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Digital Physiological Self-Monitoring in Pre-Service Physical Education Teacher Education: A Conceptual Mind-Body Model for Motivation, Self-Regulation, and Professional Competence

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ABSTRACT

Objective: This article proposes a conceptual mind-body learning model for integrating digital physiological self-monitoring into pre-service physical education teacher education.

Methods and Materials: A narrative conceptual synthesis used purposive theoretical sampling across literature on wearable monitoring, embodied cognition, interoceptive awareness, self-determination theory, self-regulated learning, teacher competence, learning analytics ethics, and digital pedagogy. No original empirical data were collected, and no effectiveness claims are made.

Findings: Educational value lies in guided comparison of device feedback with subjective bodily experience, motivational meaning, context, and pedagogical judgment. A five-phase cycle links bodily observation, subjective interpretation, motivational meaning, self-regulatory action, and pedagogical translation. The phases are iterative rather than linear.

Conclusion: The model defines its boundaries, three indicator-sensitivity tiers, no-device alternatives, cultural adaptation requirements, minimum safeguards, and indicators for future testing. Physiological self-monitoring should function as a human-centered reflective resource rather than a fitness-ranking or grading tool. Its effects on motivation, self-regulation, well-being, equity, and professional competence require empirical testing before it can be recommended as evidence-based practice.

Keywords: Self-Monitoring, Physical Education, Mind-Body Learning, Self-Regulation, Motivation, Teacher Education.

Introduction

Physical education teacher education operates at the intersection of health literacy, digital pedagogy, psychological development, and professional practice. Pre-service teachers are expected not only to perform and teach movement skills, but also to understand bodily responses, support motivation, manage risk, promote inclusive participation, and translate health-related knowledge into pedagogical decisions (Stoddart & Selanders, 2022; Zhou, 2024). Physical literacy likewise treats meaningful movement as a lifelong integration of bodily capability, confidence, motivation, and understanding (Whitehead, 2010). Within this preparation, digital physiological self-monitoring may serve as a reflective strategy through which future teachers examine relations among effort, affect, recovery, motivation, and learning.

The diffusion of wearable technologies has made physiological feedback more accessible than before. Heart rate monitors, fitness trackers, mobile applications, and consumer biosensors can provide information about activity level, exercise intensity, recovery, sleep-related patterns, and stress-related cues, and there is growing evidence that consumer activity trackers can increase physical activity participation (Brickwood et al., 2019). In sport science, such tools have long been used to monitor training load, fatigue, and adaptation (Achten & Jeukendrup, 2003; Borresen & Lambert, 2008; Halson, 2014; Impellizzeri et al., 2019). In education, wearable technologies are increasingly discussed in relation to learning analytics, engagement, embodied feedback, and personalized learning (Chu et al., 2023; Hernández-Mustieles et al., 2024; Hong et al., 2025). In physical education specifically, recent work also examines augmented reality, digital engagement, and twenty-first-century competencies in pre-service preparation (Nurhayati et al., 2025; Ridwan et al., 2025), while reviews emphasize that digital technologies may support engagement and self-regulated learning but also raise barriers related to teacher training, digital inequality, and data ethics (Martín-Rodríguez & Madrigal-Cerezo, 2025; Zhao & Su, 2026).

Research gap and novelty

Despite this growing body of work, three specific gaps remain. First, existing wearable-technology literature in sport and health science largely treats physiological data as a performance or health outcome rather than as a pedagogical prompt, and it seldom addresses how future teachers should interpret such data professionally. Second, embodied cognition and reflective-practice literature in teacher education rarely engages with the technical properties, limitations, and ethical risks of consumer biosensors, so it does not explain how digital feedback and lived bodily experience should be brought into productive tension in pre-service preparation. Third, learning analytics ethics and student-privacy scholarship offers strong critiques of datafication but rarely offers concrete pedagogical designs for how physiological data may be used responsibly in classroom or teacher-education settings. As a result, pre-service physical education teacher education currently lacks a coherent framework that connects wearable feedback, interoceptive awareness, motivation, self-regulation, and ethical professional judgment within a single instructional cycle.

The present article addresses this gap by proposing a conceptual mind-body model in which digital feedback is a reflective prompt rather than a measurement endpoint. Its novelty lies in three features: (a) body-data calibration prevents device output from overriding lived experience; (b) a five-phase cycle integrates motivation, self-regulation, learner agency, and learning-analytics ethics; and (c) educational value is judged by the quality of interpretation and professional judgment rather than by device use or physiological performance.

Roadmap of the article

Section 2 explains the narrative conceptual synthesis. Section 3 develops five theoretical anchors: wearable monitoring, embodied cognition and interoception, self-determination theory, self-regulated learning, and professional competence. Sections 4 and 5 define the model's boundaries, indicator tiers, and five-phase cycle. Sections 6-8 address application, cultural adaptation, and data

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governance; Sections 9-12 set out testing priorities, contributions, limitations, and conclusions.

The guiding premise is that data alone do not educate. A device can display heart rate, activity duration, or recovery estimates, but it cannot explain what effort means for a learner or how a future teacher should adapt instruction. Physiological feedback becomes educational only through contextual interpretation, learner choice, privacy protection, and professional translation. Claims that the model improves motivation, self-regulation, or competence therefore require empirical testing.

Methods and Materials

This article uses a narrative conceptual synthesis rather than a systematic review or meta-analysis. The aim is not to estimate intervention effects, calculate pooled outcomes, or claim comprehensive coverage of all studies on wearables and physical education. The aim is to construct a theoretically coherent pedagogical model that can later be tested empirically. Narrative conceptual synthesis is appropriate when a paper seeks to integrate several bodies of theory into a new framework, especially where the phenomenon is emerging, interdisciplinary, and not yet supported by a large body of directly comparable empirical studies.

