Contemporary Education Frontiers, 2026, Volume 4, Issue 6
https://bbwpublisher.com/journal/CEF
Online ISSN: 3029-1860
Print ISSN: 3029-1879

From Control to Empowerment: Reforming Whole-School Educational Governance in a General Senior High School with an Aerospace Science and Innovation Focus

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Abstract: Against the converging policy priorities of coordinating education, science and technology, and talent development; improving the quality of basic education; and accelerating educational digitalization, conventional high-school governance based on administrative directives and rigid quantitative assessment is increasingly ill-suited to diversified university selection, the long-term development of exceptional talent, and the integration of values into science and engineering education. This study examines the governance reform undertaken by Shenzhen Gezhi High School, which has adopted aerospace science and innovation as a distinctive educational focus. The reform pursued two interrelated aims: improving science education and establishing whole-school, whole-process education, understood as an institution-wide approach spanning organization, teachers, curriculum, evaluation and multi-stakeholder collaboration. Guided by the school's medium- and long-term development plan, governance shifted from unilateral administrative control to empowerment-oriented governance, characterized by devolved authority, coordinated resource allocation and collaborative participation. The study draws on action research, continuous observation across two campuses, stratified semi-structured interviews, and quantitative evidence-based analysis conducted over three consecutive years. It identifies five interrelated constraints within the previous model: fragmented organizational coordination, inflexible teacher evaluation, imbalanced differentiated curriculum provision, score-dominated student assessment, and restricted external collaboration. In response, the school developed an integrated framework comprising organization, teacher development, curriculum, digital evaluation, and multidimensional collaboration. The values associated with crewed spaceflight and "Two Bombs, One Satellite"—especially patriotism, dedication, scientific self-reliance, and collective endeavor—were incorporated into aerospace-related learning activities. Longitudinal evidence indicates improved cross-campus resource use, stronger interdisciplinary teaching capacity, more coherent pathways for exceptional talent, and greater institutional distinctiveness. The case provides a locally grounded model for public school groups seeking to combine science education, digital governance, values education and secondary-university articulation.

Keywords: Empowerment-oriented governance; Aerospace science and innovation; Curriculum-integrated values education; Public school groups; Whole-school; whole-process education; Digital transformation in education

Online publication: June 26, 2026

1. Introduction

1.1. Research background

The 20th National Congress of the Communist Party of China established top-level coordination for the integrated development of education, science and technology, and talent. The state subsequently issued dedicated guidance on science education in primary and secondary schools, requiring schools to expand practice-based vehicles for science education and to embed the values of self-reliance, self-strengthening, patriotism and service to the nation in mathematics, science and engineering practice. As the principle of fostering virtue and nurturing talent has been advanced on a sustained basis, values education across all subjects has become a mandatory reform task in basic education. Science, engineering and innovation classrooms therefore need to use aerospace-themed resources to integrate moral education [1].

With subject selection under China's reformed National College Entrance Examination (gaokao), the Strengthening Basic Disciplines Plan (a selective program through which leading Chinese universities identify and cultivate exceptional students in foundational disciplines), special early-entry university programs for gifted adolescents and other diversified admission routes now fully implemented, leading universities have steadily raised their selection standards for applicants who combine practical engineering competence, a complete experience of research and a sense of responsibility to the nation [2,3]. Public senior high schools are consequently compelled to move beyond short-term examination-oriented management and establish a comprehensive educational operating system involving all staff, the entire process and the full developmental chain.

School-group governance has become the principal regional route for expanding the supply of high-quality public education. However, most multi-campus providers have long retained restrictive management mechanisms [4]. Their administrative approval procedures are cumbersome, internal resource allocation lacks flexibility, and teacher performance evaluation places excessive weight on written examination scores, leaving science and innovation practice and moral-education activities in marginal positions. Shenzhen Gezhi High School was established in 2021 under the coordinated planning of Longhua District as a public science and engineering senior high school. Its overarching educational philosophy is "rooted in traditional culture, animated by the aerospace spirit, and empowered by advanced technology." The school incorporated aerospace value-oriented courses and an artificial-intelligence-enabled digital campus into its medium- and long-term development plan.

