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Practical Research and Case Analysis on Comprehensive Support Engineering System for Disadvantaged Students in Engineering Vocational Colleges

Yulu Huang
Zibo Polytechnic University
Zibo, China

Abstract: Engineering vocational colleges undertake the mission of cultivating technical and engineering talents. Low-income disadvantaged students from rural areas commonly face coupled developmental risks including economic pressure, psychological inferiority and academic underperformance. Based on systems engineering theory, this paper constructs a comprehensive support engineering system for disadvantaged students consisting of five subsystems: risk early warning, financial aid guarantee, work-study integration, academic and psychological empowerment, and multi-party long-term tracking. Taking a financially challenged student majoring in automotive engineering as an empirical case, student support coordinators carry out full-process closed-loop intervention. The research modularizes student assistance work, and multiple subsystems operate collaboratively to resolve overlapping developmental dilemmas of students. Practice verifies that the engineered and standardized hierarchical assistance framework can simultaneously balance educational equity and talent training objectives of engineering majors. Combined with the operational deficiencies reflected in the case, this paper proposes optimization paths including digital upgrading of the system, embedding school-enterprise resources and cross-departmental data interconnection, providing operable application solutions for student affairs management in engineering vocational colleges worldwide.

Keywords: engineering vocational colleges; disadvantaged students; comprehensive support engineering system; student financial aid; work-study integration; systematic intervention

1. INTRODUCTION

University student management can be regarded as a social engineering system for talent cultivation. As the carrier of industrial technical talent training, student assistance work in engineering vocational colleges bears distinct engineering application attributes. Against the backdrop of global vocational engineering education, high dropout rates, inefficient practical training and psychological imbalance among low-income students have become prominent obstacles restricting talent cultivation quality.

Traditional student financial aid adopts fragmented and decentralized operations relying merely on scholarship disbursement and one-off interviews, lacking a standardized and recyclable complete engineering framework. Such single intervention fails to address superimposed survival pressures of engineering students. Engineering majors feature high costs of practical training materials and intensive hands-on practice. For students burdened by long-term poverty and chronic medical debts of family members, isolated assistance measures tend to be ineffective.

Existing studies mostly discuss work-study post design or psychological intervention as independent modules, lacking localized cases of integrated comprehensive support engineering systems. Few literatures disassemble assistance procedures from the perspective of systems engineering logic, which fails to match the research paradigm of engineering application journals. Taking the student assistance practice of automotive engineering major in a vocational college as the research sample, this paper constructs a modular and collaborative comprehensive support engineering system, elaborates the system operation logic, intervention effects and optimization strategies, and expands practical research on engineering applied science in university student education and management.

2. RESEARCH CASE AND IDENTIFICATION OF RISK SYSTEM

2.1 Basic Overview of the Case Subject

The research subject Xiaoyu (pseudonym) is a freshman majoring in automotive engineering at a public engineering vocational college, categorized as a compound disadvantaged student. His family relies on small-scale agriculture for income with aging parents of limited labor capacity. His mother suffers from chronic mental illness, requiring long-term medication and regular medical visits that generate sustained large medical expenditures, leading to perennial household fiscal deficit. Xiaoyu dropped out of senior high school to work due to family poverty, and later re-entered higher vocational education through a special enrollment program. He expected to master automotive operation and maintenance engineering technology to improve family financial conditions. Shortly after enrollment, he was unable to pay tuition and accommodation fees. Coupled with inferiority complex stemming from long-term poverty, he exhibited social withdrawal and distracted attention during practical training, and was classified as a Level 1 high-risk object for intervention under the comprehensive support engineering system.

2.2 Four Coupled Risk Factors

Relying on the Information Collection and Risk Early Warning Subsystem of the framework, student support coordinators establish student files through dormitory visits, private one-on-one interviews and home-school communication, sorting out four interrelated developmental risks:

2.2.1 Economic Survival Risk

Agricultural income cannot cover tuition, training supplies and daily living expenses. Continuous medical expenses create a funding gap, posing risks of dropout due to unpaid fees.

