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Article

Mechanisms and Adjustment Strategies for Supply–Demand Mismatch of Physical Education Teachers in Basic Education: A School-Age Population Change Perspective

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Abstract: Amid changes in the size and structure of the school-age population, PE teacher allocation in basic education shows three supply–demand mismatches: quantity mismatch (localized shortages and redundancies driven by grade-level fluctuations), structural mismatch (rising demand for composite competencies but misaligned specialization and skills), and spatial mismatch (uneven distribution across regions, urban–rural areas, and schools). Using a linked "population–school–position" framework, the paper identifies three corresponding causes: quantity mismatch results from lagged demand forecasting and recruitment planning combined with long training cycles; structural mismatch arises from misalignment between preparation standards and competency-based job requirements and insufficient in-service upskilling; spatial mismatch is driven by weak county-level pooling, limited mobility incentives, and high redeployment costs. Accordingly, three adjustment strategies are proposed: a cohort-based rolling forecasting and early-warning system linked to establishment and hiring decisions; competency-oriented redesign of pre-service preparation and in-service training to strengthen cross-grade and multi-sport capacities; and county-level pooling with incentive-based mobility, supported by remuneration and career-development policies to improve attraction and retention in disadvantaged areas. The study offers actionable pathways to enhance anticipatory planning, precision, and equity in PE teacher allocation.

Keywords: School-age Population Change; Physical Education Teachers; Supply–Demand Mismatch; Basic Education; Teacher Allocation; Adjustment Strategies

1. Introduction

Changes in the size and structure of the school-age population are reshaping the core logic of resource allocation in basic education. Cohort fluctuations, urbanization, and population mobility alter school scale, class composition, and conditions for curriculum delivery, increasing uncertainty in staffing decisions (Zhao & Yan, n.d.). In this context, physical education (PE) is not only responsible for improving students' fitness and motor skills, but is also closely linked to school health education, holistic development, and safety governance in school sports. As the key input for effective PE delivery, the adequacy and fit of PE teacher allocation directly affect whether required instructional time is provided and whether teaching quality can be sustained, and they also signal the responsiveness of the basic education system to demographic change.

Empirically, supply–demand mismatch of PE teachers in basic education typically manifests in three forms. The first is a quantity mismatch: as the school-age population fluctuates across stages and regions, PE teacher demand rises and falls over time and across grade bands, producing localized imbalances in which shortages and redundancies may coexist (Jin, 2026). The second is a structural mismatch: school PE increasingly requires composite competencies that extend beyond single-sport instruction to include curriculum implementation, fitness promotion, organization of school-wide activities, and safety management; however, the supply of teachers often fails to align with these competency profiles in terms of specialization, skill structure, and grade-level fit. The third is a spatial mismatch: teacher distribution remains uneven across regions, urban–rural areas, and schools, with disadvantaged areas experiencing persistent pressure in attracting and stabilizing staffing, thereby widening disparities in access to and quality of PE provision (Ren et al., 2026).

These three mismatches are not isolated phenomena; rather, they emerge as demographic shocks interact with school operational conditions, teaching-load requirements, and evolving job demands. With a school-age population change perspective as the starting point, this paper systematically characterizes PE teacher supply–demand mismatch along the three dimensions—quantity, structure, and space—thereby providing a more targeted analytical lens for identifying the central tensions in PE teacher allocation and establishing the basis for subsequent discussion of adjustment pathways.

2. Literature Review

2.1 Concept and Definition of Basic Education

Basic education is commonly defined as the stage of schooling that provides universal and foundational learning for children and adolescents, with the overarching goal of building essential competencies for citizenship and lifelong development. Unlike selective or track-oriented phases, basic education is typically framed as a public service that prioritizes equity, inclusiveness, and holistic development, covering cognitive growth, physical and mental health, socio-emotional learning, and value formation (Cheng et al., 2025). In many contexts, the term refers primarily to primary and lower secondary education, although some policy and research traditions extend it to early childhood or upper secondary levels (Tan & Ren, 2025).

In research, the concept of basic education is closely tied to institutional arrangements, curriculum systems, and governance structures. As a public good with strong externalities, basic education relies on coordinated policy instruments such as fiscal financing, staffing establishments, school network planning, and quality assurance. Moreover, educational quality is understood not only as access and inputs but also as the capacity to implement curricula effectively, which depends on teacher supply, workforce structure, and school governance. From this perspective, basic education can be conceptualized as a curriculum-centered public service system, within which PE teachers constitute a crucial workforce for realizing health education and holistic development goals (Cheng et al., 2025).