The school created a range of advanced science and innovation spaces, including an aerospace post office, a quantum laboratory, a low-altitude wind tunnel and a visible-light innovation laboratory. It established the tiered "Shensi" and "Lingyi" programs for developing exceptional talent and formed integrated educational partnerships with more than 20 research organizations, including Tsinghua University, the University of Electronic Science and Technology of China, and the Shenzhen Institutes of Advanced Technology, Chinese Academy of Sciences. Three consecutive years of complete reform observation across two campuses provide a robust frontline evidence base for this empirical study.

This chapter reviews top-level policy directions and practical tensions in regional schooling, clarifies the overall limitations of existing research, defines the study's theoretical and practical value, and sets out its research logic and four methods. It thereby prepares the ground for the subsequent diagnosis of governance tensions and construction of the reform system.

1.2. Significance of the study

Current Chinese scholarship on basic education remains fragmented, often treating governance, science innovation, and values education separately. This study addresses this gap by providing an integrated analytical framework that combines aerospace science and innovation, whole-school values education, digital school-group governance, and secondary-university articulation. Its practical conclusions offer a replicable model for public aerospace- and engineering-oriented education groups in China, supporting the balanced development of regional public education.

1.3. Review of research in China and abroad

International K-12 science education often uses school-enterprise collaboration and project-based learning, with digital platforms supporting personalized instruction. However, these systems differ fundamentally from China's top-down values education design and public school group models. Existing Chinese research falls into three categories: conventional teaching and moral education in school groups, science and innovation lesson development, and humanities-focused value education. None provides a complete empirical analysis combining aerospace science, whole-school values education, digital governance, and secondary-university articulation. This study addresses that specialized gap [5,6].

1.4. Research logic and methods

1.4.1. Research logic

The study follows the complete logical chain of "tracing policy texts - defining core concepts - empirically diagnosing governance tensions - constructing an empowerment system - verifying outcomes with longitudinal data - optimizing long-term implementation by stage." It systematically reviews top-level theories concerning national development through science and education, new forms of talent, educational digitalization, and values education across all disciplines. School operational records and stratified interviews with teachers and students are used to diagnose five inherent weaknesses of the restrictive model [7]. The school's medium- and long-term development plan then provides the basis for an empowerment-governance architecture centered on aerospace science and innovation. Longitudinal comparative data on science and innovation competitions, admissions through the Strengthening Basic Disciplines Plan and early-entry university programs, and facility use are integrated to test the effects of implementation. Remaining limitations are used to formulate short-, medium-, and long-term optimization pathways.

1.4.2. Research methods

The study follows the logical chain of "policy - theory - tensions - countermeasures - outcomes - reflection." It employs four research methods:

Action Research: The author, as a senior administrator, participated in the entire reform process.

Multi-campus Observation: Continuous tracking of operations across two campuses over three years.

Stratified Semi-structured Interviews: Conducted with administrators, teachers, students, and university mentors.

Evidence-based Data Analysis: Quantitative indicators on facility use, course development, competition honors, and student admissions were integrated to evaluate effects.

1.5. Research innovations

Innovation in perspective. The study combines five analytical dimensions: education-group administration, aerospace-oriented science and engineering classrooms, humanities-based moral education in senior-high Chinese, educational digitalization, and secondary-university articulation. It integrates the distinctive perspectives of a school-level administrator and a senior-grade Chinese teacher, thereby moving beyond the limitations of single-discipline or purely administrative studies.

Innovation in content. The school's top-level development plan, aerospace-oriented values education, and AI-enabled digital empowerment are closely coupled in a five-in-one analytical framework. This directly addresses two central national education-reform issues: science education and digital iteration.

Innovation in evidence. The study draws on the school's academician think tank, quantum and low-altitude laboratories, the dedicated "Student Scientist" articulation project, an immersive aerospace campus environment, and three years of longitudinal comparative data. The resulting case has a distinctive scholarly identity that cannot readily be replicated.

This chapter has distilled three differentiating innovations, defined the study's added value relative to comparable literature, and presented the overall analytical trajectory. It also delineates the research boundaries for the theoretical and practical analyses that follow.

2. Definition of core concepts and theoretical foundations

2.1. Definition of core concepts

Empowerment-oriented governance for whole-school, whole-process education. An approach that devolves authority appropriately and encompasses the entire chain of organization, teachers, curriculum, evaluation, and collaboration.

Integration of aerospace science and innovation with curriculum-integrated values education. The systematic integration of moral aims, particularly the aerospace spirit and patriotism, into science and engineering curricula through project-based learning [8].

