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Research on the Enhancement of Job Competence of Medical Functional Experiment Technicians in the Context of Digital Transformation

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Abstract [**Objectives**] To establish a competency assessment framework for medical functional experiment technicians amid digital transformation, pinpoint specific weaknesses, and formulate systematic enhancement measures. [**Methods**] A mixed-methods approach combining literature review, structured questionnaires, and semi-structured interviews was adopted. A survey was conducted among 39 technicians at the School of Basic Medicine, Hubei University of Medicine. A two-dimensional, six-indicator competency model was constructed and subjected to further analysis. [**Results**] The scores of traditional experimental competence increased progressively with professional title level, with the senior group scoring significantly higher than the junior group ($P<0.05$). In terms of digital literacy, however, the intermediate and junior groups performed significantly better than the senior group ($P<0.05$). The major weaknesses identified included: low proficiency in digital tool application (only 32.3% reported being proficient), weak awareness of data security (61.3% lacked standardized practices), and insufficient innovation in digital teaching (fewer than 25% had participated in blended teaching design). In particular, digital literacy was significantly lower among staff with higher professional titles and those of older age. [**Conclusions**] Digital transformation imposes a dual requirement on experimental technicians: they must possess both solid traditional competencies and strong digital literacy. To address this, efforts should be synergistically advanced from three aspects, namely, individual self-directed learning, a tiered training system, and institutional incentives. Particular emphasis should be placed on enhancing digital literacy training for older staff, so as to systematically improve overall job competency.

Key words Digital transformation, Medical functional experiment technicians, Job competency, Digital literacy

0 Introduction

Medical experiments constitute an essential component of medical education, and their technical approaches and experimental models have undergone significant changes driven by digital transformation[1]. As medical laboratory technology serves as a critical support for teaching and research in disciplines such as medicine and biology, the traditional experimental teaching model faces numerous challenges. Digital technologies are promoting the intellectualization of experimental equipment, the cloud-based storage of experimental data, and the virtualization of teaching models, leading to a fundamental transformation in the form of experimental teaching. In this context, medical functional experiment technicians (who play a key role in the operation of experimental teaching, equipment maintenance, data management, and teaching reform) directly influence the quality of experimental teaching and the effectiveness of digital transformation through their job competency.

At present, laboratory technical teams in domestic medical colleges and universities generally suffer from problems such as relatively low educational attainment, unbalanced professional title distribution, an aging workforce, and lagging digital competence, which constrain the high-quality development of experimental teaching[2-3]. How to construct a job competency system that meets the needs of digital transformation, accurately identify competency gaps, and explore systematic improvement pathways has become an urgent issue for the construction of laboratory teams in local medical institutions. This study focuses on the basic medical laboratory technicians at Hubei University of Medicine, defining core concepts, constructing a competency model, conducting empirical surveys, analyzing competency deficiencies in the context of digital transformation, and proposing actionable enhancement strategies, with the aim of providing practical references for laboratory team development at similar institutions.

1 Research subjects and methods

1.1 Research subjects A total of 39 laboratory technicians were selected from the School of Basic Medicine, Hubei University of Medicine. The sample composition was as follows: 21 senior experimentalists (53.85%, aged 48 – 55 years), 15 experimentalists (38.46%, aged 30 – 45 years), and 3 junior experimentalists

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(7.69%, aged 25 – 30 years). In addition, corresponding discipline teachers and teaching administrators were concurrently included to participate in the interviews.

1.2 Methods

1.2.1 Literature review method. By consulting relevant domestic and international literature[4], we reviewed studies on digital transformation, medical experimental teaching, and job competency, and incorporated the digital education policy documents issued by the Ministry of Education to construct a job competency evaluation framework (Table 1) and assign weights. Based on the evaluation results, a feedback mechanism was established to provide specific improvement suggestions and guidance for issues and deficiencies identified during the evaluation process. Besides, the implementation outcomes of the evaluation system were regularly summarized and analyzed, and adjustments and refinements were made according to actual circumstances to render the system more scientific and rational.

