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A Study on the Construction of a "Four-Dimensional Integrated" Model for Cultivating Top-Tier Innovative Talent in Higher Education from the Perspective of Science and Education Integration

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Abstract

Science and Education Integration are the main drivers for the all-round development of education, science and technology, and talent; at the same time, they also provide the methodological basis for cultivating top-tier innovative talents in the new era. However, existing research on this problem is rather fragmented; at the same time, fundamental concepts such as "Science and Education Integration" and "outstanding innovative talent" have long lacked operational definitions, and thus an effective framework linking theoretical construction with practical reform has not been established. This study will adopt a method of "case induction - theoretical construction - framework development". Based on an inductive analysis of representative cases in China and abroad, practical experience and common problems will be derived, and a theoretical system will be constructed on this basis. By redefining the two above-mentioned core concepts, this paper builds a "Four-Dimensional Integrated" training model of "goals, pathways, evaluation and safeguards". At the core of this model is not the proposal of four dimensions, but rather the revelation of a closed-loop structure among them: "goals anchor the direction, pathways implement actions, evaluations verify effectiveness, safeguards support operations, and feedback optimizes goals." This study further investigates the mechanistic conditions for the "integration" of these four dimensions and indicates that the key factor determining the efficacy *of the training model is not the extent of refinement in each dimension, but whether a continuously operating feedback loop can be established among the four. This change in analysis is no longer about "element optimisation"; rather, it provides a tool that can explain and guide the process of implementing science and education integration in practice.*

Keywords

Science and Education Integration, Top-tier Innovative Talent, Four-Dimensional Integration, Closed-Loop Feedback, Model Development

1. Introduction

The report of the 20th National Congress of the Communist Party of China identified education, science and technology, and talent as the foundational and strategic pillars for building a modern socialist country in all respects, and explicitly called for "efforts to cultivate top-notch innovative talents." The 2023 Work Priorities of the Department of Higher Education of the Ministry of Education further propose establishing a "one department, six colleges" mechanism for Science and Education Integration to foster collaborative talent development. Judging by policy signals, the top-level design is clear. However, based on feedback from implementation, the results have fallen far short of expectations. Newly established local application-oriented undergraduate institutions generally face the dual challenge of "teaching lacking research support and research failing to translate into teaching," while modern industry colleges face bottlenecks such as insufficient integration of industry and education, superficial science and education integration, and an incomplete tripartite collaborative talent development mechanism. Empirical studies have shown that, at present, in the process of integrating education, science and technology, and talent development, there is a mismatch between the degree of institutional mechanism integration and the effectiveness of translating research results into actual applications.

Due to the above reasons, researchers have started to consider two more fundamental questions: What precisely is meant by "integration" in the science and education integration? What is meant by "outstanding" in the context of first-class innovative talents? Although the two problems are relatively small, they are in fact close to the basic ideas of this entire study. Existing studies have failed to clarify these two basic concepts in their discussions; therefore, different studies have given different definitions to them and cannot reach a common understanding. Based on the previous study, the three types of research in this field are as follows. The first is the strategic value and internal logic of science-education integration. Lu Xiaozhong and Wang Jing, based on the new quality productive forces, believe that the strategic, synergistic and integrative nature of science-education integration demands full use of research resources in the cultivation process (Xiaozhong & Jing, 2024). Wang Yanfen and his colleagues have been studying how to further promote the integration of science and education in practice at the University of Chinese Academy of Sciences. The second is a system of models and mechanisms for joint talent cultivation (Yanfen et al., 2023). Xu Guangwen and his group have studied the cooperative operations of universities and research institutions (Guangwen & Manhong, 2022), and Peng Lijun has used resource-dependence theory to explore the construction path for collaborative education (Lijun, 2024).The third line of inquiry is how to foster outstanding innovative talents through particular paths and strategies. Some studies have put forward a tripartite talent cultivation ecosystem based on the logic of "curriculum foundation, competition empowerment and enterprise collaboration". Other studies, drawing on symbiosis theory, have built a collaborative education model that integrates "colleges, research institutes and industry bases". Although each of these studies has made its own contributions, their common shortcomings are also quite obvious: most focus on a single dimension and lack a systematic examination of the entire "goals-pathways-evaluation-support" chain; most remain at the level of empirical summaries or strategic calls to action and do not provide sufficient theoretical analysis of the intrinsic structural relationships within the training model.