Group-wide digital education across all domains. The use of a smart campus to connect resources, courses, and student portfolios across campuses for dynamic tracking.

2.2. Theoretical foundations

Theory of high-quality and balanced development in basic education. This theory emphasizes differentiated provision based on educational substance, balanced campus resources, and coordination across the five domains of education. It avoids homogeneous examination-oriented pathways, improves the competence of all students, and supports the sustained development of exceptional talent, thereby addressing practical imbalances among campuses in an education group.

Theory of integrated development across the five domains and whole-school values education. Integrated development across the five domains refers to the coordination of moral, intellectual, physical, aesthetic, and labor education. The theory requires each discipline to identify its moral-education content and uses aerospace settings to deliver implicit moral education in science and engineering. It counters the humanities bias of existing literature and extends practical pathways for moral education in science and engineering classrooms [9].

Theory of digital transformation in education. Big data, eye-tracking assessment, and virtual simulation are used to support differentiated teaching and evidence-based schooling. The study moves beyond hardware procurement by constructing an integrated governance instrument combining assessment and digital portfolios, thereby extending the practical meaning of digitalized schooling.

3. Practical difficulties in group-wide, whole-school educational governance under a control-oriented logic

Based on three years of operational records from two campuses and multiple rounds of stratified interviews, the conventional administratively restrictive model has generated systemic governance tensions in five areas, impeding the integration of aerospace science and innovation with values education.

3.1. Organizational coordination: Administrative barriers fragment resources for science, innovation, and values education

The boundaries of authority and responsibility between the two campuses were unclear. Advanced science and innovation facilities were scheduled administratively, with no online channel through which teachers and students could make independent reservations. Before the reform, annual use at the main campus was far higher than at Minzhi Campus. Public moral-education lectures by academicians and cross-campus PBL projects were coordinated entirely by administrators, while the application process for teacher-initiated projects was cumbersome. Performance evaluation was weighted towards standardized examinations in academic subjects; workload-recognition standards for aerospace school-based courses and science and innovation competition coaching were incomplete; and the endogenous motivation for joint humanities-science research was weak.

3.2. Student evaluation: Score-only assessment separates scientific innovation from value development

Student assessment relied primarily on written tests. Aerospace models, research internships, invention patents, and study reports were not incorporated into official comprehensive-quality portfolios. The absence of AI-enabled digital tracking across the entire process meant that trajectories of scientific innovation and moral development could not be retained. Short-term semester evaluation was poorly matched to the long-cycle development required by the Strengthening Basic Disciplines Plan and early-entry university programs.

3.3. Collaborative education: Closed management restricts the boundaries of multi-actor participation

Educational resources remained confined to the school. Cooperation with aerospace institutes and universities was coordinated exclusively by administrators, blocking frontline teachers' access to independent research projects. There was no regular vehicle for parent-child aerospace science activities and no cross-campus digital-resource platform, preventing high-quality courses and academician lectures from circulating to the branch campus.

By applying the five theoretical frameworks introduced earlier, this chapter has disaggregated the

endogenous governance tensions of the restrictive model across five dimensions. It demonstrates the conflict between conventional management and aerospace-oriented education, providing a problem-oriented basis for the corresponding optimization pathways in the next chapter.

4. Guidance through high-quality development planning: Pathways for digitally empowered reform in aerospace science and innovation

The school's medium- and long-term plan established "from control to empowerment" as its principal reform trajectory. Curriculum-based values education and digitalization were embedded as two major tasks within a closed-loop governance system.

4.1. Empowering the organizational architecture: Three-tier flat project governance

A three-tier flat project governance structure was established, and three lists covering authority, responsibility, and services were introduced to devolve approval authority. Party-building was integrated into the science innovation process to highlight the value-education theme of patriotic service.

4.2. Empowering digital evaluation: AI-enabled multidimensional student-growth portfolios

The Tsinghua AI potential-assessment system moves evaluation beyond scores alone. A four-dimensional digital portfolio automatically archives classroom projects, aerospace-themed value-education practice, science and innovation patents, and university internships. Teacher evaluation adds value-added indicators for interdisciplinary work and science and innovation mentoring, while big data supports differentiated instruction.