Literature identification period, databases, and strategy

The literature identification process was conducted iteratively between January 2025 and June 2026, with additional checking of key references during manuscript revision. Because the article is conceptual, the identification process was purposive rather than exhaustive. Relevant literature was identified through purposive reading, reference chaining, and targeted searches in major scholarly databases, including Scopus, Web of Science, ERIC, SPORTDiscus, PubMed, PsycINFO, and Google Scholar. Google Scholar was used mainly to identify highly cited theoretical works and recently published interdisciplinary papers that may not have appeared consistently across disciplinary databases.

Keywords and thematic terms were combined across five thematic clusters. Examples included: "wearable" OR "wearable technology" OR "fitness tracker" OR "biosensor" AND "physical education"; "heart rate monitoring" OR "physiological feedback" AND "teacher education"; "interoception" OR "body awareness" AND "learning"; "self-determination theory" AND "physical education" AND "motivation"; "self-regulated learning" AND "physiological feedback"; "teacher competence" OR "teacher efficacy" AND "physical education teacher education"; "learning analytics" AND "privacy" OR "ethics"; and "wearable data" AND "education" AND "student privacy". Reference chaining was then used from core sources to identify foundational and critical literature.

Source identification, screening, and selection

Approximately 210 records were identified through database searches and reference chaining. After title and abstract screening, approximately 130 sources were read in full. Of these, 57 sources formed the conceptual core and are included in the reference list. Other full-text sources informed background reading but were superseded by stronger evidence or judged less relevant to the model. The first two figures remain approximate because sources were added or removed as the narrative synthesis developed; the final core count is exact.

Four criteria guided selection: relevance to a necessary model component; theoretical influence; direct evidence concerning wearables, physical education, teacher education, privacy, or implementation; and contribution to current debates about digital pedagogy and physiological data.

Sources were excluded when they treated wearable devices primarily as medical diagnostic tools, consumer lifestyle products, or elite sport performance systems without pedagogical relevance. Studies focused only on device accuracy were included selectively when they helped explain the limitations of physiological indicators. Sources that made strong causal claims without appropriate design or that did not address educational interpretation were used cautiously or excluded from the conceptual core.

Concept extraction and management of interpretive bias

To reduce interpretive bias, retained sources were entered into a shared concept-extraction matrix. The authors

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recorded discipline and study type, constructs contributed to the model, relevance to the five phases, and critical concerns such as validity, coercive monitoring, anxiety, and inequity. Concepts were grouped and refined across several reading passes.

More than one author cross-read the matrix, and disagreements about conceptual placement were resolved through discussion. The synthesis deliberately included critical work on self-tracking, datafication, privacy, and student autonomy. The model was then revised in response to these objections rather than only to supportive evidence.

Synthesis procedure and treatment of competing perspectives

The synthesis proceeded in four stages: identifying the theoretical role of each literature area; drafting the five-phase model; testing it against critical scholarship on learning analytics, datafication, privacy, and autonomy; and revising its boundaries, alternatives, and testable indicators.

Competing perspectives changed the design in three concrete ways. Critiques of quantified self-tracking and datafication (Lupton, 2016; Williamson, 2017) produced the calibration rule that device output must be interpreted alongside bodily experience and context. Learning-analytics ethics (Pardo & Siemens, 2014; Rubel & Jones, 2016; Slade & Prinsloo, 2013) produced the safeguard checklist and excluded physiological values from grading. Evidence concerning unequal access and cultural variation produced no-device pathways and local-adaptation guidance. Where risks could not be reconciled with educational use, restrictions such as voluntary participation, private feedback, and lower-risk indicator tiers were added.

Conceptual Background

Digital physiological self-monitoring as pedagogical feedback

Digital physiological self-monitoring refers here to the learner's guided use of digital tools or structured non-digital alternatives to observe selected bodily indicators and interpret them in relation to movement, learning, recovery, motivation, and professional reflection. The model may include heart rate, perceived exertion, activity duration, step count, sleep-related patterns, recovery cues, breathing awareness, and stress-related feedback. These indicators should not be treated as medical diagnoses or as direct measures of competence. In teacher education, they function as pedagogical prompts for reflection on effort, bodily variability, and responsible teaching decisions.

The sport science literature shows both the value and limits of physiological monitoring. Heart rate can be a practical indicator of exercise intensity, but it is influenced by hydration, temperature, stress, fatigue, medication, sleep, and individual variability (Achten & Jeukendrup, 2003; Borresen & Lambert, 2008). Training load frameworks distinguish between external load, such as the task performed, and internal load, such as the learner's physiological and psychological response to that task (Impellizzeri et al., 2019). This distinction is pedagogically useful because two students may complete the same activity while experiencing different bodily, affective, and motivational demands.

Wearable devices can make bodily differences visible, but visibility is not understanding. Reviews emphasize validity, reliability, context, and interpretation (Cardinale & Varley, 2017; Düking et al., 2018; Peake et al., 2018). A displayed number may stimulate curiosity, but it can also produce comparison, anxiety, or false confidence. Critical scholarship warns that quantified representations can reduce complex experience to metrics and reshape how learners value their bodies (Lupton, 2016; Selwyn, 2019; Williamson, 2017). Physiological feedback should therefore remain a reflective resource rather than an unquestioned authority. School-based heart-rate projection research illustrates the point: public display requires privacy rules, non-comparative framing, and careful interpretation (Cunningham-Rose et al., 2025).

Embodied cognition, interoception, and the resolution of a central tension

The premise that bodily experience is central to learning draws on embodied and grounded cognition, which links cognition to sensorimotor engagement (Barsalou, 2008; Gallagher, 2005; Wilson, 2002). Embodied learning frameworks distinguish bodily engagement from genuine task integration (Skulmowski & Rey, 2018), while body pedagogics explains how social, technological, and material

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arrangements transmit culturally organized bodily practices (Shilling, 2017). Together, these perspectives clarify why future physical education teachers must learn both through the body and about the pedagogical conditions that shape bodily knowledge. Similar integrative reasoning cautions against reducing human functioning to a single biological indicator (Seyed Alitabar, 2025).