To provide a solid theoretical foundation for the following discussion, two essential concepts are introduced in this paper first. "Science and Education Integration" refers to the all-encompassing integration of research and teaching in four areas: goals, content, process, and organisation. In terms of objectives, the direction of new scientific research and the value orientation of education are closely linked; at the level of content, research results and research methods are converted into teaching materials; at the process stage, students build knowledge in real research environments; and at the organisational level, all parties involved in education are coordinated around the development of talent. "Outstanding Innovative Talents" refers to high-level professionals with excellent abilities in knowledge integration and original scientific research, who are also committed to serving the country through science and technology in specific disciplines or interdisciplinary areas. These three levels correspond to the basic, core and leading levels of the educational goals, respectively (Wang et al., 2023; Wu, 2023).

Based on the above reflection of the problems with conceptual definition and fragmentation, this paper proposes a "Four-Dimensional Integrated" model for fostering top-tier innovative talents. The "Four Dimensions" are the four aspects of objectives, pathways, evaluation and safeguards, and the "One Integrated Whole" refers to the fact that these four parts constitute an integrated whole. Unlike the existing "four-dimensional" system, this paper does not attempt to put forward the four dimensions; instead, it changes the focus of analysis from "what standards should each dimension meet" to "how these dimensions are structurally related," and also investigates the institutional conditions necessary for the four dimensions to "form a unified whole" and how this closed-loop system functions.

2. The Theoretical Foundation and Analytical Framework of the "Four-Dimensional Integrated" Model

The construction of the "Four-Dimensional Integrated" Model is primarily based on three theoretical frameworks: Systems Theory, Synergetics, and Symbiosis Theory. According to Systems Theory, the overall performance of a system does not depend on its strongest component, but rather on how its parts are connected to one another. Applying this reasoning to the field of talent development means that even if the goals are clear, the pathways are diverse, the evaluation is scientific, and the support is adequate, the overall performance of the development system may still be low if there is no effective mechanism linking these four elements. It is not that many universities today lack reform initiatives; the problem is that these initiatives fall under the purview of different departments and lack coordination with one another, making it difficult to piece them together into a cohesive whole. Synergetics further explains that synergy among multidimensional factors does not occur naturally but requires deliberate design. Synergy among multidimensional factors does not occur naturally; it must be designed. Under the current university management system, goal-setting falls under the purview of the Office of Academic Affairs or the Graduate School; implementation is the responsibility of individual schools and departments; evaluation is handled by the teaching quality monitoring department; and support functions are managed by the Office of Human Resources, the Office of Research, the Office of Finance, and the Office of Student Affairs. Without establishing a cross-departmental coordination mechanism, these four dimensions will inevitably operate in isolation in practice. Symbiosis Theory reminds us that the relationship among the four dimensions is not a one-way relationship of domination and submission, but rather one of interdependence and mutual shaping. Goals guide the path, but the practical implementation of that path, in turn, refines the goals; evaluation tests the path, but the results of that evaluation, in turn, compel the support system to make adjustments. The two are mutually beneficial; thus, the model is expected to develop gradually and is not expected to be fixed.

Based on the theoretical resources presented above, this paper defines the “Four-Dimensional Integrated” Model as an orderly talent development system with a closed-loop feedback mechanism, comprising four dimensions: objectives, pathways, evaluation and safeguards, and is based on the method of science and education integration and the value orientation of nurturing top-tier innovative talents. The Functions of the four dimensions each have their own focuses. At the top level is “Goals”, which provides the general direction for education; the problem here is how to build a hierarchical system of educational goals. The middle-level “Pathways” dimension is used to connect the various actions, and the main problem here is how to create an uninterrupted chain linking academic programmes with practical training systems. The “Evaluation” dimension takes place at all times in the process to verify and provide feedback; its main problem is how to build an all-encompassing and flexible evaluation system. The bottom level is called “Support”, and it needs to provide a solid foundation; otherwise, the other components will not be able to function. The four components have formed a closed-loop structure to achieve this; that is to say, the purpose determines the path for implementation, these steps are implemented, results are assessed, protective measures are taken, and finally, this feedback informs adjustments to the original aim.

The three ways this system can be used are as follows. First, it addresses the problem of fragmented analysis by collecting the discussions on objectives, exploration paths, evaluation design and research safeguards that have been spread throughout many studies into a single interpretive system. Secondly, it has shifted the focus of discussion from "listing elements" to "structural analysis"; the main academic question is no longer "which dimensions are included", but rather "how these dimensions are combined and related to one another". Thirdly, it offers a testable hypothesis for subsequent empirical studies: the strength of closed-loop feedback among the four dimensions positively affects the efficiency of talent development. This hypothesis is testable, and the property of being testable is required for a scientific theory.