2.2 Research on the Supply–Demand Status of PE Teacher Allocation

Studies on the supply–demand status of PE teacher allocation commonly examine three dimensions: quantitative adequacy, structural fit, and distributive equity (Liu et al., 2025). On the quantitative side, research assesses whether staffing levels can support required PE instructional time, often using indicators such as student–teacher ratios, staffing gap estimation, teaching-load measures, and establishment quotas. Many studies suggest that PE teacher shortages persist in certain regions and schools, especially as PE responsibilities

expand beyond classroom instruction. Staffing constraints are frequently associated with practices such as substituting non-specialists, using temporary instructors, or compressing instructional time, which may compromise curriculum quality and fitness-related outcomes (Wang & Wang, 2025).

Regarding structural and spatial aspects, the literature highlights imbalances in teachers' disciplinary backgrounds, sport specializations, educational attainment, career stages, and gender composition, as well as uneven distribution across regions, urban–rural settings, and schools (Lu, 2025). Structural misalignment affects not only classroom teaching but also extracurricular sports programming, school competitions, and fitness monitoring (Cao, 2025). Spatial disparities are often linked to differences in school conditions, local fiscal capacity, job attractiveness, and mobility mechanisms, with disadvantaged areas more likely to experience a cycle of recruitment difficulty, low stability, and slow quality improvement. Overall, the research trajectory has shifted from a narrow focus on "whether there are enough teachers" to broader concerns about fitness for purpose and equitable, effective provision.

2.3 Studies Linking School-Age Population Change to PE Teacher Resource Allocation

Research on population change and teacher allocation is largely grounded in demography and education planning, emphasizing demand-side drivers through changes in cohort size, age structure, and spatial mobility. This line of work argues that birth fluctuations and enrollment waves generate "cohort transmission effects" across schooling stages, producing periodic rises and falls in teacher demand. Meanwhile, population concentration in cities and metropolitan areas reshapes regional demand patterns and increases pressure for school network adjustment and resource reallocation. In this view, teacher allocation is not a static supply issue but a dynamic governance response to demographic change (He & Wu, 2024).

For PE teachers, the linkage is more complex because demand is shaped not only by student numbers but also by PE time requirements, class size, grouping arrangements, facilities, equipment, and the intensity of school sports programming. As a result, demographic shifts that alter school scale and class composition may translate into non-linear changes in teaching load and post demand. Population mobility can also differentiate school contexts—for example, expanding schools in peri-urban areas versus shrinking small rural schools—creating distinct demand profiles for PE staffing. While emerging studies attempt to integrate population forecasting, school network planning, and curriculum load within a single framework, mechanism-based discussions focusing specifically on PE teachers remain limited and warrant further development (Zhang, 2023).

2.4 Critical Review of the Literature

Overall, the existing literature provides three major foundations. First, it clarifies the policy nature and quality logic of basic education as a public service system, offering an institutional backdrop for staffing discussions. Second, it documents the realities of PE teacher allocation from quantitative, structural, and distributive perspectives, moving the debate beyond aggregate shortages toward issues of fit and equity (Diao, 2019). Third, it establishes demographic change as a significant driver of education demand and staffing planning, supporting the development of forecasting and planning approaches. These contributions collectively inform the present study's population-change perspective on PE teacher mismatch. Nevertheless, several limitations remain. First, population-change research and PE teacher allocation research are still relatively disconnected, with insufficient integration across the "population–school–position" chain. Second, demand estimation and explanation for PE teachers often remain indicator-driven and aggregate-focused, with limited attention to how curriculum load, competency requirements, and school PE governance jointly shape demand. Third, the conceptualization of mismatch frequently stops at describing staffing gaps, without clearly distinguishing and linking quantity, structural, and spatial mismatches. Building on this review, the present paper advances a more structured analysis of mismatch across the three dimensions, providing a clearer basis for subsequent discussion of implementable adjustment pathways.

3. Research Design and Methods

To systematically examine how supply–demand mismatch of PE teachers in basic education emerges under changes in the school-age population—and to provide methodological support for developing actionable adjustment pathways—this paper adopts a problem-oriented research design. The section is organized around three components: research focus and scope, research objectives and significance, and the methods and analytical procedures. The following paragraphs clarify the study boundaries, key analytical foci, and the data analysis logic to ensure a coherent and replicable methodological framework.

