Research on the Construction of a Quality Monitoring System for Internships in Automotive Inspection and Maintenance Based on CSE

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ABSTRACT This study addresses quality monitoring challenges in automotive inspection and maintenance internships in higher vocational colleges, where frequent student rotation across diagnosis, repair, and maintenance posts complicates consistent performance evaluation. Based on the CSE concept, namely competency-oriented, student-centered, and evidence-supported, a quality monitoring system adapted to dynamic internship scenarios is constructed. The system establishes a multilevel evaluation index framework focusing on transferable competency development, student initiative, and critical reflection. A dynamic weight mathematical model and multi-source evaluation mechanism are introduced to support continuous tracking and scientific assessment of the internship process. Pilot application results show that the system improves students' initiative, evidence collection awareness, and competency development, enhances the consistency and authenticity of internship evaluation, and reduces the negative impact of job rotation on learning continuity. The study provides an operable solution and data support for quality management of automotive technology internships in higher vocational education, supporting precise tracking of student proficiency across vehicle inspection, diagnosis, and repair processes.

INDEX TERMS automotive technology internships, quality monitoring, dynamic evaluation, vocational education, cse model

I. INTRODUCTION

IN recent years, the "Internet+" era has brought profound transformations to automotive service and manufacturing models, accelerating the integration of digital diagnostics and intelligent maintenance processes while increasing the frequency of technical iteration and organizational restructuring within enterprises [1]. It is crucial to emphasize the adaptability of vocational education to economic development, technological progress, labor market changes, and individuals' developmental needs [2]. As a key collaborative educational component, internship programs must fully consider the interests of all stakeholders. This paper analyzes the current challenges in monitoring automotive technology internships and proposes effective solutions based on the CSE (Competency-oriented, Student-centered, Evidence-supported) philosophy to bridge the gap between classroom theory and practical vehicle repair shop or service center operations.

II. THE DILEMMA OF TRADITIONAL MONITORING MODE

Internships serve as vital bridges for students to engage with real-world professional environments and develop practical competencies. The scientific and systematic nature of internship management mechanisms has evolved into a key benchmark for evaluating the quality of vocational education [3]. However, data from our institution's internship management platform reveals that approximately 21.5% of interns majoring in automotive inspection and maintenance experienced at least one job rotation during their internship period. Such frequent positional changes disrupt the continuity of learning and assessment, rendering static, one-time evaluation methods ineffective. Beyond the challenge of job rotations, we identify several deep-seated structural shortcomings in prevailing internship assessment frameworks:

Imbalance among stakeholders–Evaluation often over-relies on enterprise supervisors, while the voices of students, school mentors, and peers are insufficiently incorporated [4].

Outdated evaluation standards–Many criteria remain focused on task completion and attendance, rather than on the development of transferable competencies and reflective practice.

Delayed and summative evaluation–Feedback typically arrives only at the end of the internship, missing opportunities for timely guidance and mid-course correction.

Compromised rights protection–The lack of transparent, multi-source evidence collection can leave students vulnerable to subjective or biased assessments.

As noted in prior studies, internships often demonstrate minimal effectiveness in cultivating students' capabilities and reinforcing professional knowledge, with the practical teaching function of production internships gradually diminishing [5]. Internship management requires comprehensive renewal in both conceptual and operational dimensions, necessitating systematic upgrades that incorporate dynamic monitoring throughout the process, precise procedural guidance, and multidimensional quality assessment [6].

III. OPERATIONAL MODEL OF QUALITY MONITORING SYSTEM BASED ON CSE

A. CORE CONCEPT OF CSE

The CSE (Competency-oriented, Student-centered, Evidence-supported) concept follows three core principles: competency-oriented, student-centered, and evidence-based. "Competency-oriented" refers to the evaluation focusing on the measurable and observable improvement of students' competencies, rather than purely on work output. "Student-centered" emphasizes students' initiative, reflection, and self-management during internships, as they are the main agents and evaluators of their own competency development. "Evidence-based" is based on diversified evidence (such as logs, weekly reports, monthly reports, summaries, internship evaluations, etc.), rather than solely on the impression of supervisors.