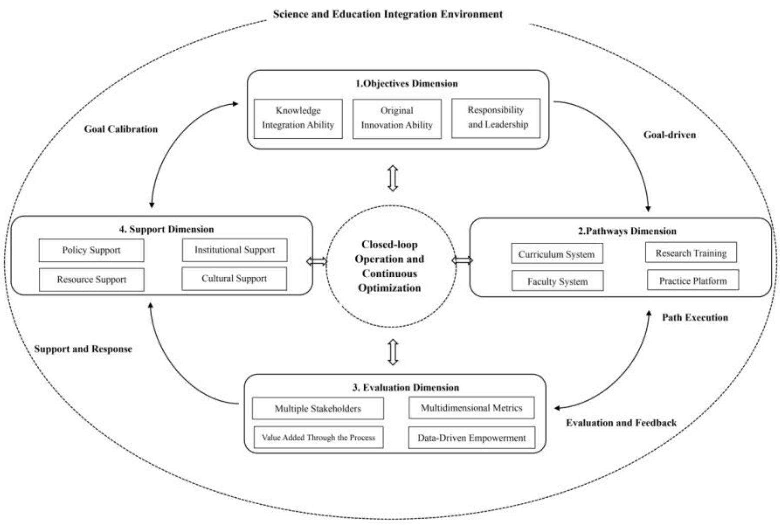

Figure 1. "Four-Dimensional Integrated" Closed-Loop Model

3. The Four Dimensions of the "Four-Dimensional Integrated" Model

3.1 Objective Dimension

Objectives serve as the logical starting point for talent development, and any ambiguity in them will carry over into all subsequent stages. The underlying reason why existing research lacks a tiered explanation of the training objectives for "top-tier innovative talent" is that the three terms—"top-tier," "innovative," and "talent"—relate respectively to selection criteria, competency objectives, and value orientation, and the intrinsic relationship among them has not been systematically analyzed from a theoretical perspective. In the section on conceptual definitions, this study has divided the concept of "outstanding innovative talent" into three dimensions: the ability to integrate knowledge, potential for original scientific research, and a sense of responsibility to serve the nation through science and technology; the target system is directly derived from this framework (Jiang, 2026).

All disciplines' accumulated knowledge and applications provide the foundation for the goal system. Outstanding and innovative talents should have a broad and solid foundation in their fields of study and be able to think interdisciplinarily. With the changes in knowledge today, a knowledge structure that is only based on a single discipline can no longer address the problems of complex science and technology and society; thus, the ability to integrate knowledge from multiple disciplines is required for learning now. The value of science and education integration at this level is to break down disciplinary barriers by means of scientific research and to promote a shift in teaching from the inheritance of knowledge to the development of skills.Research capabilities and innovative thinking provide the foundation for the goal system, and they are also required attributes of outstanding talents among the general population. Research ability refers to a series of practical skills, such as experimental design, data analysis and paper writing; it also includes the whole logical process from problem identification and hypothesis formulation to inference verification; innovation of thought is characterized by critical thinking, cross-disciplinary integration and the ability to think differently. Above the core layer is the guiding layer, and it contains social responsibility and the spirit of science. Outstanding talents should be leaders in their own areas and also feel a sense of social responsibility to serve the development of our country and advance the progress of society. The Spirit of Science should be grounded in truth and pragmatism; it should be innovative and exploratory, demonstrate a patriotic desire to serve the country through science and technology, and employ a team-oriented method for cooperative research. The three levels of the objectives are in a progressive relationship: the foundation level provides the prerequisite; the core level is the key; and the leading level is the final goal. The three levels need to be advanced simultaneously through curriculum design, research training and practical components, and should not be completed in a staggered, sequential manner.

3.2 Path Dimension

The path is the way to achieve the goal, and it will be used to implement the educational goals. The four links in the Pathway dimension are integrated: academic programmes, course clusters, faculty and a practice training system. Among them, academic programmes determine the direction, course clusters provide the content, faculty serve as guides, and the practical training system offers a setting; any deficiency in any one of these links will affect the overall strength of the pathway.