Table 1 Components of job competency

Primary indicator	Weight	Secondary indicator	Weight	Core connotation
Traditional experimental competence	0.4	Professional theoretical and technical knowledge	0.25	Basic medical theory, principles of functional experiments, instrument principles
		Practical skills and equipment operation & maintenance	0.25	Routine experimental operations, calibration and maintenance of precision instruments, fault troubleshooting
		Emergency response and safety management	0.20	Handling of sudden malfunctions, laboratory safety regulations, hazardous chemical management
		Basic data recording and organization	0.15	Standardized recording of experimental data, archiving of paper/electronic files
		Offline communication and collaboration	0.15	Teacher-student communication, teamwork, teaching coordination
Digital literacy competence	0.6	Digital tool application ability	0.25	Office software, professional statistical software, operation of digital terminals for experimental equipment
		Data management and security capability	0.25	Cloud based data storage and backup, database operations, data desensitization and privacy protection, cyber risk prevention and control
		Virtual/remote experiment technology	0.15	Operation of virtual simulation platforms, remote experiment monitoring, online experiment guidance
		Digital teaching innovation ability	0.15	Blended teaching design, digital development of experimental resources, AI-assisted experiment applications
		Online collaboration and lifelong learning	0.10	Collaboration on online platforms, self-directed learning of digital skills, receptivity to new technologies
		Digital ethics and normative awareness	0.10	Authenticity of experimental data, copyright of digital resources, ethics of AI applications

1.2.2 Questionnaire survey. A questionnaire was designed based on the components of job competency, using a 5-point Likert scale (1 = below standard, 5 = excellent). A total of 100 questionnaires were distributed to technicians, teachers, and administrators, among which 93 valid responses were returned, yielding an effective response rate of 93%.

1.2.3 Expert interview method. Semi-structured interviews were conducted with 27 participants, including key technical staff, laboratory teachers, teaching administrators, and student representatives. The interviews focused on competency dimensions, training needs, competency gaps, and enhancement pathways, with the aim of gaining in-depth insights into the underlying causes of the identified issues. The entire investigation strictly followed scientific protocols to ensure the authenticity and validity of the data.

1.2.4 Case study method. Representative medical schools and research institutions were selected as cases to analyze their successful experiences and existing problems in enhancing the job competency of medical laboratory technicians[5-6].

1.2.5 Statistical analysis. SPSS 26.0 was used for data processing. Measurement data were expressed as mean ± standard deviation (SD). Comparisons among groups were performed using one-way analysis of variance (ANOVA), and a P-value < 0.05 was considered statistically significant.

1.2.6 Construction of the job competency model. Based on literature review and expert consultation, a two-dimensional, six-factor job competency model was constructed. It comprises two primary dimensions: traditional experimental competence (weight 0.4) and digital literacy competence (weight 0.6), which are further subdivided into 12 secondary indicators (Table 1).

2 Results and analysis

2.1 Comparison of competency scores across professional title/age groups As shown in Table 2, for traditional experimental competence, the scores followed a descending order of senior group > intermediate group > junior group, with statistically significant differences among the groups ($P < 0.05$). For digital literacy, the intermediate and junior groups were comparable and both outperformed the senior group; the senior group scored significantly lower than the intermediate and junior groups ($P < 0.05$), indicating that older staff had prominent deficiencies in digital skills. Overall, the intermediate group demonstrated a balanced profile, possessing both traditional competence and digital literacy, and thus constituted the core strength of the team.

2.2 Major competency gaps Proficiency in digital tools was insufficient. Only 32.3% of the staff were proficient in using professional data analysis software, and less than 40% demonstrated adequate operational proficiency on virtual simulation platforms. Awareness of data security was weak. A total of 61.3% of the staff lacked standardized practices for data backup and privacy protection, posing potential risks of experimental data leakage or loss. Digital teaching innovation was inadequate. Fewer than 25% of the staff had ever participated in the design of blended (online-offline) experimental teaching, and the application of AI-assisted experiments was almost nonexistent. Cross-disciplinary collaboration and lifelong learning awareness were deficient. Older staff showed low motivation to proactively acquire digital skills, the team's digital collaboration efficiency was suboptimal, and the pace of knowledge renewal lagged behind the rhythm of technological iteration.

Table 2 Comparison of competency scores across professional title/age groups ($\bar{x} \pm s$)

Professional title/age	Number	Traditional experimental competence	Digital literacy	Comprehensive score//points
Senior (48 – 55 years)	21	59.00 ± 5.42 *	31.00 ± 2.62	42.20 ± 3.85
Intermediate (30 – 45 years)	15	55.00 ± 2.85	37.00 ± 3.40 *	44.20 ± 2.11 *
Junior (25 – 30 years)	3	46.50 ± 6.20	36.00 ± 1.40 *	40.20 ± 3.58

NOTE * $P < 0.05$ compared with the dimension of traditional experimental competence.

2.3 Causal analysis In terms of staff composition, senior-ranked personnel accounted for over 50% of the workforce, with a relatively older age profile (48 – 55 years), limited motivation for knowledge updating, and low receptivity to new technologies. Regarding the training system, there was a lack of tiered and regular digital skills training; the training content was disconnected from job requirements and lacked practical applicability. At the institutional level, digital competence was not incorporated into performance appraisal or promotion criteria, which further diminished staff motivation for learning. Moreover, the updating of laboratory digital equipment lagged behind, and the construction of virtual simulation platforms and data management systems remained inadequate, thereby hindering the translation and application of acquired competencies.

