

COMPETENCY-BASED IMPROVEMENT OF UNIVERSITY TRACK AND FIELD INSTRUCTION THROUGH DIGITAL-BIOMECHANICAL PEDAGOGY, INDIVIDUALIZED LOAD MANAGEMENT, AND DATA- INFORMED ASSESSMENT

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Abstract

This article theoretically and methodologically substantiates an integrated competency-based, digital-biomechanical, and load-monitored model for improving university track and field instruction. Its central claim is that effective athletics teaching cannot be reduced to routine drill repetition or the isolated use of technology; it must align technical structure, differentiated workload, augmented feedback, data-informed assessment, and reflective student participation within a single instructional architecture. The study develops a four-layer model applicable to sprint, jump, throw, and endurance units in mixed-ability higher-education cohorts. In this model, movement quality, functional adaptation, digital analysis, and pedagogical transfer are treated as interdependent rather than separate outcomes. The article demonstrates that such a design can reduce persistent technical errors, improve instructional individualization, strengthen students' capacity for self-analysis, and shift evaluation from narrow normative testing toward multidimensional competence growth.

Keywords: track and field, higher education, sport pedagogy, digital pedagogy, biomechanical feedback, load monitoring, blended learning, competency-based education, data-informed assessment, e-portfolio

Introduction

Annotatsiya

Ushbu maqolada oliy o'quv yurtlarida yengil atletika mashg'ulotlarini takomillashtirish uchun kompetensiyaviy, raqamli-biomekanik va yuklama monitoringiga tayanuvchi integrallashgan pedagogik model nazariy-metodik jihatdan asoslanadi. Modelning markaziy g'oyasi shundan iboratki, yengil atletikani samarali o'qitish alohida mashqlar majmui yoki texnik vositalar yig'indisi sifatida emas, balki texnik tuzilma, differensial yuklama, tezkor qayta aloqa, ma'lumotga asoslangan baholash va reflektiv o'quv faoliyati birligida tashkil etilishi lozim. Tadqiqot natijasida sprint, sakrash, uloqtirish va chidamlilik

yo'nalishlari uchun qo'llanishi mumkin bo'lgan to'rt qatlamli model ishlab chiqildi; unda harakat sifati, funksional moslashuv, raqamli tahlil va pedagogik transfer o'zaro bog'liq ko'riladi. Maqolada bunday model aralash tayyorgarlik darajasiga ega talabalarda texnik xatolarni kamaytirish, yuklamani individuallashtirish, mustaqil tahlil ko'nikmasini rivojlantirish va yakuniy natijani faqat normativ ko'rsatkichlar bilan emas, balki kompetensiyaviy o'sish bilan baholash imkonini berishi ko'rsatiladi.

Kalit so'zlar: yengil atletika, oliy ta'lim, sport pedagogikasi, raqamli pedagogika, biomekanik qayta aloqa, yuklama monitoringi, blended learning, kompetensiyaviy yondashuv, data-informed assessment, elektron portfolio

Аннотация

В статье теоретически и методически обосновывается интегрированная компетентностная, цифрово-биомеханическая и нагрузочно-мониторинговая модель совершенствования преподавания лёгкой атлетики в высшей школе. Её ключевая идея состоит в том, что эффективное обучение лёгкой атлетике не может сводиться к повторению упражнений или эпизодическому использованию технологий; оно должно объединять техническую структуру движения, дифференцированную нагрузку, оперативную обратную связь, оценивание на основе данных и рефлексивное участие студента в рамках единой педагогической архитектуры. В исследовании разработана четырёхслойная модель, применимая к спринту, прыжкам, метаниям и видам на выносливость в условиях смешанных по подготовленности студенческих групп. Показано, что такая организация обучения позволяет сокращать устойчивые технические ошибки, индивидуализировать нагрузку, развивать навыки самоанализа и смещать оценивание от узких нормативных показателей к многомерному росту компетентности.