A central boundary of the model is the distinction between digital physiological feedback and interoceptive awareness. Digital feedback is technologically mediated information produced by a device or application. Interoceptive awareness refers to the learner's attention to internal bodily signals such as effort, arousal, fatigue, discomfort, calmness, or recovery (Craig, 2002; Mehling et al., 2012). Reflective and mindfulness-based practices can strengthen this attentional capacity by cultivating non-judgmental awareness of internal states (Shapiro et al., 2006). These two forms of awareness may support each other, but they are not identical.

These literatures generate a productive tension. Wearable-based approaches direct attention to external metrics and may foster numeric dependence or distrust of felt experience. Interoceptive approaches prioritize internal states but may underuse relevant physiological information. Pre-service teachers need to interpret both without treating either as infallible.

The model addresses this tension through body-data calibration: learners compare device output, felt experience, and context. A high heart rate may reflect exercise intensity, anxiety, heat, poor sleep, or social pressure; a low activity score may reflect injury, recovery, disability, or an activity the device captured poorly. The pedagogical question is therefore how the three sources of information should be interpreted together. Calibration makes digital feedback part of embodied reflection without allowing it to dominate.

Motivation under autonomy-supportive conditions

Motivation is central to physical education because participation depends on perceived competence, autonomy, enjoyment, social climate, and the meaning attached to movement. Self-determination theory distinguishes between intrinsic motivation, extrinsic regulation, and self-determined behavior (Deci & Ryan, 1985; Ryan & Deci, 2000, 2017). In physical education, motivation is strengthened when learners experience autonomy, competence, and relatedness in a supportive climate (Ntoumanis, 2005; Standage et al., 2003, 2005), and a broad review of exercise contexts confirms that autonomy-supportive conditions are consistently associated with more self-determined forms of motivation (Teixeira et al., 2012). Motivational processes also apply to teachers themselves, since the reasons future teachers choose and feel confident in physical education shape their subsequent practice (Spittle et al., 2009; Spittle et al., 2022).

Digital physiological self-monitoring does not automatically support autonomy or competence. If wearable data are used to rank students, monitor compliance, shame bodies, or grade fitness, the same technology may undermine motivation and increase pressure. Therefore, the motivational value of the model depends on autonomy-supportive pedagogy. Learners should be able to set personal goals, interpret feedback privately, choose appropriate strategies, opt for non-device alternatives where possible, and discuss data without being publicly compared. In this model, physiological feedback may contribute to motivation only when it helps learners develop informed self-understanding and agency. Motivational effects therefore depend on pedagogical mediation and learner agency.

Self-regulated learning as the feedback-to-action mechanism

Self-regulated learning provides the main psychological mechanism connecting physiological feedback with educational action. Self-regulated learners set goals, monitor progress, control strategies, manage motivation, and reflect on outcomes. Zimmerman (2000, 2002) describes self-regulation as a cyclical process involving forethought, performance, and self-reflection. Pintrich (2004) similarly connects cognition, motivation, behavior, and context in college learning.

Physiological self-monitoring can enrich this cycle when it is supported by strategy instruction. Before an activity, learners may set goals related to pacing, effort, or attention. During activity, they may observe heart rate, perceived exertion, breathing, or fatigue. After activity, they may

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compare digital feedback with subjective experience and decide how to adjust their next strategy. Without guided reflection, however, feedback may remain superficial. Evidence on self-regulated learning training suggests that structured support is necessary for feedback to become strategy (Schunk & Greene, 2018; Theobald, 2021).

Professional competence in pre-service physical education teacher education

Professional competence is multidimensional. Blömeke et al. (2015) conceptualize competence as a continuum connecting knowledge, skills, motivation, beliefs, and performance. Physical education teachers require integrated competence: they must understand bodily processes, motivate diverse learners, organize safe activity, interpret student responses, and make ethical pedagogical decisions (Stoddart & Selanders, 2022; Zhou, 2024). Teacher efficacy is also relevant because teachers' beliefs about their capacity to influence learning affect professional behavior (Bandura, 1997; Tschannen-Moran & Woolfolk Hoy, 2001).

In the proposed model, professional competence is not the ability to operate a wearable device; it is the ability to interpret body-related information responsibly and translate it into teaching. This translation follows reflective practice by treating experience as material for inquiry and revised action (Schön, 1983). Future studies may assess it through teacher efficacy scales, lesson plans, microteaching observation, reflective journals, ethical reasoning, and inclusive activity adaptation.

Distinctive contribution beyond existing frameworks

The model draws on embodied learning, reflective practice, self-regulated learning, learning-analytics ethics, and digital pedagogy, but each leaves a specific problem unresolved. Embodied learning does not specify how physiological metrics should be read alongside felt experience; reflective practice rarely addresses biosensor validity and privacy; self-regulated learning does not treat bodily indicators as a distinctive feedback stream; and digital pedagogy does not centre the body or the motivational effects of physiological display.

The model's contribution is to connect these concerns in one teacher-education cycle. Digital feedback remains a prompt, the calibration rule prevents either metrics or felt experience from dominating, motivation depends on learner agency, ethics constrains the design from the outset, and value is judged through reflection and pedagogical translation. The framework is proposed for empirical testing, not presented as a validated pedagogy.

Scope and Boundaries of the Proposed Model

The model is designed for pre-service physical education teacher education, not for clinical diagnosis, elite athlete management, or institutional monitoring. Introductory courses may compare perceived exertion with heart rate or activity duration. Intermediate courses may connect feedback with motivation, self-regulation, and journals. Advanced courses may use microteaching, practicum reflection, and lesson adaptation to translate self-monitoring into professional judgment.

Indicator sensitivity tiers

Not all physiological indicators carry the same pedagogical or ethical weight. To make the boundaries of the model more explicit, indicators are grouped into three tiers by educational feasibility and data sensitivity. Tier 1 indicators are the default starting point and require the fewest safeguards; Tier 3 indicators should be used only when strong safeguards, opt-in consent, and clear pedagogical justification are in place. Table 1 summarizes the tiers.