B. EVALUATION FRAMEWORK

Yang Guangrong et al. (2021) developed an evaluation framework for performance indicators in design-related vocational internships [7], while Zhu Chenglin (2021) established a theoretical model explaining the formation mechanisms of internship quality in design vocational education, with particular emphasis on three key factors: student engagement, institutional resource allocation, and corporate resource provision [8]. However, with the rapid advancement of next-generation information technologies such as big data, artificial intelligence, and blockchain, governance is evolving toward a more refined, intelligent, and collaborative approach [9]. Guided by the CSE (Competency-oriented, Student-centered, Evidence-supported) concept, we propose a quality monitoring system operational model structured around three dimensions: competency orientation, student-centeredness, and evidence-based support. The relationship between the evaluation dimensions in the model and the CSE concept is shown in Table 1:

IV. INDICATOR QUANTIFICATION AND MODEL CONSTRUCTION SUPPORTED BY BIG DATA

A. MULTI-LEVEL EVALUATION INDEX SYSTEM

Teachers can flexibly adjust their teaching strategies based on real-time feedback, create a collaborative learning environment centered around an inquiry community, promote deep interaction, and continuously optimize teaching effectiveness [10]. Therefore, a four-level (comprising four first-level indicators) evaluation index system is established, covering four first-level indicators: educational objectives, resources, processes, and outcomes. The four level evaluation indicators are shown in Table 2:

B. DYNAMIC WEIGHT MATHEMATICAL MODEL

Due to changes in positions and companies, different enterprise mentors may provide vastly different evaluations. Therefore, when quantifying various indicators, a dynamic weight mathematical model should be established.

Let the indicator set be $T = (T_1, T_2, \ldots, T_n)$, where T_i represents the third-level indicators being evaluated, and $S = (S_1, S_2, \ldots, S_n)$, where S_i represents the evaluation ratings (excellent, good, fair, average, and unqualified). A weighted evaluation scheme is adopted to quantify the internship performance.

Let the final internship score to be evaluated be G. Its calculation relies on a set T consisting of m evaluation indicators, as $T = (T_1, T_2, \ldots, T_m)$, where T_i represents the ith tertiary evaluation indicator (such as "Initiative in evidence collection", "Cross-situational application ability", etc.). Each indicator T_i corresponds to a weight w_i, and all weights constitute a weight vector $W = (w_1, w_2, \ldots, w_m)$, satisfying Let the evaluation language set be $S = (S_1, S_2, S_3, S_4, S_5) = (\text{Excellent}, \text{Good}, \text{Medium}, \text{Qualified}, \text{Unqualified})$, and assign a standard score range to each level (e.g., Excellent: 90-100 points, Good: 80-89 points, and so on). The weight of indicators, denoted as W, is pivotal in this model. Given that different positions have varying focuses, the relative importance of indicators may also shift. Therefore, we employ the 1-9 scale method proposed by T.L. Saaty to construct a judgment matrix [4], determining the relative importance of indicators through pairwise comparisons.

Step 1: An expert group consisting of professional leaders, school mentors, and enterprise experts will be formed to construct a benchmark judgment matrix A_{base} based on the general competency requirements for internships, and calculate the benchmark weight vector W_{base}.

Step 2 (Dynamic Representation): When students enter a new position, the school mentor, in conjunction with the enterprise mentor for that position, can make minor and rule-bound adjustments to the indicators in A_{base} that are significantly influenced by the specific characteristics of the position (such as "professional skill application" vs "communication and collaboration"). Specifically, adjustments are confined to a limited number of tertiary indicators directly tied to the position (e.g., $\leq 30\%$). The adjustment to

TABLE 1. Relationship between evaluation dimensions and CSE concept in the model

evaluation dimension	core issue	Evaluate the sources of evidence	Embodiment of CSE concept
Capability development and application	What professional and general abilities have students demonstrated, applied and improved upon?	Pre-test/post-test: self-assessment and supervisor's assessment of abilities at the beginning and end of the internship. Project set: design drawings, reports, and specific problem-solving cases. Skill inventory: new tools, technologies, and processes mastered.	Competency-based: focusing on incremental improvement in abilities, rather than static levels.
Take the initiative to participate and engage	Do students take the initiative to take responsibility, seek opportunities, and actively participate in the team?	Student Zhou Zhi/Diary: record the initiatives taken, questions asked, and additional responsibilities undertaken. Observation record by enterprise mentor: descriptive evaluation of students' initiative and participation. Peer feedback: team members' evaluations of their collaborativeness and contribution.	Student participation: evaluate their behavioral patterns and level of engagement.
Critical reflection and learning	How can students reflect on their practice, connect theory, and establish connections with future learning?	Structured anti-internship report: utilizing a specific model for in-depth analysis. Final defense/presentation: explain how the internship has influenced your career planning and learning direction. Theoretical application example: clearly indicate in the report where the theories learned in class have been applied.	Student-centered: emphasis on metacognitive ability and deep learning.
Formation of professional identity	What changes have occurred in students' understanding of their professional roles, responsibilities, and ethics?	Compare the changes in their career cognition between the initial and final interviews. The approach to handling dilemmas or ethical predicaments in the workplace. Description of the process of understanding and adapting to industry norms and corporate culture.	Competency-based and student-centered: focusing on the transformation of intrinsic qualities and identity recognition.