Ключевые слова: лёгкая атлетика, высшее образование, спортивная педагогика, цифровая педагогика, биомеханическая обратная связь, мониторинг нагрузки, смешанное обучение, компетентностный подход, оценивание на основе данных, электронное портфолио

University track and field instruction requires revision not because athletics has lost relevance, but because its pedagogical organization in many higher-education settings still remains methodologically thinner than the movement demands it is expected to develop. The traditional scheme - brief explanation, demonstration, collective repetition, and final norm-based control - is administratively simple, yet it poorly addresses mixed student readiness, weak technical self-awareness, uneven adaptation to training loads, and the growing expectation that university learning should be analytical, digitally supported, and competence-oriented. In athletics this contradiction is especially visible. Sprinting,

jumping, throwing, and endurance work are not merely sets of exercises; each depends on highly organized coordination, rhythm, spatial control, force application, error detection, and the ability to adjust performance under fatigue and feedback. When instruction treats these events as uniform motor routines, students may remain active without becoming technically literate. More prepared learners are often insufficiently challenged, while weaker learners accumulate compensatory errors that later become stable. Consequently, visible participation increases, but movement economy, technical accuracy, and pedagogical transfer remain limited.

The problem is sharpened by changes in the university environment. Athletics is now taught within institutions where blended learning platforms, smartphone video, basic timing systems, wearable monitoring, cloud documents, and e-portfolios are increasingly available. Higher education now expects students not only to perform but also to interpret, regulate, explain, and transfer what they learn. Accordingly, track and field should cultivate technical execution, biomechanical understanding, workload self-regulation, reflective analysis, and, where relevant, future teaching competence. A course that measures success only through attendance and terminal performance norms therefore captures too little of its actual educational mission. The central issue is not the absence of devices themselves; it is the persistence of an instructional logic in which technology, assessment, and load planning remain add-ons instead of integrated pedagogical mechanisms.

Existing scholarship provides useful but incomplete foundations for modernization. Motor-learning research highlights the value of augmented feedback, variable practice, cueing, and the gradual transfer from externally controlled execution to self-regulated performance. Sport pedagogy and physical-education research emphasize formative assessment, differentiated task design, learner agency, and reflective participation. Training science demonstrates the importance of individualized load management, readiness monitoring, and the coordinated use of sprint, jump, resistance, and conditioning work. Digital-education literature, meanwhile, offers models for blended delivery, platform-supported instruction, video-based analysis, and data-informed feedback. Yet these traditions are often applied separately. Some studies examine elite athletes rather than mixed university cohorts; others discuss digitalization in generic terms without event-specific biomechanics; still others preserve norm-based grading while merely decorating it with technological tools. As a result, university teachers still lack a sufficiently coherent framework for redesigning athletics instruction under real institutional constraints such as limited contact time, heterogeneous groups, uneven infrastructure, and simultaneous educational and performance goals.

This article addresses that gap by developing a dense model for the improvement of university track and field instruction through the integration of competency-based design, digital-biomechanical feedback, and differentiated load regulation. The study proceeds from four assumptions. First, the educational value of athletics lies in the quality of structured motor learning rather than in mechanical drill volume alone. Second,

technology is pedagogically meaningful only when it improves perception, diagnosis, correction, regulation, or assessment. Third, performance indicators should be interpreted together with movement quality, learning progress, and self-regulatory competence. Fourth, the university athletics course must reconcile collective organization with individual developmental pathways. On this basis, the article conceptualizes modernization not as a technological upgrade, but as the redesign of the instructional system itself. The object of analysis is university track and field as a pedagogical system; the subject is the methodological mechanism through which contemporary educational technologies can improve learning quality, technical stability, and instructional differentiation. The aim is to justify and model an instructional architecture that links event-specific technique, load management, feedback design, reflective learning, and multidimensional assessment in a form applicable to higher education. The article's novelty lies in treating athletics instruction as a single educational, biomechanical, and data-analytic process rather than as a loose combination of drills, tests, and digital supplements. Its practical significance lies in offering a transferable basis for curriculum revision, lesson planning, assessment design, and pedagogical decision-making in university sport programs.