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Table 1.

Indicator sensitivity tiers

Tier	Indicators	Educational use and safeguards
Tier 1 (lower risk)	Heart rate during activity; perceived exertion (RPE); activity duration; simple movement diary	Suitable for routine use in introductory and intermediate courses. Discussed openly with attention to validity and context. Non-comparative framing recommended.
Tier 2 (moderate)	Breathing awareness; short-term recovery cues (e.g., post-exercise heart rate return); step count over a defined period	Appropriate in intermediate and advanced courses when framed as reflective indicators. Individual data should not be publicly displayed; peer discussion should not require numeric disclosure.
Tier 3 (higher sensitivity)	Sleep-related patterns; longitudinal recovery and readiness scores; stress-related signals derived from HRV or similar measures	Optional and opt-in only. Data should be interpreted individually, not aggregated or graded. Requires explicit consent, minimal storage, and clear opt-out. Should not be a course requirement.

The model does not require that all indicators be used at once. In many teacher education settings, using one or two Tier 1 indicators may be more educationally appropriate than collecting multiple streams of data. The design principle is relevance to learning: feedback should be included only when it directly supports reflective interpretation and pedagogical decision-making.

The model also has clear exclusions. It should not be used to grade students' bodies, rank fitness, diagnose health conditions, enforce compliance, or compare students publicly. It should not require disclosure of sensitive physiological information to peers. It should not assume that device ownership is universal. Where wearable technologies are unavailable or inappropriate, perceived exertion scales, breathing logs, reflective journals, movement diaries, and teacher-guided observation can serve as no-device alternatives.

Proposed Mind-Body Self-Monitoring Model

The model is organized as a five-phase reflective cycle: bodily observation, subjective interpretation, motivational meaning, self-regulatory action, and pedagogical translation. Numbering aids exposition, but practice is recursive. Interpretation and motivation may reshape observation within one activity, while pedagogical translation may generate goals for the next cycle.

The novelty of the model lies in translating physiological self-monitoring from a performance-tracking practice into a teacher-education cycle. Unlike conventional wearable monitoring approaches, the model treats body data as a prompt for interpretation rather than as an endpoint. Unlike general self-regulated learning models, it begins with embodied feedback and interoceptive awareness. Unlike technology-adoption approaches, it evaluates educational value by the quality of guided reflection, ethical use, and professional judgment rather than by frequency of device use.

The five phases and their links with professional judgment are summarized in Table 2. The recursive relationships within the conceptual cycle are illustrated in Figure 1.

Table 2.

Proposed mind-body self-monitoring cycle for pre-service physical education teacher education.

Phase	Learner question	Feedback or experience	Professional competence link
1. Bodily observation	What is happening in my body during this task?	Heart rate, perceived exertion, breathing, fatigue, activity duration, recovery cues	Awareness of bodily variability in movement learning
2. Subjective interpretation	How do I understand this feedback in context?	Task difficulty, anxiety, confidence, sleep, temperature, peer pressure, previous activity	Context-sensitive interpretation of student responses
3. Motivational meaning	How does this experience affect my motivation?	Autonomy, competence, relatedness, enjoyment, pressure, amotivation	Design of autonomy-supportive motivational climates
4. Self-regulatory action	What should I adjust next time?	Pacing, rest, breathing, goal setting, strategy change, help-seeking	Teaching learners to regulate effort and recovery
5. Pedagogical translation	How can this inform my future teaching?	Lesson adaptation, inclusive alternatives, privacy rules, safe feedback language	Responsible use of body-related information in practice

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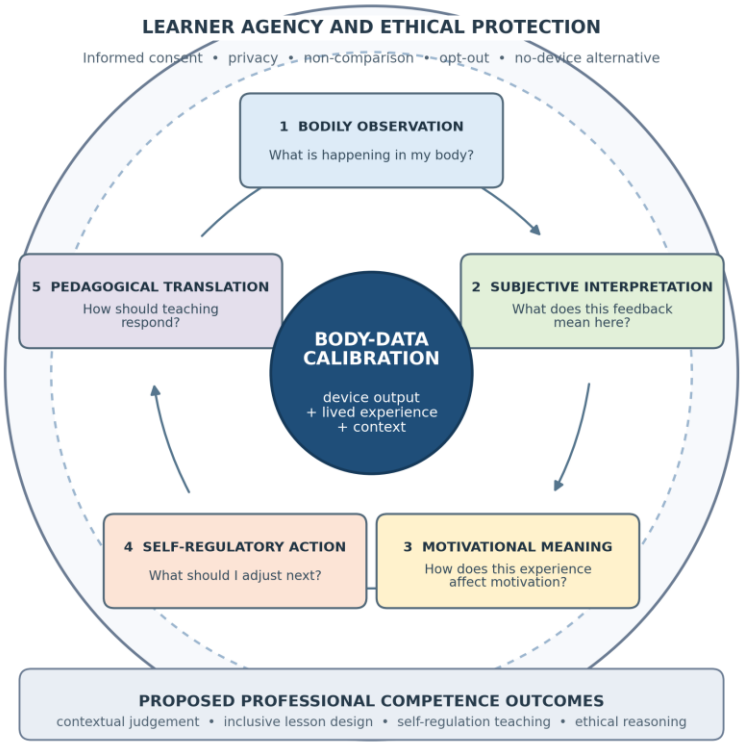


Figure 1.

Conceptual model of mind-body digital physiological self-monitoring in pre-service physical education teacher education.

Note. The five phases form a recursive cycle around body-data calibration. The surrounding band represents learner agency and ethical protection; the outer band identifies proposed professional competence outcomes. Arrows indicate iterative movement rather than a fixed sequence. All relationships require empirical testing.