TABLE 2. Four-level Evaluation Indicators

Primary indicator	Secondary indicator	Tertiary indicator	Evaluation Points (Observation Points)	Primary evidence sources and evaluation subjects (key optimization points)
A1 Educational Goal Evaluation Whether the Evidence: Mentor training records.	A1.1 Goal Adaptability	A1.1.1 Transferable Competence Goal Setting	Preset goals focus on cross-enterprise, cross-position general transferable competencies (such as communication, problem-solving, learning ability).	Stakeholders: Students (S), School Mentors (T).
		A1.1.2 Dynamic Target Adjustment Mechanism	After job rotation, can the student quickly review with the school mentor and set short-term learning goals for the new position. Evidence: Mentor training records after job rotation.	Stakeholders: Student (S), School Mentor (T).
A2 Educational Resource Evaluation	A2.1 School Support	A2.1.1 Coaching Ability of School Mentors	Whether school mentors have the ability to provide career counseling, psychological support, and learning guidance, rather than merely serving as administrators.	Evidence: Mentor training records, teacher-student guidance records. Subject: Intern Administrator (M).
		A2.1.2 Digital Archive Library Whether	Convenient tools (such as the online Xixun Cloud Platform) are provided to allow students to upload, organize, and display learning evidence at any time.	Evidence: digital archives of the internship management platform. Responsible party: M.
A3 Education Process Evaluation (Core Optimization Area)	A3.1 Ability Evidence Collection Process (Alternative to Ability Application)	A3.1.1 Proactivity and Systematicness of Evidence Collection	Whether actively and consciously collecting physical evidence (photos, documents, code) and case evidence to prove one's own abilities in a new position.	Evidence: "Internship Management Platform Digital Archives" (core evidence), collection checklist. Subject: Student self-assessment (S), school mentor review (T).
		A3.1.2 Cross-contextual Application Skills	The ability to proactively apply skills or methods acquired at Company A to diverse tasks at Company B.	Evidence: Zhou Zhizhong's description of knowledge transfer and related works in the evidence set. Subjects: School tutor (T) evaluation and student (S) self-evaluation.
A4 Educational Effectiveness Evaluation quality demonstrate the development of multiple	A4.1 Effect of Transferable Competence Development	A4.1.1 Richness and Quality of Competence Evidence Set Whether the finally submitted ' Competence Evidence Set' can sufficiently and of high transferable competences	Does the finally submitted "Competence Evidence Set" sufficiently and of high quality demonstrate the development of its multiple transferable abilities?	Evidence: Digital records of the internship management platform. Subject: School mentors (T) evaluations, professional groups.
		A4.1.2 Evidence-based defense performance	Can skillfully cite cases from the evidence set during the defense, clearly demonstrating one's capability development and value creation.	Evidence: Performance in the final defense. Subject: Professional Group.

any single weight (Δw_i) is constrained (e.g., $|\Delta w_i| \leq 0.1$ relative to its benchmark value in W_{base}). The resulting position adaptability judgment matrix, A_{adapt}, must be recalculated for consistency, maintaining a Consistency Ratio (CR) < 0.1. This process yields the dynamic weight vector, W_{adapt}, that is applicable to the current position. This mechanism ensures that the weight distribution maintains overall consistency while flexibly adapting to the uniqueness of different internship situations.

For a single indicator Ti, its score si is no longer dependent on the evaluation of a single mentor, but rather on the scores from k different evaluation sources (such as corporate mentors, school mentors, student self-assessment, and even peer review). Let the score (quantified by the language set S) of the j-th evaluation source for indicator Ti be sj, and its credibility or importance weight be vj (for example, corporate mentors can be set to have the highest weight, followed by school mentors, and student self-assessment having the lowest weight). Then, the composite score si for indicator Ti is calculated as follows:

$$s_i = \sum_{k=1}^{n} (u_j \bullet s_{ij}) \tag{1}$$

After obtaining the synthetic score s_i for each indicator T_i and its corresponding weight w_i, the final internship grade G is calculated using the following weighted sum formula:

$$G = \sum_{i=1}^{m} (w_i \bullet s_i) \tag{2}$$

The obtained score G can be mapped back to the evaluation language set S, providing final grades such as "excellent" and "good", and generating a "competency profile" that includes the scores for each indicator, providing students with clear feedback on their abilities.