2.2.2 Cognitive Psychological Risk:

Past dropout experience and long-term material deprivation solidify inferiority cognition, leading to deliberate avoidance of peer communication and strong psychological defense.

2.2.3 Engineering Academic Risk:

Economic anxiety consumes mental energy, and the student dares not consult teachers on mechanical and circuit practical difficulties during training, resulting in slow progress in professional skill acquisition.

2.2.4 Lack of External Support:

Parents lack the ability to provide academic and psychological counseling. On-campus work-study posts matching training schedules are insufficient, trapping the student in a dilemma: part-time work delays practical training while full-time study fails to cover living costs.

2.3 Systematic Deficiencies of Traditional Assistance Modes

Before the standardized support engineering system was established, conventional assistance mechanisms suffered from obvious structural flaws. Each assistance link operated independently without communication channels among financial aid, teaching, psychological counseling and logistics departments. Risk identification relied on passive post-hoc screening without pre-warning procedures. Work-study posts were disconnected from professional training and unable to realize integration of work and study. No long-term tracking and feedback module was available, making short-term intervention effects difficult to sustain. In response to the above drawbacks, this paper designs a closed-loop support engineering system with collaborative multi-subsystem operation.

3. ARCHITECURE AND IMPLEMENTATION OF THE COMPREHENSIVE SUPPORT ENGINEERING SYSTEM

Led by student support coordinators as overall schedulers, the five functional subsystems share information and connect procedures to form a complete closed-loop intervention workflow.

3.1 Subsystem 1: Information Collection and Risk Early Warning Subsystem

As the input port of the entire system, this module undertakes student file establishment and risk grading. Upon enrollment, data including household income, chronically ill family members, educational experience and psychological status are collected uniformly to build electronic student growth archives. Risks are divided into three warning levels based on severity. Xiaoyu was classified as Level 1 high-risk and triggered full-set intervention procedures. Interviews are conducted in independent private spaces with a commitment to confidential storage of household information to eliminate student resistance, providing data support for targeted intervention.

3.2 Subsystem 2: Hierarchical Financial Aid Guarantee Engineering Subsystem

As the core underpinning module of the framework, this subsystem builds a multi-layer funding supply structure. Student support coordinators fully assist students in sorting poverty certification documents and filling out financial aid application forms, coordinating with the college student financial aid administration department. A gradient guarantee system integrating national need-based grants, temporary campus hardship subsidies and tuition deferral policies is constructed. Temporary subsidies covering meals and training supplies are issued during the review period of formal grants. All application materials are filed separately, and student privacy information is concealed during public notification to reduce psychological pressure caused by poverty. After implementation, Xiaoyu successfully obtained national need-based grants, fully covering tuition and accommodation fee gaps.

3.3 Subsystem 3: Work-Study Integration Engineering Subsystem

Aligned with the talent training objectives of engineering majors, work-study posts are embedded in automotive training scenarios to balance financial subsidies and skill training. Special posts including equipment sorting, laboratory operation maintenance and tool inventory management are set up in training centers, with job content matching automotive maintenance and mechanical operation courses. Schedules are arranged according to student timetables and training plans to avoid teaching hours. Assessment criteria cover equipment maintenance quality and work responsibility, with outstanding performers recommended to participate in school-level engineering skill competitions. While working, Xiaoyu consolidated practical operation capabilities, and labor income fully covered daily living expenses, realizing mutual promotion between work and study.

3.4 Subsystem 4: Collaborative Academic and Psychological Empowerment Subsystem

This subsystem operates two parallel branches: academic tutoring and psychological intervention, cooperating with professional teachers and the campus mental health center. For academic support, automotive engineering teachers are coordinated to carry out differentiated teaching with one-on-one guidance on difficult training items such as engine maintenance and circuit debugging. For psychological intervention, private counseling sessions are held weekly to guide students to distinguish family economic conditions from personal engineering competence and eliminate inferiority cognition. Growth workshops for disadvantaged students are organized to carry out peer sharing and career planning lectures to alleviate social withdrawal. After intervention, Xiaoyu took the initiative to preview practical training operations and showed significantly higher classroom participation.