3.1 Research Focus and Scope

This research investigates the allocation of PE teacher resources in basic education from a school-age population change perspective, with a specific focus on how supply–demand mismatch manifests and operates. The scope covers supply-side elements (training supply, entry into posts, workforce composition, and mobility patterns), demand-side elements (cohort size and structure, school scale and class composition, PE teaching load, and post demand), and their matching status across regions, urban–rural settings, and schooling stages. To enhance analytical clarity, mismatch is conceptualized in three dimensions—quantity, structural, and spatial mismatch—which guides the analytical framework and indicator construction.

Accordingly, the study is organized around three strands. First, it provides a structured depiction of PE teacher demand through a linked "population–school–position" logic, connecting demographic change with school operation and teaching-load requirements. Second, it identifies key chains through which mismatch is produced and sustained across training, allocation, and mobility processes, explaining the emergence of quantity, structural, and spatial mismatch. Third, it develops actionable adjustment strategies based on the mechanism diagnosis and discusses their feasibility and boundary conditions in terms of policy instruments and implementation pathways, forming a coherent logic of "problem identification–mechanism explanation–strategy generation."

3.2 Research Objectives and Significance

The immediate objective is to develop an analytical framework that can simultaneously explain quantity, structural, and spatial mismatches under demographic change, and to address three core questions: where mismatch comes from, how it is amplified and institutionalized, and how it can be adjusted. Specifically, the study pursues three goals: (1) identifying the dynamic pattern of PE teacher demand by linking cohort change with school scale and PE teaching load; (2) extracting mismatch mechanisms from training cycles, competency profiles, establishment and post management, and pooling/mobility arrangements; and (3) generating a mechanism-aligned strategy package that can inform forecasting, allocation, and redeployment practices at the local level.

The contribution is threefold. Theoretically, the study integrates demographic change into PE teacher allocation analysis, strengthening explanations that connect external population shocks with internal governance constraints in basic education staffing. Methodologically, it operationalizes a "population–school–position" chain by integrating demographic forecasting, school-scale and curriculum-load accounting, post-demand estimation, and spatial distribution analysis into a reusable approach. Practically, the study provides evidence and a structured basis for education authorities to improve demand forecasting, workforce structure optimization, and county-level pooling under new demographic conditions, aiming to enhance anticipatory planning, precision, and equity in PE teacher allocation.

3.3 Research and Data Analysis Methods

The study adopts a policy-problem-oriented mixed design, combining quantitative estimation with qualitative interpretation and emphasizing an aligned sequence of "macro trend identification–meso demand accounting–micro mechanism explanation." It first assesses demand-side trends driven by school-age population change and estimates post demand by incorporating school scale, class size, PE time requirements, and teaching organization. It then analyzes supply- and allocation-side structures and compares matching conditions across regions, urban–rural settings, and schooling stages to identify concrete manifestations of quantity,

structural, and spatial mismatch. Finally, it interprets the mechanisms through an institutional and governance lens and translates evidence into implementable policy instrument combinations and adjustment pathways.

Analytically, three sets of methods are applied. First, demand estimation and gap identification: cohort/enrollment data and school/class data are used to estimate PE teaching load and derive post demand, which is compared with existing PE teacher supply to identify temporal and regional gaps. Second, structural and spatial analyses: workforce composition (specialization, qualification/career stages, and grade fit) is descriptively profiled, while spatial disparities are assessed via grouped comparisons and inequality measures across regions, urban–rural areas, and schools. Third, mechanism synthesis and strategy derivation: quantitative findings are triangulated with institutional contexts through logical chain analysis to locate constraints in forecasting, training, establishment management, and mobility/pooling, thereby informing an actionable strategy framework and implementation priorities.

4. Causal analysis

Having identified the three dominant manifestations of PE teacher supply–demand mismatch, the next step is to examine the underlying generative logic and binding constraints. From a school-age population change perspective, this section analyses how demand dynamics, supply responsiveness, and allocation governance interact to produce and reinforce mismatch, thereby clarifying how quantity, structural, and spatial imbalances emerge and persist.

4.1 Lagged demand forecasting and hiring decisions combined with long training cycles: drivers of quantity mismatch

Under continuous fluctuations in the size and structure of the school-age population, demand for PE teachers varies by cohort, grade band, and schooling stage. Enrollment waves transmit across stages over time and are further complicated by regional mobility and school network adjustments, producing rapid local increases or decreases in staffing needs. Quantity mismatch emerges when demand behaves as a “fast-moving variable” but forecasting and hiring are tied to fixed annual budgeting cycles, establishment approvals, and administrative procedures. When demand rises, recruitment and placement cannot be completed in time; when demand declines, staffing levels cannot contract accordingly. This temporal misalignment makes it possible for shortages and redundancies to coexist within and across jurisdictions.