In terms of the construction system for academic programmes, a flexible mechanism should be established to adapt dynamically, and attention should be paid to avoid a simple addition or deletion of majors. At the core of such a system is a closed-loop “early warning - response - evaluation” process. Specifically, the first is to construct an early warning system for talent demand to monitor talent shortages in key areas in real time; based on this, establish a rapid response mechanism for academic disciplines to reduce the time from identifying needs to adjusting curriculum plans; at the same time, a feedback mechanism for academic program evaluations should be built, and graduates' career paths can provide a reference for adjusting programs.In terms of curriculum development, the construction of a “research-oriented” course cluster has three tiers. A regular channel should be set up to transform the results of research into teaching materials and update the course content. To combine research-oriented methods with teaching, we need to implement a “Three Early” strategy: early participation in research projects, early use of laboratories, and early inclusion in research teams; thus, students can build their knowledge through actual research rather than in a simulated environment. In the course module, a broad theme of science and technology is chosen as the organizing principle instead of the traditional structure based on individual school subjects. Based on foreign research, curriculum-based undergraduate research experiences (CUREs) are positively correlated with the retention rate of students in STEM disciplines, but the magnitude of this effect varies based on various characteristics of the students, such as race and gender (Bradshaw et al., 2023). Faculty development for the science and education integration needs to equip teachers with both research and teaching capabilities; however, the "role tension" teachers face in practice is not fundamentally a problem of how they manage their own energy but rather a defect in the institutional incentive system (Asif et al., 2023). At present, the evaluation system gives more weight to research output, and teaching contributions are given considerably less weight in professional title assessments and performance-based pay. Therefore, we need to optimise the "dual-mentor system" and build a cooperative mechanism for university and industry mentors; at the same time, we should also overhaul the faculty evaluation system to give equal weight to contributions in teaching and research at the institutional level. In terms of the practical training system, the "tiered and categorised" design is based on the basic assessment that the development of top-tier talents is non-linear and different for each person; thus, a standardised training system will not meet all the needs of different students. Research on intensive summer research training programs shows that early exposure to research can enhance both the career interest and academic ability of students from all sectors of society (Galvez et al., 2024; Savoca et al., 2023). At the foundation, research methodology is taught to all students to ensure that "everyone understands research"; at the advanced level, promising students are selected to participate in research groups and conduct real-life projects to ensure that "everyone conducts research"; at a higher level, students are encouraged to apply the results of their research in innovation and entrepreneurship to ensure that "everyone puts research into practice". Together, these three stages form a progressive structure that spans from general education to selective education and finally to elite education.

3.3 Evaluation Dimension

Evaluation is to assess how well education and training have achieved their goals; at the same time, it can also guide the future development direction of this work. In light of the development of science and education integration, the top-tier innovative talents will exhibit three features: interdisciplinary knowledge integration, application of research capabilities in practice, and a sense of social responsibility. Therefore, the assessment will no longer be based on the old school exams. Tests are good at evaluating "what one knows", but not very good at assessing "what one can do" and "what kind of person one is". Interdisciplinary integration skills cannot be tested in a one-time exam; research capabilities must be observed in the process of actual research; and social responsibility requires long-term behavioural tracking. Research on the value of research training for undergraduates has shown that students from underrepresented groups give considerable attention to all parts of research training programmes, such as mentor support, peer interaction and the development of research skills

(Nelson et al., 2023). The current trend in assessment practices to “prioritise outcomes over process” is due to the ease of quantification for summative assessments and the difficulty of long-term tracking in formative assessments; the root cause of the tendency to “prioritise knowledge over skills” lies in the simple assessment of knowledge via standardised tests and the need for qualitative judgment in evaluating skills. However, we must acknowledge that high costs and a high degree of subjectivity are precisely the characteristics that cannot be avoided when evaluating top-tier innovative talent; attempting to evaluate highly complex subjects using low-cost, objective methods is, in itself, a methodological mismatch.

Based on the above analysis, this paper proposes an evaluation index system of four types. The level of knowledge mastery is based on students' grades in their classes; at the same time, we will also evaluate their ability to combine knowledge from different areas. Research ability refers to the process-oriented level of performance in research practice that includes experimental design, data analysis and interpretation, academic paper writing, and the scope of participation in research projects. Further divisions of the evaluation indicators include the quality of the literature review, the newness of the research hypothesis, the scientificity of the experimental design, the correctness of data interpretation, and the standardisation of academic expression; therefore, we will no longer be judged solely on the number of published papers. The innovation ability dimension has achieved some results in innovation and includes patents, competition awards, research papers, etc. In addition to the quantity of the results, the quality of these results should also be considered in the evaluation; therefore, peer experts can provide qualitative judgments on the newness, scientific value and social benefits of the new results. Collaboration and Humanistic Literacy refer to team performance, awareness of academic ethics, critical thinking ability and humanistic literacy. Evaluation data for this attribute can be obtained from the records of cooperation in project teams, demonstrations of critical thinking during academic discussions, and tests of academic integrity.