3.5 Subsystem 5: Multi-party Collaborative Long-term Tracking and Feedback Subsystem

As the closed-loop output module of the system, this channel realizes two-way communication between the college and student families. Parents are contacted proactively to synchronize intervention plans and unify positive guidance both on and off campus. Regular weekly communication is

maintained, with updated records of students' training performance, interpersonal interaction and emotional fluctuations stored in growth archives. Students are guided to participate in financial aid policy lectures for freshmen and volunteer training assistance, transforming external support into internal motivation for self-improvement and forming a positive cycle. Two months of follow-up observations show that Xiaoyu can independently form teams to complete engineering training projects without recurrence of negative psychological risks.

4. OPERATIONAL EFFECTS AND EXISTING SHORTCOMINGS OF THE SYETEM

4.1 Practical Operational Effects

First, economic risks are fully resolved through the collaboration of financial aid guarantee and work-study subsystems, eliminating dropout risks completely. Second, psychological and social imbalance is repaired via continuous intervention of the psychological empowerment subsystem, enabling students to adapt to team-based practical training modes of engineering majors. Third, professional learning enters a positive cycle: hierarchical tutoring removes barriers between theoretical learning and hands-on training, lifting the student's academic ranking from the middle to upper tier of the class. Fourth, a standardized closed-loop system is formed with complete workflows of five subsystems, replicable for assistance work of disadvantaged students in other engineering vocational colleges.

4.2 Existing Shortcomings of the System

Firstly, the number of work-study posts integrated with professional training is limited, only covering a small number of Level 1 high-risk students with great room for system expansion. Secondly, the digitalization level of risk early warning remains low, as information collection relies on manual visits without online automatic grading algorithms. Thirdly, funding channels are relatively single, dominated by national and campus subsidies, while special school-enterprise financial aid modules are not fully embedded in the system.

5. OPTIMIZATION STRATEGIES FOR THE SOPPORT ENGINEERING SYSTEM OF ENGINEERING VOCATIONAL COLLEGES

Combined with system deficiencies and engineering application design ideas, the framework is improved from five dimensions:

Upgrade digital early warning modules: Build online information collection portals based on campus information platforms embedded with risk grading algorithms to realize automatic identification and advance warning of student risks, reducing manual screening costs.

Expand work-study integration posts: Cooperate with training centers and school-run factories of all engineering majors to add skill-oriented work-study positions covering automotive, mechanical and electrical disciplines, and incorporate work-study practice into comprehensive quality evaluation.

Expand school-enterprise funding interfaces: Deepen industry-education integration, cooperate with local manufacturing and automotive enterprises to set up special student aid funds, and construct a multi-layer funding supply framework of "national grants + campus subsidies + enterprise support".

Break through cross-departmental data sharing channels: Build a unified data platform for student affairs, practical training teaching and mental health centers to eliminate information silos and improve collaboration efficiency among multiple subsystems.

Establish a system iterative optimization mechanism: Regularly review tracking archives, collect feedback from teachers, students and enterprises, and iterate workflows of the five subsystems annually to adapt to new demands of engineering talent training.

6. CONCLUSION

Constructing a comprehensive support system based on systems engineering theory is an innovative path for engineering vocational colleges to balance educational equity and improve engineering talent cultivation quality. Taking a disadvantaged student majoring in automotive engineering as the empirical sample, this paper designs five collaborative subsystems including risk early warning, financial aid guarantee, work-study integration, academic and psychological empowerment, and long-term tracking, forming a complete closed-loop assistance framework. Practice proves that modularized and engineered assistance can simultaneously resolve overlapping economic, psychological and academic risks of low-income students, fulfilling multiple educational objectives including material relief, psychological cultivation and engineering skill training.

Student affairs practitioners in global engineering vocational colleges should abandon fragmented assistance thinking and build standardized, replicable support frameworks for disadvantaged students based on systems engineering logic. Continuous optimization of the system can be realized through digital transformation, embedding school-enterprise resources and cross-departmental data interconnection. Future research can expand case samples covering multiple engineering majors, improve digital upgrading schemes of the system, further expand the research boundary of engineering applied science in university student education and management, and provide practical references for equitable development of global vocational engineering education.

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