Pedagogical Application in Teacher Education

The pedagogical application of the model should be concrete, staged, and ethically limited. The following sample module illustrates one possible four-week integration into a physical education teacher education course. It is a proposed rather than validated design. It may be shortened, extended, or adapted according to institutional resources, device availability, privacy regulations, and course level. A four-week instructional example is presented in Table 3.

Table 3.

Sample four-week module with reflection prompts and no-device alternatives.

Week	Learning focus	Example activity and reflection prompt	Output	No-device alternative
1	Bodily observation and device limitations	Learners complete a moderate activity and compare heart rate or perceived exertion with felt effort. Prompt: What did the device or observation show? What did I feel? Where did they match or differ?	Short reflection on what was observed and what cannot be concluded from one indicator.	RPE scale; breathing awareness log; fatigue scale; movement diary
2	Subjective interpretation and motivational meaning	Learners analyze how sleep, anxiety, confidence, task difficulty, and peer presence may influence physiological response. Prompt: Did the task support my autonomy, competence, and relatedness, or did it create pressure and comparison?	Reflection connecting bodily feedback with autonomy, competence, and relatedness.	Written reflection; peer discussion without numeric disclosure
3	Self-regulatory action	Learners select one strategy such as pacing, rest, breathing, goal adjustment, or help-seeking and test it in a second activity. Prompt: What strategy will I try next time and why?	Before-after reflection on strategy choice and perceived usefulness.	Personal action plan without physiological data
4	Pedagogical translation through microteaching	Learners design and teach a short activity with privacy rules, optional feedback, and inclusive alternatives. Prompt: How would I adapt this activity for students with different fitness levels, confidence, disabilities, or privacy preferences?	Lesson plan, microteaching observation, and ethical justification.	Inclusive lesson redesign and teacher observation notes

Assignments may include a reflective journal comparing digital feedback with experience and context, a microteaching task explaining effort without ranking students, an inclusive lesson plan with no-device options, and a scenario

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distinguishing supportive feedback from coercive monitoring. These designs remain hypothetical and have not been validated for feasibility, acceptability, or learning outcomes. A proposed assessment framework for future empirical and pedagogical testing is provided in Supplementary Table S1.

Cultural and Institutional Adaptation

Cultural and institutional adaptation is integral because body-related data acquire meaning within norms concerning privacy, gender, health, assessment, teacher authority, technology, and public comparison. A task experienced as empowering in one setting may feel intrusive or disciplinary in another. Local pilot work should therefore precede wider adoption.

Adaptation should examine device access, rules for collection and deletion, who may view data, gendered comfort with disclosure, language for describing bodily experience, and whether students interpret monitoring as reflection or discipline. Participation without sharing personal physiological information must remain possible.

Kazakhstan serves only as an illustrative case of rapidly digitalizing higher education. Local pilots should address urban-rural and socioeconomic differences in device access, multilingual instruction in Kazakh, Russian, and English, institutional data rules, teacher educator readiness, and willingness to discuss body-related information. Comparable contextual analysis would be required elsewhere; the model is not presented as an empirically proven national solution.

A culturally adapted implementation should also include no-device pathways from the beginning. Perceived exertion scales, breathing-awareness logs, movement diaries, recovery reflections, and teacher-guided observation can allow students to participate without wearable devices or without disclosing sensitive data. This is especially important in classes where students differ by health status, disability, gendered comfort with body data, religious or cultural norms of modesty, and prior experience with digital monitoring.

Cultural adaptation prevents the assumption that the same device-based activity has the same meaning everywhere. Physiological feedback is pedagogically legitimate only when aligned with local expectations, institutional rules, inclusive access, and students' right to interpret their bodies without coercion or public comparison.

Ethical and Pedagogical Safeguards

Ethics is a condition of educational legitimacy. Physiological data may reveal information about health, sleep, stress, lifestyle, or emotional state and may also produce anxiety, comparison, or excessive self-quantification. Learning-analytics scholarship requires deliberate governance rather than default collection (Drachsler & Greller, 2016; Francis et al., 2023; Jones, 2019), while school-wearable research raises parallel concerns about consent, coercive data use, and protection of minors (Jovanovic & Kay, 2022). Table 4 translates these concerns into minimum practice rules.

Table 4.

Ethical and pedagogical safeguards checklist.

Safeguard	Practical rule	Reason
Voluntary participation	Students should be able to choose a no-device alternative whenever possible.	Supports autonomy and reduces coercion.
Data minimization	Collect only the indicator needed for the learning task and avoid unnecessary storage.	Reduces privacy risk and data misuse.
Confidentiality	Personal physiological data should not be displayed publicly or shared with peers without consent.	Prevents embarrassment, comparison, and misuse.
No fitness grading	Assessment should focus on reflection, ethical reasoning, and pedagogical translation, not physiological values.	Avoids body ranking and unfair evaluation.
Non-comparative feedback	Feedback should be personal, contextual, and supportive rather than competitive.	Protects motivation and dignity.
Device limitations	Educators should explain validity, reliability, and contextual influences on device readings.	Prevents false certainty and overinterpretation.
Support for anxiety	Students who become worried about physiological data should be allowed to stop and receive supportive guidance.	Protects well-being.
Cultural sensitivity	Tasks should consider gender, language, privacy expectations, and local norms of monitoring.	Improves ethical fit across contexts.

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Minimum ethical requirements for future empirical studies

Because this article proposes the use of physiological data in teacher education, the following minimum ethical requirements should apply to any future empirical study that operationalizes the model. First, informed consent should be obtained in writing and should specify which indicators will be collected, how they will be stored, who will have access, and when they will be deleted. Second, an opt-out or no-device alternative must be available at every phase and must not disadvantage the student's grade or standing. Third, data minimization should govern the study: only indicators directly required by the learning task should be collected. Fourth, physiological data should be stored in de-identified form wherever possible and deleted at the end of the study period unless retention is separately justified and consented to. Fifth, physiological values should never be publicly displayed and should not be used as grading criteria. Sixth, students who show signs of monitoring-related anxiety, body dissatisfaction, or distress should be able to withdraw at any time and should be offered supportive guidance. Seventh, ethics approval should be obtained from the appropriate institutional review board, and vulnerable populations, including minors, should receive additional safeguards consistent with local regulation.