Many forms of evaluation are available now and are frequently changed. The “Research Development Portfolio” system will systematically collect students' research results, accomplishments and reflections at all times during their research training, and provide both an assessment basis and a material support for students' self-examination and their advisors' guidance. The “Research Participation Point System” will award students a certain number of points for their participation and contributions to the research project to acknowledge the value of the process. Even if the paper is not published in the end, participating in the research training is still worthwhile. The idea of value-added assessment focuses on how far students have advanced in their studies during a certain period, rather than their final grades, and can thus find “late bloomers” with special talents. Digital and intelligent ways are applied to collect and analyse data from multiple sources automatically and intelligently using big data and artificial intelligence, and previous studies have begun to explore the feasibility of this approach.

3.4 Support Dimension

Although support occupies a foundational position and serves as the bedrock, it is the most easily overlooked yet most decisive factor. The internal structure of the support dimension comprises four levels: policies provide a basis of legitimacy and guidance; institutions translate policy requirements into actionable rules of conduct; resources provide the material foundation; and culture provides spiritual motivation and a shared sense of values. The relationship among these four elements is such that policy guides institutions, institutions allocate resources, and culture nurtures everything. Without the deep-rooted support of culture, policies and institutions will ultimately become mere formalities; without the material support of resources, ideals and culture will struggle to endure.

In terms of policy safeguards, the main challenge currently faced is that “while top-level design is adequate, implementation at the grassroots level is lacking.” Policy documents provide a thorough explanation of “what should be done,” but lack specific provisions regarding “who will do it, how it will be done, and what to do if it is not done properly.” Strengthening policy support requires the formulation of targeted policies that clearly define development plans rather than being generalized as broad reforms; it also requires clarifying the boundaries of authority and responsibility among diverse stakeholders, while establishing cross-departmental coordination mechanisms to break down institutional barriers between different sectors—such as education, science and technology, and human resources. The latter is the weakest yet most critical link in the current policy framework. In terms of institutional safeguards, while policies specify “what should be done,” institutions define “what happens if it is done well or not.” Effective institutional design requires incorporating the educational contributions of science and education integration into the systems for evaluating faculty promotions and allocating performance-based compensation; it also requires factoring students’ participation in research training and related achievements into scholarship evaluations and recommendations for further education. At the same time, a system for the two-way flow of talent between universities and research institutions should be built; the system of intellectual property ownership and sharing of research results enhanced; institutional barriers to cross-organizational collaboration reduced. Resource support should be strengthened by fostering a network of universities, research institutes and enterprises to share resources, constructing a cross-institutional platform for sharing research resources, allocating resources according to the actual needs of talent development rather than institutional affiliation, and increasing funding channels through university-industry cooperation, private donations and government grants. A study based on a case study by the School of Materials Science and Engineering at Yanshan University investigated the mechanism for cultivating innovative undergraduate talent driven by the integration of science and education. Based on the above, it has been determined that building a cross-institutional resource-sharing platform is required to support the construction of this system (Tianyu et al., 2026).Culture serves as a “soft safeguard” outside of institutions and also functions as one. Where policies and institutions are lacking, culture can step in to fill the gap; if these policies and institutions are inconsistent with reality, culture can provide the flexibility required for adaptation. In other words, the above measures aim to promote a philosophy of science and education integration through outreach and guidance; stimulate students' interest in research by organising activities such as academic festivals, innovation forums and research open houses; and foster a sense of shared core values and build a synergistic educational environment by developing academic communities. Only when the science and education integration evolves from a policy requirement into a cultural consciousness can the cultivation of top-tier innovative talent gain a lasting and profound source of inspiration.

4. The Internal Logic and Operational Mechanisms of the "Four-Dimensional Integrated" Model

4.1 The Path to "Integration"

Terms such as "four-dimensional synergy" and "four-dimensional integration" are not uncommon in existing research, but they generally share a common limitation: while they propose the concept of "four dimensions," they fail to explain how these four dimensions form a unified whole. The difference between the "four dimensions" and the "integration" is, in essence, the difference between "listing elements" and "structural integration."