Materials and Methods

The study used an integrative design-based methodology whose purpose was not to test a single intervention on one student cohort, but to construct and justify a pedagogically workable model for university track and field by synthesizing evidence from sport science, motor learning, physical-education research, and digital pedagogy. Four analytical procedures structured the work. First, an integrative review was undertaken across official guidance and peer-reviewed literature relevant to physical activity, athletics coaching, blended learning, augmented feedback, athlete monitoring, sprint and jump development, strength training transfer, and competence-based education. Preference was given to sources with direct methodological value: WHO guidance on physical activity, UNESCO and OECD materials on educational technologies and digital transformation, World Athletics coaching resources, and review-level research on feedback, load management, blended learning, and motor-skill development. The review was selective rather than encyclopedic: only concepts that could be translated into higher-education athletics instruction were retained.

Second, university track and field was decomposed into event clusters defined by common coordination and pedagogical demands: acceleration and maximal-speed sprinting, hurdle and relay rhythm, jump take-off mechanics, throwing force-transfer patterns, endurance pacing, and integrative conditioning for mixed groups. This decomposition allowed the model to be built around movement logic rather than administrative labels. For each cluster, the study identified characteristic technical errors, feedback needs, load tolerances, and feasible performance indicators. Third, a competency-mapping procedure was used to

determine what a university student should be able to execute, explain, regulate, and evaluate after completing an athletics course. Five domains were distinguished: technical-executive competence, biomechanical-conceptual competence, load-regulatory competence, digital-analytical competence, and pedagogical-communicative competence. These domains were treated as mutually dependent: technical execution without conceptual understanding weakens transfer, while data collection without self-regulation produces monitoring without learning.

Fourth, a pedagogical modelling procedure translated the analytical results into a course architecture governed by alignment, progression, differentiation, and evidence sufficiency. Alignment means that aims, drills, feedback channels, and assessment criteria must refer to the same target actions. Progression means that students move from basic movement literacy toward event-specific refinement and reflective independence. Differentiation means that task difficulty, feedback density, and workload are adjusted to readiness, skill history, and adaptation. Evidence sufficiency means that any technological tool must serve a defined pedagogical function and remain proportionate to institutional reality. Within this framework, modern pedagogical technologies were interpreted broadly: flipped micro-content, structured video feedback, station-based practice, rubric-guided peer observation, digital performance logs, simple dashboards, session-RPE monitoring, and e-portfolios. The model intentionally avoids technological inflation; a smartphone camera, a validated field timing procedure, and a well-designed observation rubric may generate more learning than expensive devices used without methodological logic.

The model was additionally screened against typical university constraints: large classes, limited weekly contact hours, mixed ability, uneven facility quality, variable staff digital competence, and the need to combine educational inclusion with measurable performance improvement. This screening prevented idealized solutions disconnected from institutional practice. Two further principles shaped the method. The first was pedagogical safety: findings from performance science were included only when they remained appropriate for non-elite or mixed-ability university populations. The second was disciplinary translation: elite-training knowledge was not copied mechanically but reformulated for teaching contexts in which feedback clarity, technical stability, and progressive adaptation are as important as output gains. Tasks were considered methodologically valid when they preserved the informational structure of the target skill, generated interpretable feedback, and imposed a physiological cost appropriate to the learning aim. This criterion distinguished acquisition tasks from transfer tasks and conditioning tasks, thereby increasing instructional economy and protecting the model from the common error of treating any strenuous activity as pedagogically productive athletics work.