At the same time, the supply of PE teachers is characterized by strong rigidity due to long training and entry cycles. Pre-service preparation, certification, and placement require substantial lead time, and training capacity cannot be scaled up or down quickly in response to short-term demographic shifts. Although temporary hiring, reassignment, or cross-subject teaching may be used as short-run remedies, these measures often compromise professionalism and stability, with consequences for instructional time and quality. In combination, lagged forecasting/hiring and long supply cycles constitute a structural institutional foundation for persistent quantity mismatch.

4.2 Misalignment between preparation standards and competency-based job requirements, and insufficient in-service upskilling: drivers of structural mismatch

Structural mismatch is fundamentally about “what kind of teachers are needed,” not merely “how many.” As school PE expands from single-sport classroom instruction to broader responsibilities—fitness promotion, organization of school-wide activities, and safety/risk management—the competency profile of PE posts becomes increasingly composite. However, parts of the preparation system remain anchored in traditional disciplinary knowledge and single-specialization training, creating a gap between graduates’ competence structures and the task requirements of real school posts. Common manifestations include mismatches between sport specializations and curricular needs, limited cross-sport instructional capacity, inadequate competencies related to health education and fitness monitoring, and weak grade-level pedagogical fit.

This mismatch is further amplified by limited and uneven in-service professional development. When job demands upgrade, teachers require structured pathways for competency migration—from single-speciali-

zation to multi-sport, cross-grade, and multi-task performance. Without sustained training, micro-credentialing, and school-based professional support, the cost of capability conversion remains high, and opportunities for development differ widely across schools. As a result, the pace of demand upgrading outstrips the pace of workforce re-skilling, turning initial entry-stage misalignment into a persistent structural gap that varies systematically across local contexts.

4.3 Weak county-level pooling, limited mobility incentives, and high redeployment costs: drivers of spatial mismatch

School-age population change often materializes spatially: population concentration in urban areas, expansion of peri-urban schools, and contraction of some rural communities reshape where educational demand is located. Spatial mismatch becomes pronounced not only because demand shifts geographically, but also because staffing governance is fragmented and pooling capacity is limited. When teacher allocation is managed in siloed ways across schools or sub-districts, and when mechanisms for sharing, reassigning, and coordinating posts and teaching loads are underdeveloped, teacher resources cannot move in step with demand. This generates a persistent pattern in which shortage areas remain chronically understaffed while surplus areas struggle to reabsorb staffing.

Mobility is additionally constrained by a combination of weak incentives and high costs. Disadvantaged areas often offer lower perceived job attractiveness and limited career prospects, reducing the supply of teachers willing to relocate. Meanwhile, redeployment entails tangible costs (commuting, housing, children's schooling) and intangible costs (social ties, professional adaptation), while existing incentive packages may be insufficient in magnitude, duration, or predictability to offset these burdens. Consequently, mobility mechanisms fail to function as an effective reallocation channel, and spatial mismatch is institutionalized through persistent frictions, widening disparities in access to and quality of PE provision across regions and schools.

5. Countermeasures and suggestions

Mechanism diagnosis alone is insufficient for policy improvement; it must be translated into implementable governance options. Accordingly, this section follows a "problem–mechanism–instrument" logic and develops three corresponding sets of countermeasures, emphasizing (i) linkage between forecasting and staffing decisions, (ii) alignment between competency supply and job demand, and (iii) coordinated pooling and incentive-based mobility to strengthen anticipatory capacity and system resilience in PE teacher allocation.

5.1 Establish a cohort-based rolling forecasting and early-warning system linked to establishment and hiring

First, demographic change should be embedded into the routine decision chain for PE teacher allocation through a closed-loop mechanism of "forecasting–early warning–response." Using data on births, enrollment, stage transitions, and population mobility, local authorities can develop county-level (and above) rolling projections that are updated regularly to estimate student enrollment, school scale, and class composition over the coming years, and then translate these estimates into PE teaching-load and post-demand calculations. The core value lies less in one-off precision than in iterative updating, enabling timely identification of turning points, peaks, and structural shifts that can inform staffing decisions with sufficient lead time.

