findings highlight the need for professional development and materials, including e-modules, that explicitly support HOTS in PE.
6	Yulianto et al. (2024)	20 wheelchair tennis athletes (aged 28-36)	Research and development using a 4D model (define, design, develop, disseminate) to create a wheelchair-tennis-specific HIIT	The HIIT programme showed excellent content validity (CVR = 1.00) and significantly improved athletes' reactive agility. The

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
			programme; content validity assessed by experts and effectiveness tested using reactive-agility measures.	structured development approach offers a strong model for designing movement-training projects to be adapted into e-module activities for students.
7	Gravel & Puckett (2023)	Teachers and students in a large comprehensive high school in the United States	Qualitative, multi-year ecological organisational study exploring teachers' implementation of a STEM makerspace through observations and interviews.	Four "distances" (skills and expertise, physical space, disciplinary learning, structural factors) influenced how teachers implemented makerspace projects. The study emphasises the need to view teachers as multilevel actors and to provide structural support for project-based reform.
8	Elvianasti et al. (2023)	Betawi silat beksi practitioners and observations of movement for biology-education purposes	Descriptive ethnoscience study reconstructing silat beksi movements as contexts for learning the movement system; data collected through	Twelve movement sequences were mapped to bones, joints, muscles, and types of movement. Silat beksi was shown to be a rich context for teaching the

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
			interviews and observation.	human movement system, illustrating the value of integrating indigenous movement into biology curricula and e-modules.
9	Lampert et al. (2021)	22 junior- and 20 senior-secondary students in Germany; 9 scientific publications representing scientists' conceptions	Mixed-methods study comparing students' and scientists' conceptions of socioeconomic growth within planetary boundaries by analysing statements and literature.	Students tended to attribute environmental change mainly to population growth, whereas scientists emphasised resource consumption by wealthy nations. The study produced instructional guidelines to help learners develop more sophisticated conceptions, relevant for situating movement and lifestyle within sustainability discourse.
10	Carraro et al. (2022)	Secondary-school PE teachers and their classes in Italy	Cluster-randomised trial protocol for PE4MOVE, an internet-supported continuous professional	The protocol details a blended CPD model combining face-to-face sessions, webinars, and online workshops, with

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
			development programme to promote physical activity among students.	planned measures of teacher and student outcomes. It demonstrates how online platforms can drive changes in PE teaching, offering a framework for teacher-facing components of movement e-modules.
11	Addivinola et al. (2021)	45 Grade 11 students (three groups of 15) learning volleyball serving	Experimental study with three didactic approaches: cognitive, ecological-dynamic, and mixed; hand-eye coordination and serve performance were assessed pre- and post-intervention using ANOVA and Bonferroni post hoc tests.	All groups improved, but the mixed approach produced the largest and statistically significant gains in hand-eye coordination and serve performance. Combining technical, experiential, and motivational elements appears most effective, informing the design of project tasks in movement e-modules.
12	Imparato et al. (2021)	12 swimmers (6 with lower-limb disability, 6 non-disabled)	Multi-component training intervention over several weeks including HIIT,	The programme improved performance in both groups and reduced the

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
			Tabata, Pilates, and physiotherapy to improve hip joint range of motion and performance.	performance gap between disabled and non-disabled swimmers. The study highlights how structured training projects can support social inclusion and adaptive movement, relevant for inclusive e-module activities.
13	Sekarningsih et al. (2021)	Secondary-school students and teachers trialling a web-based dance-learning platform	Design-based research developing and evaluating a web-based dance-learning site; expert validation and user testing with mixed qualitative and quantitative analysis.	The web platform was found feasible, relevant, and accessible, and it supported digital literacy and dance learning during remote education. Its structure and features offer a concrete model for web-based e-module design in movement education.
14	Gaetano et al. (2021)	Adults in Italy responding to an online questionnaire about physical activity before and during COVID-19 restrictions	Cross-sectional survey with cluster analysis of changes in indoor and outdoor physical activity and adaptation strategies during gym closures.	Many respondents continued to exercise, shifting to independent and outdoor activities under health protocols. The study underscores the importance of flexible, safe activity options

No	Authors (year)	Sample / Participants	Research design & intervention	Main findings / Conclusions
				and digital guidance – conditions that project-based movement e-modules can help provide.
15	Kovari et al. (2020)	Participants completing computer-based tasks involving drawing and tracking	Quantitative correlational study examining relationships between visual attention and eye-hand coordination using mouse-tracking and eye-tracking measures.	Negative correlations were found between visual-attention indices and certain hand and eye parameters, while the distance between gaze and cursor showed no correlation. The study suggests that computer interfaces can be used to train and assess visual-motor coordination in educational tasks.

DISCUSSION

The findings of this SLR indicate that teaching the human movement system requires concrete, contextualised task design so that abstract concepts become more accessible to learners. Integrating makerspaces at secondary level demonstrates how engineering-style projects enable teachers to orchestrate more meaningful and scaffolded STEM experiences (Gravel & Puckett, 2023). The use of 3D models for biomolecules similarly enhances understanding and retention by allowing students to manipulate physical representations that would otherwise remain purely textual (Gul & Yalinkilic, 2025). At the same time, science teaching that situates the body within planetary boundaries challenges how students construe the relationship between human activity and Earth systems (Lampert et al., 2021). Overall, this evidence suggests that project-based e-modules on the human movement system should combine strong visual representations, space for exploration, and global science contexts to deepen and sustain conceptual understanding.