Results

The principal result of the study is a four-layer model for improving university track and field instruction. The first layer is structural-didactic. It reorganizes the athletics course around event logic, competency targets, and staged progression rather than around routine lesson repetition. Each unit begins with a clear technical problem, a compact biomechanical explanation, and a limited set of actionable cues. Technical content is therefore reduced to its decisive coordinative variables: for sprinting these include projection, front-side mechanics, rhythm growth, and trunk control; for jumps, approach regulation, penultimate step organization, take-off stiffness, and landing control; for throws, sequencing, block mechanics, and release organization; for endurance work, pace regulation, stride economy, and effort distribution. This layer replaces generic explanation with selective instructional focus. Instead of overloading students with numerous corrections, the model isolates the errors that most strongly affect performance and safety and links them to observable indicators. As a result, the teacher's explanation becomes shorter but more diagnostic, and student attention is directed toward variables that can actually be corrected within the session.

The second layer is digital-biomechanical feedback. Its function is not to technologize the lesson superficially, but to shorten the distance between execution and correction. The model proposes a feedback hierarchy. Immediate verbal cueing remains the first line, because some corrections must be made in real time. Delayed visual feedback through short video clips serves the second line by allowing students to compare intended and actual movement structure. Analytical feedback constitutes the third line and is used selectively for recurrent or technically decisive errors; it includes simple frame-based comparisons, segmental checkpoints, split times, take-off marks, contact rhythm patterns, or workload-response notes. The critical point is that data are never treated as self-explanatory. Every digital trace must answer a pedagogical question: What exactly failed or improved? Why did it happen? Which cue or task modification follows from this observation? Thus, technology functions as a translator of movement information rather than as an ornamental record of activity. The model also distinguishes between teacher-generated and student-generated feedback. Students are gradually trained to use video, rubrics, and logs not just to receive comments, but to identify one or two primary error patterns, formulate corrective cues, and compare successive attempts. This shift is essential because higher education should produce not only performer compliance but also analytical autonomy.

The third layer is differentiated load regulation. Traditional university athletics often applies the same volume, intensity, and drill density to all students in the group, even when readiness differs markedly. The proposed model replaces this with regulated differentiation based on three categories of evidence: observable technical stability, subjective response, and selected objective indicators. Observable technical stability refers to whether the student can maintain target mechanics under increasing speed or fatigue.

Subjective response includes session-RPE, perceived recovery, and confidence in execution. Objective indicators may include sprint splits, jump outputs, heart rate where appropriate, simple readiness questionnaires, or tracked work-rest patterns. On this basis, students are not separated into rigid ability tracks but move through flexible load zones. A technically unstable student may remain in a lower-speed acquisition zone even if physically strong; another may progress to higher-intensity transfer work because the movement pattern remains stable under load. This principle is especially important in sprinting, plyometric work, and throwing, where premature intensity frequently amplifies error and injury risk. In endurance units the same logic supports pace education and response monitoring rather than indiscriminate mileage accumulation. The model therefore redefines individualization not as total separation of learners, which is often impossible, but as differentiated prescription within a shared lesson architecture.

The fourth layer is multidimensional assessment. Instead of relying almost exclusively on terminal norms, the model evaluates learning through four linked dimensions: performance output, movement quality, regulatory competence, and reflective-digital evidence. Performance output remains important because athletics is a measurable discipline; sprint time, jump distance, throw result, or pacing stability cannot be ignored. Yet these indicators are interpreted together with movement quality, that is, whether improvement emerged from more effective coordination rather than random effort or compensatory action. Regulatory competence assesses whether the student can adjust effort, pace, rest, and technical focus in response to instructions and feedback. Reflective-digital evidence includes training logs, error analyses, short video commentaries, or portfolio entries showing how the student understands change over time. This assessment structure solves a persistent pedagogical problem: norm-based grading can reward raw physical advantage while failing to register substantial learning in less prepared students. The new model does not abolish standards, but contextualizes them within growth, technical literacy, and self-regulation.