Second, projection output should be institutionally linked to establishment approval, post setting, recruitment plans, and—where relevant—teacher education capacity planning. In practice, demand estimates can be converted into annual and medium-term staffing plans with a dual structure: a "mandatory baseline quota" to secure minimum curriculum provision and a "flexible reserve quota" to buffer demographic volatility. For fast-growing areas, staged recruitment and early placement can be used to smooth demand surges; for areas facing declining demand, teaching-load coordination, cross-school sharing, and post-structure adjustments can prevent cyclical overstaffing or under-supply driven by administrative lag.

5.2 Redesign pre-service preparation and in-service development around job competencies, strengthening cross-grade and multi-sport capacities

First, competency standards should be aligned with real job tasks in school PE, shifting from single-sport specialization to a composite competency portfolio. In pre-service preparation, core modules can include multi-sport instructional capacity, fitness promotion and monitoring, classroom safety and risk management, and organization and assessment of school-wide physical activity. Practice-oriented coursework and authentic teaching simulations can strengthen "job readiness," while grade-specific pedagogy training can improve fit for different learning characteristics and curricular expectations across primary and lower secondary education, reducing structural mismatch at entry.

Second, a sustainable in-service development system is needed to lower the cost of competency migration, with modular training and micro-credentials as practical instruments. In-service programs can target cross-sport instruction, integration of health education, class organization, and risk governance, and be reasonably connected to promotion, post advancement, or performance appraisal to strengthen participation incentives. For shortage segments and critical specializations, targeted training and school–local partnerships can enhance supply efficiency. Through a continuous pathway of "entry requirements–in-service upgrading–competency certification," teacher capability structures can evolve in step with upgrading job demands.

5.3 Strengthen county-level pooling and incentive-based mobility, supported by remuneration and career-development policies

First, counties should be positioned as the key governance unit for optimizing PE teacher allocation, enabling integrated coordination of establishment quotas, posts, and teaching loads to improve cross-school adjustability. County-level sharing and support mechanisms—such as cross-school teaching assignments, professional learning communities, and school-group governance—can provide short-term coverage, while clear rules for post and teaching-load coordination can ensure minimum staffing standards for small and disadvantaged schools. The central aim is to move from "school-level optimization" toward "system-level optimization," improving efficiency and equity at the regional level.

Second, incentive-based mobility should be used to open effective reallocation channels with predictable and sustainable policy packages. For disadvantaged areas and shortage posts, differentiated incentives may include performance-based allowances, housing support, establishment prioritization, accelerated promotion opportunities, and enhanced training access, accompanied by clear service terms and safeguards to improve policy credibility. Reducing institutional and life-course costs—streamlining redeployment procedures, supporting family needs, and providing commuting/accommodation assistance—can further increase mobility feasibility. With the dual drivers of coordinated pooling and incentive guarantees, spatial disparities in PE teacher distribution can be gradually alleviated.

6. Conclusion

Under ongoing changes in the size and structure of the school-age population, the allocation of physical education (PE) teachers in basic education faces supply–demand mismatches that are triggered by demographic fluctuations and spatial shifts and amplified through governance constraints. From a linked "population–school–position" perspective, this paper systematically characterizes three forms of mismatch: quantity mismatch (the coexistence of localized shortages and redundancies over time), structural mismatch (a growing demand for composite competencies that is not matched by the capability profile of the workforce), and spatial mismatch (uneven distribution across regions, urban–rural settings, and schools). The analysis further shows that these mismatches are associated with key constraints, including lagged forecasting and recruitment decisions combined with long supply cycles, misalignment between preparation standards and competency-based job requirements alongside insufficient in-service upskilling, and limited county-level pooling with weak mobility incentives. Based on this mechanism diagnosis, the paper proposes an integrated policy package comprising cohort-based rolling forecasting and early warning linked to establishment and hiring, competency-oriented redesign of pre-service preparation and in-service development, and county-level pooling with incen-

tive-based mobility to improve spatial reallocation. Collectively, these measures aim to enhance the anticipatory capacity, precision, and equity of PE teacher allocation and to support stable provision and quality improvement of school PE under new demographic conditions.

DATA AVAILABILITY STATEMENT

All data supporting the findings of this study are available within the article and its supplementary materials. Additional data may be obtained from the corresponding author upon reasonable request.

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AUTHOR CONTRIBUTIONS

Shengchao Du: Conceptualization, Methodology, Data Collection, Formal Analysis, Investigation, Validation, Visualization, Writing – Original Draft, Writing – Review & Editing.

Liang Shang: Supervision, Project Administration, Writing – Review & Editing, Funding Acquisition.

All authors have read and approved the final version of the manuscript.

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COMPETING INTERESTS

The authors declare no competing interests.

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