Future Empirical Testing

Because this article is conceptual, future research should test the model before strong claims are made about effects. A possible design would compare a guided mind-body self-monitoring group with a conventional reflection group across one academic module. Outcomes could include learning motivation, self-regulated learning, body awareness, perceived professional competence, teacher efficacy, lesson plan quality, microteaching performance, reflective journal quality, and ethical reasoning. Validated instruments may support such work; for example, motivation could be assessed with established measures such as the Academic Motivation Scale (Vallerand et al., 1992), and interoceptive awareness with the Multidimensional Assessment of Interoceptive Awareness (Mehling et al., 2012). Qualitative data from journals, interviews, focus groups, and microteaching observations could explain how students interpret feedback and whether the model helps them connect bodily experience with professional judgment.

Mixed-methods and design-based research may be especially appropriate because physiological feedback, motivation, and professional competence include both measurable and interpretive dimensions. Physiological indicators should be treated as contextual learning data, not as medical outcomes. Any empirical study should follow the minimum ethical requirements identified in Section 8.1.

Future research should also examine teacher educator readiness. The model requires instructors who can integrate physiology, psychology, pedagogy, digital ethics, and inclusive teaching. Without this competence, digital self-monitoring may remain superficial or become misused. Professional development for teacher educators is therefore an important condition for implementation.

Discussion and Conclusion

The framework repositions digital physiological self-monitoring as a mind-body learning strategy rather than a technology-adoption outcome. Its conceptual contribution is a cycle linking embodied cognition, interoception, motivation, self-regulation, professional competence, and learning-analytics ethics through calibrated interpretation. Its pedagogical contribution is a set of revisable journals, microteaching tasks, lesson plans, ethical scenarios, no-device alternatives, and assessment indicators. Its professional contribution is to frame the body as a source of inquiry rather than a performance object.

This article offers a conceptual framework and practical implementation principles, not evidence of effectiveness. It argues that physiological feedback becomes educational when digital indicators, bodily experience, context, motivation, self-regulatory strategy, and pedagogical judgment are interpreted together.

Physiological data should support autonomy, competence, body awareness, and ethical teaching rather than comparison, fitness ranking, or grading. The model may help future teachers treat the body as a source of

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professional knowledge, but it cannot yet be recommended as evidence-based practice. Testing in real teacher education settings must examine measurement validity, feasibility, acceptability, cultural adaptation, well-being, equity, and professional competence before wider adoption.

Anticipated implementation failures

Four failure modes require direct testing. First, educators may lack the digital, physiological, or ethical competence to guide comparative interpretation, reducing wearable use to demonstration or ranking. Second, students may distrust devices because of privacy, accuracy, or prior negative experience; no-device pathways must therefore be non-penalizing. Third, institutions may seek to repurpose data for assessment, accreditation, or performance control; formal agreements must exclude those uses. Fourth, monitoring may provoke anxiety or excessive self-quantification, requiring explicit stop-rules and supportive guidance. Educator preparation is consequently a precondition, and these scenarios should be treated as central feasibility outcomes.

Limitations

This conceptual synthesis reports no original data, and the model has not been tested for feasibility, acceptability, well-being, learning, competence, or equity. The purposive narrative search may omit relevant studies; the initial search and full-text counts in Section 2.2 are approximate. Transfer beyond pre-service physical education teacher education requires adaptation, and implementation depends on resources, educator readiness, device access, privacy regulation, and student preference. Cultural sensitivity may further constrain use. Consumer-sensor accuracy varies across devices and populations, and the model does not resolve those limitations. Finally, no-device alternatives are complementary rather than equivalent: perceived exertion and breathing awareness cannot reproduce objective heart-rate data.

Declaration of Interest

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Authors' Contributions

All authors equally contribute to this study.

References

Achten, J., & Jeukendrup, A. E. (2003). Heart rate monitoring: Applications and limitations. *Sports Medicine*, *33*(7), 517-538. https://doi.org/10.2165/00007256-200333070-00004

Bandura, A. (1997). Self-efficacy: The exercise of control. W. H. Freeman. https://books.google.com/books?vid=ISBN9780716728504

Barsalou, L. W. (2008). Grounded cognition. *Annual Review of Psychology*, *59*, 617-645. https://doi.org/10.1146/annurev.psych.59.103006.093639

Blömeke, S., Gustafsson, J.-E., & Shavelson, R. J. (2015). Beyond dichotomies: Competence viewed as a continuum. *Zeitschrift für Psychologie*, *223*(1), 3-13. https://doi.org/10.1027/2151-2604/a000194

Borresen, J., & Lambert, M. I. (2008). Autonomic control of heart rate during and after exercise: Measurements and implications for monitoring training status. *Sports Medicine*, *38*(8), 633-646. https://doi.org/10.2165/00007256-200838080-00002

Brickwood, K.-J., Watson, G., O'Brien, J., & Williams, A. D. (2019). Consumer-based wearable activity trackers increase physical activity participation: Systematic review and meta-analysis. *JMIR mHealth and uHealth*, *7*(4), e11819. https://doi.org/10.2196/11819

Cardinale, M., & Varley, M. C. (2017). Wearable training-monitoring technology: Applications, challenges, and opportunities. *International Journal of Sports Physiology and Performance*, *12*(Suppl 2), S2-55-S2-62. https://doi.org/10.1123/ijspp.2016-0423

Chu, S. L., Garcia, B. M., & Rani, N. (2023). Research on wearable technologies for learning: A systematic review. *Frontiers in Education*, *8*, Article 1270389. https://doi.org/10.3389/feduc.2023.1270389