When these four layers are combined, the course acquires a more coherent internal logic. A typical teaching cycle begins with diagnostic entry profiling, not to classify students permanently, but to identify starting conditions in mobility, acceleration mechanics, coordination, endurance readiness, and technical comprehension. Instruction then proceeds through microcycles in which each event cluster contains acquisition tasks, transfer tasks, and load-managed performance tasks. Acquisition tasks simplify the skill while preserving its informational core; transfer tasks place the skill into variable conditions; performance tasks test stability under greater speed, amplitude, or fatigue. Each cycle ends with a short reflective closure where students record dominant cues, recurrent errors, response to load, and the next technical priority. Over time this produces cumulative evidence for both the teacher and the learner. The model is therefore not a set of isolated innovations but a chain in which diagnosis, task selection, feedback, load management, and assessment mutually constrain one another.

The results of the modelling process also include concrete event-cluster implications. In sprint instruction, the model prioritizes acceleration mechanics, rhythm emergence, and the management of technical breakdown at higher speed. Video is most useful when linked to one or two focal variables such as projection or front-side action; excessive detail is avoided. In jump units, the decisive issue is often not strength deficit alone but the relationship between approach consistency and take-off organization; hence the model recommends a strong coupling between rhythm drills, approach marking, and immediate visual review. In throwing, verbal cueing is supplemented by sequential analysis only when gross timing faults persist; otherwise instruction risks cognitive overload. In endurance units, digital support is used less for complex biomechanics and more for pace distribution, internal-load interpretation, and self-regulatory planning. These distinctions matter because “technology in athletics” has no single meaning; different events demand different balances among observation, feedback, and monitoring.

A further result is the identification of pedagogical conditions for successful implementation. The model requires compact but clear rubrics, limited sets of high-value cues, routine reflective logging, and teacher ability to move between collective instruction and local individual correction. It also requires restraint: not every lesson needs advanced analytics, and not every error deserves immediate technological intervention. Methodological economy is itself a result of the model. Because the course is organized around decisive variables, unnecessary drill accumulation is reduced, feedback becomes more targeted, and lesson time is used more efficiently. Finally, the model yields a revised understanding of the university athletics teacher’s role. The teacher becomes not merely a demonstrator and evaluator, but a designer of learning conditions, interpreter of performance evidence, regulator of load, and mediator between movement experience and analytical understanding. In this sense, the result of the study is not only a proposed teaching scheme, but a redefinition of what counts as quality pedagogy in university track and field.

Discussion

The proposed model allows several substantive conclusions about the modernization of university athletics instruction. First, the main deficit of conventional practice is not simply low technological use; it is the weak integration among technique teaching, load prescription, feedback, and assessment. When these elements operate separately, even well-intentioned innovation remains superficial. A teacher may record video, collect times, and conduct tests, yet still reproduce a routine in which students do not understand what changed, why it changed, or how to regulate further improvement. The present model therefore argues for integration as the decisive methodological principle. Technology becomes valuable only when it sharpens diagnosis, clarifies correction, or improves self-regulation; otherwise it merely increases the quantity of information without raising educational quality.

Second, the model supports a shift from result-centered instruction toward competence-centered instruction without abandoning measurable athletic outcomes. This point is important because athletics, more than many physical-education domains, naturally attracts norm-based evaluation. Times, distances, and counts are clear, comparable, and administratively attractive. Yet exclusive dependence on them narrows pedagogy and systematically obscures learning processes. A student may improve technically while remaining below a rigid standard; another may achieve a high result through prior training history while displaying little analytical or regulatory growth. The proposed framework resolves this tension by retaining performance outputs but embedding them within movement quality, reflective evidence, and workload control. Such an approach is more consistent with the educational mission of higher education, especially in programs preparing future teachers or coaches.

Third, the discussion confirms that digitalization in sport pedagogy should be understood as an epistemic aid rather than an infrastructural slogan. The practical relevance of a device or platform lies in the type of knowledge it produces for teaching. A short video clip can be powerful if it reveals an otherwise invisible technical fault and is tied to a clear corrective task; the same clip is nearly useless if it is shown without error taxonomy or follow-up action. A readiness questionnaire or session-RPE scale is valuable when it informs load adjustment; it becomes empty paperwork when collected but not interpreted. In other words, the pedagogical meaning of technology depends less on sophistication than on translation. This conclusion is especially relevant for universities with limited resources, because it shows that methodologically intelligent low-cost tools can outperform expensive but pedagogically underused systems.