3 Discussion

In light of current trends in scientific and technological development[7], the overall quality, professional expertise, and digital proficiency of laboratory teams must be further enhanced to ensure the sustainable development of laboratory construction. Consequently, strengthening the laboratory teaching workforce and improving the comprehensive competency of experimental technicians have become critically important. Digital transformation imposes a dual requirement on medical functional experiment technicians: they must possess both solid traditional competencies and robust digital literacy. This study revealed that the laboratory technical team exhibited a profile characterized by strong traditional skills but weak digital abilities, with pronounced deficiencies among older staff and considerable potential among young and middle-aged personnel (a finding consistent with studies conducted at similar domestic institutions). Although senior-ranked and older staff possessed extensive hands-on experimental experience, their digital skills lagged significantly behind, making them the primary bottleneck in workforce transformation. By contrast, young and middle-aged staff had a better digital foundation but required further strengthening of their traditional experimental skills, suggesting that systematic training is needed to achieve complementary capabilities. At present, the role of experimental technicians is shifting from "equipment operators and laboratory assistants" to "digital laboratory managers, teaching innovators, and data analysts", with digital literacy, innovative capacity, and cross-disciplinary collaboration emerging as core competencies[8]. Institutions should tailor their approaches to local realities, avoid blind emulation of other models, and adhere to the principle of being "practical, sufficient, and effective" in building a competency enhancement system suited to local medical schools. This can be achieved through coordinated efforts at three levels.

3.1 Individual level At the individual level, experimental technicians should embrace the concept of lifelong learning and proactively enhance their digital literacy. First, individualized learning plans should be developed: young and middle-aged staff should focus on strengthening their traditional experimental skills, while senior/older staff should prioritize learning basic digital tools and data security protocols. Second, hands-on training should be actively pursued, including self-directed practice with virtual simulation platforms and data analysis software, as well as participation in digital experiment projects to accumulate practical experience. Third, peer exchange should be strengthened by attending academic conferences and online seminars, learning from the digital laboratory management experiences of advanced institutions, and broadening one's professional horizons.

3.2 Organizational level At the organizational level, a tiered training system should be established to enhance training effectiveness. First, differentiated training plans should be developed for different staff groups. For senior/older laboratory technicians, the training should focus on general digital literacy, data security management, and digital teaching concepts, while reducing pressure from technical hands-on requirements. For the intermediate group, training should emphasize the application of digital tools, virtual experiment design, and in-depth data analysis, with the aim of developing them into digital backbone personnel. For newly recruited medical laboratory technicians, training should help them familiarize themselves with the work environment and procedures as quickly as possible, solidify their traditional experimental skills, and systematically acquire digital technologies, thereby cultivating interdisciplinary talents. Second, the training formats should be diversified by adopting a blended model combining expert lectures, practical drills, case-based discussions, and online micro-courses, with digital technology experts and front-line teaching staff invited as instructors to improve the practicality and effectiveness of the training[9-11].

3.3 Institutional level At the institutional level, incentive and support mechanisms should be improved to stimulate intrinsic motivation. First, an assessment and evaluation mechanism should be established, in which digital literacy is incorporated as a core indicator in performance appraisal, professional promotion, and award selection, with quantified scoring to strengthen its guiding role. Second, resource investment should be increased by establishing special funds for digital construction, upgrading intelligent experimental equipment, building virtual simulation platforms, and deploying data security management systems, thereby providing hardware support for competency enhancement. Third, the incentive mechanism should be refined: staff who demonstrate outstanding digital capabilities and notable achievements in teaching innovation should be rewarded with bonuses, prioritized for external training opportunities, and offered career development pathways, so as to stimulate their enthusiasm for continuous learning.

4 Conclusions and prospects

This study constructed a two-dimensional, six-factor job competency model for medical functional experiment technicians in the context of digital transformation. Empirical analysis revealed that basic medical laboratory technicians possessed a relatively solid foundation in traditional competencies, yet exhibited notable deficiencies in digital literacy, with senior-ranked and older staff requiring urgent improvement in their digital capabilities. Future efforts should focus on coordinated actions at three levels (individual self-directed learning, tiered training, and institutional incentives) to promote competency upgrading among experimental technicians and align their skills with the demands of digital-driven experimental teaching.

Several limitations of this study should be acknowledged. The validity of the proposed competency model requires further verification. Subsequent research will expand the sample scope to include experimental technicians from different tiers and various institutions; conduct longitudinal tracking studies to explore the developmental patterns of digital competence; develop a digital competency assessment scale and establish a precision-oriented training system; and investigate the in-depth application of AI and big data in experimental teaching, with the aim of empowering high-quality development of experimental education.

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