The former is "what has been included", and it believes that once all the relevant components have been listed, the task is complete; the latter focuses on "how they are connected" and requires an explanation of the function and feedback relationship among all parts. The former is a static taxonomy; the latter is dynamic system analysis. This paper believes that the way to achieve the integration of the four aspects is to construct a closed-loop feedback mechanism, rather than a one-way linear connection. "Closed-loop feedback" refers to a situation where A influences B, B modifies C, C affects D, and finally D also influences A; thus, any change at any point in the chain will be fed back to affect the other links in a chain reaction throughout the entire system. Without this closed-loop mechanism, the four dimensions would only be "grouped together" but not "coordinated". Specifically, the logical connections among the four dimensions are as follows: Goals provide the objectives for travel, and the three-level goal structure offers direction for journey design; Paths aim to achieve goals, and the standard of a particular path determines the efficiency with which those goals will be realised; Evaluating an experimental path can reveal defects in the design of that path through evaluation results, and this evaluation motivates correcting deficiencies in protection measures; Problems found in the assessment require adaptations to the safeguard system, and support furnishes the foundation for all elements, including policies, resources, systems and culture.The most critical closed-loop element in this process is that improvements in safeguards optimize the conditions for path execution; a new round of path execution generates new evaluation results, which in turn may indicate that the objectives themselves need to be recalibrated. This cycle repeats, forming a self-optimizing system.

4.2 Three Institutional Conditions

Closed-loop feedback does not occur automatically; certain mechanistic conditions must be satisfied for it to function. These conditions are not abstract theoretical assumptions, but rather critical elements that actually exist within the university management system yet are commonly lacking. First is the cross-dimensional flow of information. Feedback is essentially the transmission and response to information; it requires that evaluative information be promptly conveyed to those who set goals and design strategies, ensuring that decision-makers are fully aware of any shortcomings in the implementation process. However, a common problem currently facing universities is that data is scattered across different administrative departments; there is a lack of effective integration between the academic records held by the Office of Academic Affairs, the research paper data held by the Office of Research, and the activity data held by the Office of Student Affairs, creating de facto “data silos.” Even if data is shared at the physical level, it cannot be transformed into effective feedback signals without the appropriate analytical mechanisms and interpretation capabilities. The widespread phenomenon in reality of “having data but no information, and having information but no feedback” clearly illustrates that there are breaks in the information flow at multiple points along the chain. Next is cross-departmental cooperation in the organization. Objectives have been established in the present university management system, strategies have been implemented, an organisation of evaluation has been built, and all departments are providing support. Although this division of labour is convenient for daily operations, it creates a problem for institutional reform that aims to integrate science and education and requires interdepartmental cooperation. Without a cooperative system for joint meetings, joint work groups or an integrated information platform, the four dimensions would have to work independently in practice. Changes in objectives are not promptly reflected in the design of the path, and the evaluation results fail to drive improvements in the support system effectively; thus, the whole system cannot form a true closed-loop.

Next is the slow accumulation over time. The results of a closed-loop feedback system will not appear immediately; they generally take some time to manifest. Find out what the problems are from the feedback, fix them, change the strategy and set new goals, and all of these improvements will take some time to develop and implement. The operation of the feedback loop itself also requires a “break-in” period; at this time, the level of coordination among all parts and the speed at which information is transmitted and organisational response occurs need to be gradually improved through repeated operation. Therefore, the development of the “Four-Dimensional Integrated” Model should not be achieved through sporadic, project-based initiatives but rather by continuous institutionalisation and implementation. All three of the above are necessary conditions. Without the cross-dimensional flow of information, there will be no feedback; without cross-departmental cooperation within the organisation, even if feedback is given, it will not be implemented in practice; and without continuous accumulation of feedback over time, it will fail to form an institutionalised capacity for self-improvement. It can be said that the three conditions above are the basic requirements for the “Four-Dimensional Integrated” Model to go from an idea to practice.

4.3 The Five Parts of the Operating Mode

If the above conditions are met, then the working mode of the “Four-Dimensional Integrated” Model can be summarised as a spiral cycle of five stages: goal-driven action, path execution, evaluation and feedback, support and response, and goal calibration. The five links are connected in sequence to form a full circle; at the start is the aim, then implementation and evaluation, and finally, after adjustment based on this assessment, a new cycle commences.