V. IMPLEMENTATION EFFECT

To scientifically verify the effectiveness of the new internship quality monitoring system based on the CSE model constructed in this study, students majoring in automobile inspection and maintenance were selected as the research subjects for pilot application, employing an experimental group-control group pre-post comparison method. gradeTec, llsfs model) and the control group (n=43, adopting the traditional management model). Both groups of students were guided by the same team of on-campus and off-campus mentors, and were arranged to intern at cooperating enterprises with similar technical levels as much as possible. This study was approved by the Ethics Committee of Chongqing Three Gorges Vocational College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

Acknowledging a key methodological limitation, we note that subtle differences in corporate culture, management style, and specific work tasks between the enterprises hosting the experimental and control groups might exist and represent a potential confounding variable. Therefore, the reported improvements, while

strongly indicative, should be interpreted with this caveat in mind. Other extraneous variables (e.g., student pre-internship competency levels, internship duration) were controlled to the greatest extent possible. Satisfaction scores for both enterprise mentors and students were obtained through post-internship surveys using standardized 5-point Likert scales (1=Very Dissatisfied, 5=Very Satisfied). Separate questionnaires were administered to the enterprise mentors supervising the experimental and control groups, and to the students themselves upon completion of their internships.

After the pilot, the experimental group significantly outperformed the control group in process indicators characterizing deep learning and initiative (see Table 3). This indicates that the new system effectively guides students to transition from being "passive task performers" to "active learners and evidence collectors".

TABLE 3. Comparison of procedural data

Indicator	Experimental group (mean)	Control group (mean)	Improve effectiveness
Zhou Zhi's submission rate	98.5%	87.2%	+11.3%
Average word count per blog post	450 words	210 words	+114%
Average number of uploads per person	18.5 portions	5.2 portions	+255%

We conducted self-assessment and peer assessment (by both on-campus and off-campus mentors) on the experimental group before and after their internship. The data (Figure 1) reveals that the difference in scores (i.e., ability increment) between pre and post-tests for core transferable skills such as fault diagnosis and troubleshooting, communication and collaboration, and active learning among students is significantly higher than that of the control group. This demonstrates the direct effect of the new system in promoting the development of students' intrinsic abilities.

TABLE 4. Comparison of result data

Indicator	Experimental group (mean)	Control (mean)	Group improve effectiveness
Average score of internship summary	89.5	82.1	+7.4 points
Enterprise satisfaction score	4.65/5.0	4.20/5.0	+10.7%
Student internship satisfaction	4.70/5.0	4.15/5.0	+13.3%

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and troubleshooting, communication and collaboration, and active learning among students is significantly higher than that of the control group. This demonstrates the direct effect of the new system in promoting the development of students' intrinsic abilities.

The pilot data convincingly demonstrates that the new CSE internship quality monitoring system constructed in this study has achieved remarkable implementation effects:

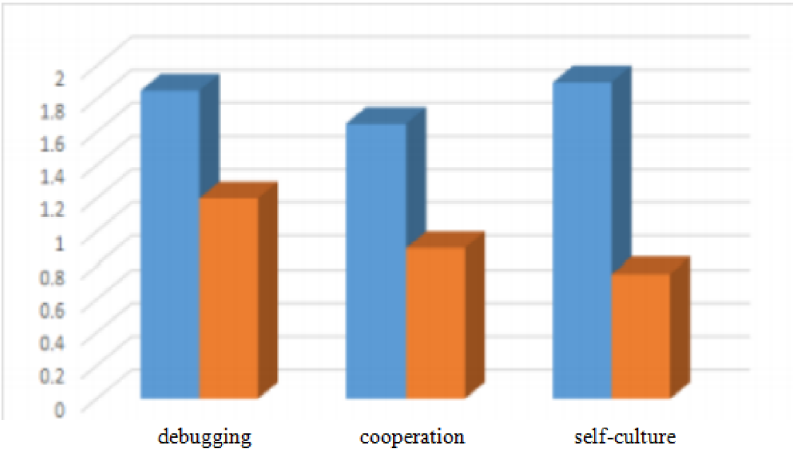

FIGURE 1. Comparison of core competency increments between the experimental group and the control group

it effectively reduces the negative impact of job transitions. Through tools such as "dynamic goal adjustment" and "competency evidence collection", students maintain continuous learning and have a basis for evaluation during the transition between old and new positions, ensuring the coherence of the learning process and consistency of evaluation.