Cultural and sport dimensions of movement open wide possibilities for authentic projects within e-modules. Reconstruction of silat beksi as indigenous knowledge shows that patterns of bones, joints, and muscles can be explained through familiar movement sequences (Elvianasti et al., 2023). A wheelchair-tennis-specific HIIT programme illustrates how carefully designed bouts and rest intervals can significantly increase reactive agility (Yulianto et al., 2024). A mixed cognitive and ecological-dynamic approach to volleyball serving contributes to greater hand-eye coordination gains than single-path instruction (Addivinola et al., 2021). A multi-component adaptive swimming programme also improves joint range of motion and reduces performance gaps between disabled and non-disabled athletes (Imparato et al., 2021). Thus, human-movement e-modules for secondary schools can be designed as sequences of analysis and design projects grounded in local culture and inclusive sport practices.

Digital technology emerges as crucial for expanding the range of projects and movement assessment. AI-driven exercise-monitoring systems within collaborative learning environments have been shown to improve engagement, motivation, and safety in physical-education programmes (Oshanova et al., 2025). Web-based dance-learning platforms for secondary students demonstrate that online environments can serve as both repositories of movement resources and spaces for creative exploration during remote learning (Sekarningsih et al., 2021). Cluster-randomised protocols for internet-supported CPD show how blended online models can progressively transform PE teachers' practices (Carraro et al., 2022). Research on visual attention and eye-hand coordination using mouse tracking confirms that computer interfaces can be harnessed to train fine motor skills (Kovari et al., 2020). Consequently, project-based e-modules should embed tasks using digital monitoring, screen-based training, and web platforms as integral components of movement-learning experiences.

Teacher readiness appears as a key determinant of whether projects and technologies are enacted in classrooms. Self-efficacy among physical-education teachers in contributing to national sport strategies is at a moderate-to-high level but still requires strengthening through structured training (Kusmiyati et al., 2024). Attitudes towards HOTS are more positive among certified teachers than non-certified peers, with little variation by gender or experience (Hardiansyah et al., 2024). In high-school makerspaces, institutional position, workload, and organisational structures shape how teachers interpret and enact project tasks (Gravel & Puckett, 2023). Decisions about STEM equipment procurement are heavily influenced by teachers' perceptions of usefulness, safety, and practicality (Wang et al., 2025). Looking ahead, human-movement e-modules must be accompanied by realistic teacher guides that address professional capacity, school policy, and facility constraints so that project work does not remain a rhetorical aspiration.

The physical and social environments in which students move also shape project design in e-modules. Evidence on STEM equipment procurement shows that schools prioritise multifunctional, easy-to-operate tools compatible with limited classroom space (Wang et al., 2025). During the COVID-19 pandemic, restrictions drove a shift from gym-based exercise to independent home- or

outdoor-based activities while adhering to strict health protocols (Gaetano et al., 2021). AI-based exercise monitoring can help oversee movement quality even when practice occurs in less controlled settings than school gyms (Oshanova et al., 2025). These findings imply that projects in e-modules should be designed to be flexible, feasible at school and at home, and supported by simple devices and clear safety guidelines so that students' physical activity can be sustained under varying conditions.

Assessment and movement data occupy a central position in designing genuinely evidence-driven e-modules. Use of 3D models in biomolecule teaching illustrates how achievement tests and interviews can capture changes in conceptual understanding and retention after representational projects (Gul & Yalinkilic, 2025). Hand-eye coordination tests before and after volleyball-serve training provide concrete indicators of the effectiveness of mixed didactic routes for motor skill development (Addivinola et al., 2021). Correlational analysis of visual-attention parameters and hand-eye measures confirms the feasibility of low-cost computer-based tools for coordination assessment (Kovari et al., 2020). Adaptive swimming programmes that track range-of-motion changes similarly emphasise the value of functional movement indicators (Imparato et al., 2021). Accordingly, human-movement e-modules should embed project assessment schemes that integrate cognitive tests, motor indicators, and simple digital data to generate comprehensive feedback.

Dimensions of sustainability, inclusion, and movement literacy converge as key value orientations for e-module development. Silat beksi as a context for the movement system illustrates the integration of science, culture, and local identity in biology learning (Elvianasti et al., 2023). HIIT programmes for wheelchair-tennis athletes show how training design can enhance performance while affirming the social presence of athletes with disabilities (Yulianto et al., 2024). Teaching Earth systems within planetary boundaries helps students appreciate the consequences of lifestyles and human activity on global ecosystems (Lampert et al., 2021). Web-based dance learning and adaptations in physical activity during the pandemic demonstrate the capacity of digital media to sustain movement literacy and bodily expression under constrained conditions (Sekarningsih et al., 2021; Gaetano et al., 2021). Overall, project-based e-modules for the human movement system should not only address anatomy and mechanics, but also foster sustainability, inclusion, and cultural sensitivity in students' movement practices.

CONCLUSION

This systematic review shows that developing project-based e-modules for teaching the human movement system in secondary schools requires the integration of three main pillars: authentic movement experiences, purposeful use of digital technologies, and strengthened teacher capacity. Projects rooted in local culture, sport, and structured physical training have been found to enhance conceptual understanding, motor skills, and motivation, while also opening space for inclusion across different abilities. AI-enabled monitoring systems,

web-based platforms, and computer interfaces provide new ways to organise tasks, deliver feedback, and conduct richer movement assessments.

At the same time, teacher self-efficacy, attitudes towards higher-order thinking, facility availability, and school-level policies substantially influence the likelihood that project-based and technological approaches will be implemented. Synthesising evidence from 15 empirical studies, this review recommends that human-movement e-modules for secondary schools be designed as flexible, contextualised, and equitable project packages, accompanied by teacher guidance and multimodal assessment schemes that integrate cognitive, affective, and psychomotor domains. Such e-modules can connect anatomical and physiological content with students' lived experiences, while cultivating movement literacy, sustainability, and care for the body and environment. Future research should focus on design-based and experimental studies that implement and evaluate these e-modules in real classrooms, examining their impact on diverse learner groups and school contexts.

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