The first link in the chain is goal-oriented thinking. At this time, the three-tiered goal system has been transformed into specific demands at all levels of education; the knowledge goals to be achieved in a particular course, the competency objectives to be met in a specific research training activity, and the innovation requirements to be realised in a particular practical project have all been clearly defined, and thus a chain of goals that can be broken down and monitored has been formed. First, change the general goal into a specific and achievable demand; otherwise, it will be difficult to know how to proceed with the following steps because the goal is too vague. Next is the Path Execution stage. All links in the training plan have specific goals and demands, and at the same time, formative data are gathered, such as course grades, research results and practical skills, to provide a basis for the final assessment. The quality of the path execution directly affects the efficiency of the whole cycle, so at the time of execution, it needs to achieve the goals while also being flexible enough to handle changes in actual circumstances. Collect a considerable amount of data, then conduct the evaluation and feedback stage. Based on the above-mentioned multi-dimensional evaluation indicator system, a system of targeted assessments will be conducted to determine how well the implemented pathways have performed, and the resulting feedback will be divided into two types: individual feedback for students, which will cover academic progress and skill development; and overall system feedback, which will identify which pathways are effective, what support measures are still lacking, and whether the original goals need to be revised. Promptly address the problems in the assessment and provide corresponding support and countermeasures. Supplement the resources where they are lacking; correct the deficiencies in the system; strengthen the weak links in culture, and thus ensure that the support system can address actual problems effectively. The impact of this stage will be relatively low if the support system is not very sensitive and responsive; otherwise, if the system is slow to respond or difficult to adjust reasonably, the weight of the feedback will be reduced considerably. Finally, we move on to the goal calibration phase. Improvements in safeguards optimize the conditions under which the process operates; a new round of implementation yields new evaluation results, which in turn may indicate that the objectives themselves need to be adjusted; For example, some standards are no longer in line with the changing demands of society or reflect the current state of industrial development. Therefore, the goals have been revised, and the next round will start.

The five steps are nota simple linear sequence; they are rather dynamic and intertwined, and each stage contains the others and feeds back into them. The end of each stage sends a new signal to the next, thus initiating a chain reaction. Each cycle is an improved version of the previous one, and therefore, it can be considered to have a certain degree of self-modification. The “Integrated” part of the “Four-Dimensional Integrated” Model is realised and maintained by this continuous cycle; it is not a fixed structure established once and for all, but rather an order that is dynamically generated through operation.

5. Conclusions and Recommendations

The first contribution of this paper is to change the analytical system and, by doing so, shift the focus of the discussion on cultivating top-tier innovative talents in the era of science and education integration from "factor optimisation" to a structural relationship-based analytical paradigm. Previously, most research has centered on the question of "to what extent each dimension should be addressed"; now, this study explores "how these dimensions should be structured and combined to achieve systemic effects". The significance of this change is that it has raised the discussion of training models from "how to do each part well" to "how to build synergy among the parts". In the latter case, the unit of analysis is no longer a single dimension but rather the connections, feedback loops and interactions among dimensions. It offers a new reference for the following empirical studies and institutional reforms.

This study has reached the following results. The problem of fragmentation in the existing research is not merely one of "incomplete coverage"; its root cause is a lack of operational definitions for core concepts and the fact that analytical perspectives have long remained at the level of listing elements. At the same time, the essence of what distinguishes the "Four-Dimensional Integrated" Model from existing "four-dimensional" frameworks lies not in which four dimensions are proposed, but in the revelation of the closed-loop feedback structure among them. The key variable determining the effectiveness of the development model is not the degree of refinement of each dimension, but whether a continuously functioning feedback loop can be established among the four. Looking further, the effective operation of "integration" depends on three institutional conditions: the cross-dimensional flow of information, cross-departmental collaboration within organizations, and the continuous accumulation of time. Finally, "integrated" is not a fixed structure but an order that is dynamically generated in a cycle of goal setting, path execution, evaluation and feedback, support and response, and goal recalibration. Therefore, this paper puts forward the following three suggestions. The top-level Design Mechanism for the "Four-Dimensional Integrated" Model of higher education institutions should be established to promote cross-departmental information sharing and collaboration, and individual departmental reform proposals should no longer be submitted independently. The education authorities may add the "Four-Dimensional Integration Index" to the talent development quality assessment system, and in addition, conduct evaluations of the coherence among all dimensions, the timeliness of feedback, and the completeness of the closed-loop process for disciplinary evaluations and programme accreditation. All types of higher education institutions should explore institution-specific implementation paths for the "four-dimensional integrated" model according to their positions, and diversity in implementation methods should be maintained under a unified framework.