Craig, A. D. (2002). How do you feel? Interoception: The sense of the physiological condition of the body. *Nature Reviews Neuroscience*, *3*(8), 655-666. https://doi.org/10.1038/nrn894

Cunningham-Rose, R., Garrett, N., Lonsdale, C., & Harris, N. (2025). The acute effect of heart rate monitor projection on exercise effort in school students. *European Physical Education Review*, *31*(3), 415-425. https://doi.org/10.1177/1356336X241280834

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior*. Plenum. https://doi.org/10.1007/978-1-4899-2271-7

Drachsler, H., & Greller, W. (2016). *Privacy and analytics: It's a DELICATE issue: A checklist for trusted learning analytics*. In Proceedings of the Sixth International Conference on Learning

Analytics & Knowledge (pp. 89-98). ACM. https://doi.org/10.1145/2883851.2883893

Düking, P., Fuss, F. K., Holmberg, H.-C., & Sperlich, B. (2018). Recommendations for assessment of the reliability, sensitivity, and validity of data provided by wearable sensors designed for monitoring physical activity. *JMIR mHealth and uHealth*, *6*(4), e102. https://doi.org/10.2196/mhealth.9341

Francis, M., Avoseh, M., Card, K., Newland, L., & Streff, K. (2023). Student privacy and learning analytics: Investigating the application of privacy within a student success information system in higher education. *Journal of Learning Analytics*, *10*(3), 102-114. https://doi.org/10.18608/jla.2023.7975

Gallagher, S. (2005). *How the body shapes the mind.* Oxford University Press. https://doi.org/10.1093/0199271941.001.0001

Halson, S. L. (2014). Monitoring training load to understand fatigue in athletes. *Sports Medicine, 44(Suppl 2)*, S139-S147. https://doi.org/10.1007/s40279-014-0253-z

Hernández-Mustieles, M. A., Lima-Carmona, Y. E., Pacheco-Ramírez, M. A., Mendoza-Armenta, A. A., Romero-Gómez, J. E., Cruz-Gómez, C. F., Rodríguez-Alvarado, D. C., Arceo, A., Cruz-Garza, J. G., Ramírez-Moreno, M. A., & Lozoya-Santos, J. de J. (2024). Wearable biosensor technology in education: A systematic review. *Sensors*, *24*(8), 2437. https://doi.org/10.3390/s24082437

Hong, H., Dai, L., & Zheng, X. (2025). Advances in wearable sensors for learning analytics: Trends, challenges, and prospects. *Sensors*, *25*(9), 2714. https://doi.org/10.3390/s25092714

Impellizzeri, F. M., Marcora, S. M., & Coutts, A. J. (2019). Internal and external training load: 15 years on. *International Journal of Sports Physiology and Performance*, *14*(2), 270-273. https://doi.org/10.1123/ijspp.2018-0935

Jones, K. M. L. (2019). Learning analytics and higher education: A proposed model for establishing informed consent mechanisms to promote student privacy and autonomy. *International Journal of Educational Technology in Higher Education*, *16*, Article 24. https://doi.org/10.1186/s41239-019-0155-0

Jovanovic, P., & Kay, R. (2022). Exploring ethical issues with using wearable technology in K-12 classrooms: A review of the literature. *Journal of Digital Life and Learning*, *2*(2), 3-11. https://doi.org/10.51357/jdll.v2i2.203

Lupton, D. (2016). *The quantified self: A sociology of self-tracking.* Polity Press. https://researchprofiles.canberra.edu.au/en/publications/the-quantified-self-a-sociology-of-self-tracking/

Martín-Rodríguez, A., & Madrigal-Cerezo, R. (2025). Technology-enhanced pedagogy in physical education: Bridging engagement, learning, and lifelong activity. *Education Sciences*, *15*(4), 409. https://doi.org/10.3390/educsci15040409

Mehling, W. E., Price, C., Daubenmier, J. J., Acree, M., Bartmess, E., & Stewart, A. (2012). The Multidimensional Assessment of Interoceptive Awareness (MAIA). *PLOS ONE*, *7*(11), e48230. https://doi.org/10.1371/journal.pone.0048230

Ntoumanis, N. (2005). A prospective study of participation in optional school physical education using a self-determination theory framework. *Journal of Educational Psychology, 97*(3), 444-453. https://doi.org/10.1037/0022-0663.97.3.444

Nurhayati, F., Tuasikal, A. R. S., Nurhasan, N., Muhammad, H. N., Indahwati, N., Kartiko, D. C., & Pranoto, A. (2025). Analysis of pre-service teachers' 21st century skills in Indonesia by gender. *International Journal of Body, Mind and Culture, 12*(4), 64-71. https://doi.org/10.61838/ijbmc.v12i4.895

Pardo, A., & Siemens, G. (2014). Ethical and privacy principles for learning analytics. *British Journal of Educational Technology*, *45*(3), 438-450. https://doi.org/10.1111/bjet.12152

Peake, J. M., Kerr, G., & Sullivan, J. P. (2018). A critical review of consumer wearables, mobile applications, and equipment for providing biofeedback, monitoring stress, and sleep in physically active populations. *Frontiers in Physiology*, *9*, Article 743. https://doi.org/10.3389/fphys.2018.00743

Pintrich, P. R. (2004). A conceptual framework for assessing motivation and self-regulated learning in college students. *Educational Psychology Review*, *16*, 385-407. https://doi.org/10.1007/s10648-004-0006-x

Ridwan, M., Aswanda, N., Sumarno, S., Ahmedov, F., & Pranoto, A. (2025). Augmented reality's impact on learning motivation in physical education: A systematic review. *International Journal of Body, Mind and Culture*, *12*(2), 5-12. https://doi.org/10.61838/ijbmc.v12i2.838

Rubel, A., & Jones, K. M. L. (2016). Student privacy in learning analytics: An information ethics perspective. *The Information Society*, *32*(2), 143-159. https://doi.org/10.1080/01972243.2016.1130502