Fourth, the model reframes differentiation. In large university groups, individualized instruction is often considered unrealistic, leading teachers either to accept uniform prescription or to reserve adaptation for exceptional cases. The present analysis suggests a more workable alternative: differentiated pathways within common organizational structures. Students can share the same lesson theme while working in different load zones, feedback densities, or task variants. This form of individualization is neither absolute nor cosmetic; it is functionally tied to readiness, technical stability, and learning rate. Such a principle also improves safety. Many technical faults in sprinting, jumping, and throwing become more pronounced when speed or intensity rises prematurely. By using technical stability as a criterion for progression, the model protects both learning quality and injury prevention.

Fifth, the model has implications for teacher preparation. If university instructors are to implement such a framework, they need more than event knowledge and demonstration skill. They require competence in task analysis, error prioritization, feedback design, basic data interpretation, and digital mediation. This does not mean every teacher must become a biomechanist or data scientist. It means that pedagogical professionalism in athletics now includes the ability to decide which variable matters, which evidence is sufficient, and

which intervention is proportionate. Without this competence, either under-analysis or over-analysis becomes likely: the first reproduces generic drill culture, while the second overloads learners with detail and fragments lesson flow.

At the same time, the model should not be interpreted as universally complete or free of constraints. Its application depends on teacher training, lesson time, institutional support, and the availability of at least minimal digital infrastructure. Some universities may lack stable platforms, adequate field facilities, or staff confidence in feedback technologies. Mixed cohorts may include students whose health status or prior motor experience sharply limits progression speed. Moreover, because the present study is model-building rather than a controlled longitudinal experiment, its claims are theoretical and design-based rather than causal in a narrow statistical sense. This is a real limitation. The model is intended as a strong instructional framework, not as definitive proof that one package of methods will produce identical effects in all settings. Future empirical work should therefore test the model in semester-length implementations, compare differentiated and conventional course structures, and examine how students with different starting profiles respond to video feedback, load-regulation strategies, and multidimensional assessment. Even with these limits, the broader implication remains clear: university track and field should no longer be organized as a simplified derivative of either school physical education or specialized competitive coaching. It occupies its own pedagogical space. Unlike school PE, it can demand greater analytical precision and learner responsibility; unlike elite training, it must remain inclusive, educationally transparent, and adaptable to varied readiness. The proposed model is valuable precisely because it acknowledges this in-between status. It preserves the measurable specificity of athletics while re-centering teaching on competence formation, reflective learning, and methodologically justified technology use. In that sense, the modernization of university athletics is not a matter of adding novelty to an unchanged lesson. It is a matter of redefining what counts as effective instruction: not the visible busyness of the group, but the coordinated development of movement quality, adaptive workload management, analytical understanding, and transferable pedagogical competence.

Conclusion

The study developed a dense model for improving university track and field instruction through the integration of competency-based design, digital-biomechanical feedback, differentiated load regulation, and multidimensional assessment. Its central conclusion is that athletics in higher education becomes pedagogically stronger when technique, monitoring, reflection, and evaluation are organized as a single instructional system rather than as separate practices. The model preserves measurable performance outcomes but interprets them together with movement quality, self-regulation, and reflective evidence, thereby aligning athletics teaching more closely with the educational mission of the university. Its practical value lies in offering a realistic framework for curriculum revision,

lesson sequencing, feedback design, and differentiated teaching in mixed-ability groups. The model also indicates that meaningful modernization does not require maximal technology; it requires methodologically precise use of proportionate tools. Future research should empirically test the model across event groups, semester structures, and student profiles in order to determine its instructional effects under different institutional conditions.

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