A significant defect of this study is that although a model has been built, empirical verification is still required; thus, the primary hypothesis of this paper, that "an increase in the strength of closed-loop feedback leads to improved training efficiency", has not yet been experimentally confirmed. The quantitative relationships among the four factors, such as the relative weights of each factor and the effect of feedback lag times at different stages on system performance, still need to be modelled in research. Differences in the application scope of this model among different types of universities also need to be investigated further. Research will be carried out in the future to develop measurement tools for "four-dimensional integration", conduct comparative verifications of multiple cases, and explore different implementation paths.

References

Asif, M. Z., Edison, A. S., & Dolan, E. L. (2023). Postgraduate perspectives on mentoring undergraduate researchers for talent development. *Annals of the New York Academy of Sciences*, *1521*(1), 155-162. https://doi.org/10.1111/nyas.14966

Bradshaw, L., Vernon, J., Schmidt, T., James, T., Zhang, J., Archbold, H., Cadigan, K., Wolfe, J. P., & Goldberg, D. (2023). Influence of CUREs on STEM retention depends on demographic identities. *Journal of Microbiology & Biology Education*, *24*(3), e00225-22. https://doi.org/10.1128/jmbe.00225-22

Galvez, G., Killilea, D. W., Berry, S., Narayanaswami, V., & Fung, E. B. (2024). Increasing STEM skills, knowledge and interest among diverse students: Results from an intensive summer research program at the university of california, san francisco. *Innovative Higher Education*, *49*(4), 645-664. https://doi.org/10.1007/s10755-024-09701-z

Guangwen X., & Manhong L. (2022). Exploring collaborative talent cultivation through science-education integration between universities and research institutes. *China Higher Education*, (1), 41-43. https://kns.cnki.net/KCMS/detail/detail.aspx?dbcode=CJFQ&dbname=&filename=

Jiang, M. (2026). Disruptive innovation and sustaining innovation: Identification and selection logic for different types of top innovative talents. *China Higher Education Research*, *42*(6), 64-73. https://doi.org/10.16298/j.cnki.1004-3667.2026.06.08

Lijun P. (2024). Mechanism construction for collaborative talent cultivation through science-education integration between universities and research institutes: From the perspective of resource dependence theory. *Journal of Graduate Education*, (2), 73-79. https://doi.org/10.19834/j.cnki.yjsjy2011.2024.02.11

Nelson, K., Honoré, M., Crist, R., Zell, A., Lindwall, J. L., & Keller, T. E. (2023). How undergraduates historically underrepresented in biomedical sciences value multiple components of a research training program. *Journal for STEM Education Research*, *6*(1), 131-158. https://doi.org/10.1007/s41979-022-00083-5

Savoca, M., Kernan, K., Scott, C., & Bugallo, M. F. (2023). Early exposure to STEM research as a foundational experience for STEM careers. *Experiential Learning and Teaching in Higher Education*, *6*(1), 46-55. https://doi.org/10.46787/elthe.v6i1.3567

Tianyu, X. U. E., Yijun, L. I., Hailong, Q. I. U., & Xinyu, Z. (2026). Mechanism construction for undergraduate innovative talent cultivation driven by science–education integration: Taking the school of materials science and engineering at yanshan university as an example. *Research in Teaching*, *49*(3), 83-92. http://jxyj.ysu.edu.cn/en/article/id/1dbaa4be-d808-43b1-bec6-7706a8122eaa

Wang, Y., Newton, D., Moger, P., Ion, G., & Arnau-Sabates, L. (2023). What do we know so far about the research-teaching nexus in initial teacher training? Findings from a systematic review. *Review of Education*, *11*(2), e3405. https://doi.org/10.1002/rev3.3405

Wu, J. (2023). *The research-teaching nexus: Student experiences and engagement from the perspective of business school undergraduates at research-intensive universities in China and the UK* (Doctoral dissertation, University of Southampton). https://eprints.soton.ac.uk/475834/

Xiaozhong L., & Jing W. (2024). Promoting the cultivation of top-notch innovative talents through science-education integration from the perspective of new quality productive forces. *Jiangsu Higher Education*, (8), 13-24. https://doi.org/10.13236/j.cnki.jshe.2024.08.002

Yanfen W., Jian L., Yueliang W., Zuomin X., & Jianming M. (2023). Deepening science-education integration to cultivate future scientific and technological leaders. *Bulletin of Chinese Academy of Sciences*, *38*(5), 693-699. https://doi.org/10.16418/j.issn.1000-3045.20230418003