Ryan, R. M., & Deci, E. L. (2000). Self-determination theory and the facilitation of intrinsic motivation, social development, and well-being. *American Psychologist*, *55*(1), 68-78. https://doi.org/10.1037/0003-066X.55.1.68

Ryan, R. M., & Deci, E. L. (2017). Self-determination theory: Basic psychological needs in motivation, development, and wellness. The Guilford Press. https://www.guilford.com/books/Self-Determination-Theory/Ryan-Deci/9781462538966

Schön, D. A. (1983). *The reflective practitioner: How professionals think in action.* Basic Books. https://www.hachettebookgroup.com/titles/donald-a-schon/the-reflective-practitioner/9780465068784/

Schunk, D. H., & Greene, J. A. (Eds.). (2018). *Handbook of self-regulation of learning and performance (2nd ed.).* Routledge. https://doi.org/10.4324/9781315697048

Selwyn, N. (2019). What's the problem with learning analytics? *Journal of Learning Analytics*, *6*(3), 11-19. https://doi.org/10.18608/jla.2019.63.3

Seyed Alitabar, S. H. (2025). The biopsychosocial model in modern healthcare: Overcoming barriers to holistic patient care. *International Journal of Body, Mind and Culture*, *12*(2), 1–4. https://doi.org/10.61838/ijbmc.v12i2.950

Shapiro, S. L., Carlson, L. E., Astin, J. A., & Freedman, B. (2006). Mechanisms of mindfulness. *Journal of Clinical Psychology*, *62*(3), 373-386. https://doi.org/10.1002/jclp.20237

Shilling, C. (2017). Body pedagogics: Embodiment, cognition and cultural transmission. *Sociology*, *51*(6), 1205-1221. https://doi.org/10.1177/0038038516641868

Skulmowski, A., & Rey, G. D. (2018). Embodied learning: Introducing a taxonomy based on bodily engagement and task integration. *Cognitive Research: Principles and Implications*, *3*, Article 6. https://doi.org/10.1186/s41235-018-0092-9

Slade, S., & Prinsloo, P. (2013). Learning analytics: Ethical issues and dilemmas. *American Behavioral Scientist*, *57*(10), 1510-1529. https://doi.org/10.1177/0002764213479366

Spittle, M., Jackson, K., & Casey, M. (2009). Applying self-determination theory to understand the motivation for becoming

a physical education teacher. *Teaching and Teacher Education, 25*(1), 190-197. https://doi.org/10.1016/j.tate.2008.07.005

Spittle, S., Spittle, M., Encel, K., & Itoh, S. (2022). Confidence and motivation to teach primary physical education: A survey of specialist primary physical education pre-service teachers in Australia. *Frontiers in Education, 7*, Article 1061099. https://doi.org/10.3389/feduc.2022.1061099

Standage, M., Duda, J. L., & Ntoumanis, N. (2003). A model of contextual motivation in physical education: Using constructs from self-determination and achievement goal theories to predict physical activity intentions. *Journal of Educational Psychology, 95*(1), 97-110. https://doi.org/10.1037/0022-0663.95.1.97

Standage, M., Duda, J. L., & Ntoumanis, N. (2005). A test of self-determination theory in school physical education. *British Journal of Educational Psychology, 75*(3), 411-433. https://doi.org/10.1348/000709904X22359

Stoddart, A. L., & Selanders, K. P. (2022). Preparing for physical literacy: Exploring pre-service teachers' training and understanding. *Teaching and Teacher Education, 120*, Article 103886. https://doi.org/10.1016/j.tate.2022.103886

Teixeira, P. J., Carraça, E. V., Markland, D., Silva, M. N., & Ryan, R. M. (2012). Exercise, physical activity, and self-determination theory: A systematic review. International *Journal of Behavioral Nutrition and Physical Activity, 9*, Article 78. https://doi.org/10.1186/1479-5868-9-78

Theobald, M. (2021). Self-regulated learning training programs enhance university students' academic performance, self-regulated learning strategies, and motivation: A meta-analysis. *Contemporary Educational Psychology, 66*, Article 101976. https://doi.org/10.1016/j.cedpsych.2021.101976

Tschannen-Moran, M., & Woolfolk Hoy, A. (2001). Teacher efficacy: Capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805. https://doi.org/10.1016/S0742-051X(01)00036-1

Vallerand, R. J., Pelletier, L. G., Blais, M. R., Brière, N. M., Senécal, C., & Vallières, E. F. (1992). The Academic Motivation Scale: A measure of intrinsic, extrinsic, and amotivation in education. *Educational and Psychological Measurement, 52*(4), 1003-1017. https://doi.org/10.1177/0013164492052004025

Whitehead, M. (Ed.). (2010). *Physical literacy: Throughout the life course.* Routledge. https://doi.org/10.4324/9780203881903

Williamson, B. (2017). *Big data in education: The digital future of learning, policy and practice.* SAGE. https://uk.sagepub.com/en-gb/eur/big-data-in-education/book245288

Wilson, M. (2002). Six views of embodied cognition. *Psychonomic Bulletin & Review, 9*(4), 625-636. https://doi.org/10.3758/BF03196322

Zhao, Z., & Su, Y. (2026). Wearable technologies in school physical education: A systematic review of pedagogical implications. *Physical Education Theory and Methodology, 26*(1), 79-89. https://doi.org/10.17309/tmfv.2026.1.07

Zhou, T. (2024). The role of pre-service physical education teachers in physical education: A bibliometric and systematic review. *Heliyon, 10*(7), Article e28702. https://doi.org/10.1016/j.heliyon.2024.e28702

Zimmerman, B. J. (2000). *Attaining self-regulation: A social cognitive perspective. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), Handbook of self-regulation (pp. 13-39).* Academic Press. https://doi.org/10.1016/B978-012109890-2/50031-7

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory Into Practice, 41*(2), 64-70. https://doi.org/10.1207/s15430421tip4102_2