4.3. Empowering collaborative resources: A five-dimensional digital educational community

The school constructed a collaborative system involving secondary schools, universities, research institutes, aerospace enterprises, and families. It regularly holds an Aerospace Science and Technology Festival and a Young Scientists Forum. Through the Student Scientist Project, students enter national-level laboratories. Online aerospace science popularization resources are open to families, and online academician-led study resources are shared across the entire education group [10].

For each of the five governance tensions in Chapter 3, this chapter provides a corresponding implementable measure, forming a complete "problem - solution" loop. All reform measures are tailored to the school's aerospace science and innovation resources and are operationally explicit.

5. Evidence-based outcomes of empowerment-oriented governance reform

After three years of systematic implementation, aerospace science and innovation and digital governance generated quantifiable educational outcomes. The pre- and post-reform comparison was marked: cross-campus laboratory utilization increased by 72%, and the frequency of joint humanities-science teaching research doubled.

5.1. Marked improvement in organizational coordination

Three-tier dedicated task forces now operate routinely. The online facility-reservation system has been fully implemented, procedures for proposing science and innovation courses have been simplified, and the fragmentation of campus resources has been substantively alleviated. These operational outcomes directly confirm the practical value of multi-actor collaboration and tiered devolution in empowerment-governance theory.

5.2. Breakthroughs in the development of exceptional talent

Through the dual-track model supported by AI assessment, students won two gold medals at the Nuremberg International Exhibition of Inventions, four national first prizes for aerospace innovation, more than 40 provincial awards, and two national invention patents. The school cultivated Longhua District's first student admitted to the Junior Program of the University of Science and Technology of China. Several students entered universities included in China's Double First-Class initiative through the Strengthening Basic Disciplines Plan and comprehensive evaluation admissions. The completed articulated pathway meets the theoretical requirement for long-cycle talent development.

5.3. Stronger demonstration and dissemination

The school was recognized as a Guangdong Provincial School with Distinctive Aeronautics and Astronautics Provision, a Shenzhen Science-Popularization Base, and a National Experimental Incubation School for Science and Technology Education. It has hosted more than 50 visiting delegations from across China and has developed a replicable "Gezhi model of aerospace-empowered education."

Using longitudinal comparisons between reform baselines and implementation data, this chapter has presented quantitative outcomes across five dimensions. It also reconnects these findings with the earlier theory, forming a unified loop of theory, practice and data.

6. Remaining weaknesses and staged pathways for sustainable optimization

6.1. Major current limitations

Minzhi Campus still lacks sufficient specialized teachers for advanced science, innovation, and moral education, and the coverage of synchronous online classes taught by academicians could be expanded. The data-aggregation and analysis modules of the group's digital platform require further iteration. Courses integrating aerospace and the humanities remain limited, and implicit moral-education content in science and engineering is not explored in sufficient depth. Channels for translating students' inventions and small-scale research projects into practical outcomes also remain underdeveloped.

6.2. Staged strategies for sustainable optimization

Short term (within one year): Introduce cross-campus rotation for backbone science and innovation teachers; complete the placement of two advanced teachers at the branch campus; iterate the basic modules of the digital platform; and simultaneously develop small-scale integrated courses in aerospace, literature and history.

Medium term (two to three years): Institutionalize synchronous online moral-education classes

delivered by academicians and construct a systematic case-resource repository for implicit moral education in science and engineering.

Long term (more than three years): Work with intellectual-property organizations and advanced aerospace enterprises to establish implementation pathways for student innovation; continue collecting complete three-year practice cases to supplement the relevant chapters of the author's monograph; and sustain reciprocal validation between educational practice and theory.

This chapter has objectively identified four existing practical limitations and divided optimization measures into short-, medium-, and long-term stages. It addresses current weaknesses while supporting long-term theoretical accumulation, completing the study's practical-reflection component.

7. Conclusion

Against the converging contexts of educational quality, digitalization, and values education, traditional control-oriented governance is insufficient. Guided by its development plan, Shenzhen Gezhi High School transitioned from control to empowerment, establishing a five-in-one system of whole-school governance that addresses multi-campus imbalances and talent development discontinuities. Three years of evidence demonstrate that this governance system can balance resources, connect talent pathways, and enhance students' innovation competence and the school's brand. The model offers a locally grounded reference for public aerospace- and engineering-oriented education groups in China implementing science education and values education. Future work will continue to deepen this integration, using school practice to enrich educational governance theories for the new era.

Disclosure statement

The author declares no conflict of interest.

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