Significantly enhanced students' sense of achievement and satisfaction: Through constructing personal evidence sets and deep reflection, students have gained a clear and visual understanding of their own growth, with their subjectivity and sense of achievement greatly enhanced, and their satisfaction significantly improved.

Enhanced evaluation authenticity: The evaluation model based on multiple pieces of evidence effectively mitigates the subjective evaluation fluctuations caused by changes in supervisors.

VI. SUMMARY AND OUTLOOK

A. DATA-DRIVEN SUPERVISION: FROM EXPERIENCE-DRIVEN TO DATA-DRIVEN

The system establishes a data-driven supervision mechanism with an "early warning model" to identify deviations in automotive technical, ensuring that student performance across diagnosis and repair workshops remains aligned with industrial safety and quality standards. When indicators such as abnormal attendance, delayed task progress, or negative feedback from enterprises appear as warning signals, the system automatically alerts relevant personnel to intervene, significantly improving problem response efficiency and the timeliness of student support [11]. This achieves proactive, precise, and efficient supervision.

B. CHALLENGES AND COUNTERMEASURES IN SYSTEM OPERATION

Burden issue: It is necessary to enhance willingness to participate through special lectures, demonstration cases, and simplified processes.

Capability issue: It is imperative to establish a complementary mentor training and certification mechanism, with a focus on enhancing their abilities in guiding reflection, career counseling, and process evaluation.

Technical issues: Continuously develop and optimize the management platform, aiming to automate data collection, quantitative analysis, and visual presentation in the backend, thereby maximally reducing the burden on mentors and providing intelligent data support for their monitoring and guidance.

C. SUBLIMATION OF EVALUATION RESULTS: FROM A SINGLE SCORE TO ABILITY PORTRAIT

The final personalized "Internship Ability Development Report" clearly presents the student's ability increment and growth trajectory in various dimensions, accompanied by representative evidence-based examples and suggestions for future development, serving as a "diagnosis" and "roadmap" for students' career planning and lifelong learning.

D. STUDY LIMITATIONS AND FUTURE RESEARCH DIRECTIONS

This study has several limitations. First, the pilot application was conducted within a single major (automotive inspection and maintenance) at one institution, which may limit the generalizability of the findings to other vocational fields or educational contexts. Second, although efforts were made to control variables, the potential influence of differing enterprise environments between the experimental and control groups cannot be completely ruled out, as acknowledged earlier. Future research should involve larger and more diverse samples across multiple majors and institutions to enhance external validity. Additionally, longitudinal studies tracking the long-term career development of students who experienced the CSE-based monitoring system would be valuable to assess its sustained impact. Further refinement of the dynamic weight adjustment algorithm and exploration of its fully automated implementation based on job description analysis are also promising directions.

VII. OUTLOOK

The system constructed in this study is not only a management tool but also a practice of an educational philosophy. Integrating the CSE concept to build a quality system, vocational college students are mostly oriented towards technical positions and frontline work fields. The abilities they need include not only professional skills but also comprehensive qualities such as career cognition, teamwork, communication, and time management [12]. While ensuring the quality of enterprise internships, we optimize professional skill levels and cultivate students' job adaptability [13]. Through dynamic assessment, we focus on results while valuing the process, promote teacher-student interaction, and facilitate the all-round development of both teaching and students [14]. In the future, by deepening industry-university-research cooperation and jointly developing work-study alternating training programs with universities, systematic arrangements will be made in full-process cultivation, end-to-end design, and comprehensive element configuration [15], to continuously deepen the application of the CSE model in the quality management of vocational college internships.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee of Chongqing Three Gorges Vocational College, and was performed in accordance with the principles of the Declaration of Helsinki. All eligible participants signed an informed consent form.

AUTHOR CONTRIBUTIONS

Conceptualization –Yu Cai and Huan Xie; methodology – Yu Cai and Huan Xie; investigation – Yu Cai and Huan Xie; writing-original draft preparation – Yu Cai and Huan Xie. All authors have read and agreed to the published version of the manuscript.

CONFLICTS OF INTEREST

The authors declare no conflict of interest.

FUNDING

This research was supported by,

Project name: Teaching Application Research on the ALoT-Enabled Intelligent Internet of Vehicles New Energy

Vehicle Technical Major Group, Source: Development Center for Scientific Research in Higher Education Institutions of the Ministry of Education, Project Number: 2024WA074

ACKNOWLEDGEMENTS

Not applicable.

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