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Thinking and Exploration of the Organic Connection between Market Demand and Talent Training of Medical Laboratory Technology Specialty

Nannan Zhong[1], Wen Qin[1], Cejuan Ji[1], Dan Zheng[1], Zhenzhu Li[2], Lei Mei[3], Ruochun Li[1], Rui Zhang[1,*]

[1]Department of Medical Science and Technology, Guiyang Healthcare Vocational University, Guiyang 550081, Guizhou, China
[2]Department of Medical Laboratory, Medical technology College, Shaanxi Energy Institute, Xi'an 710699, Shaanxi, China
[3]Department of Medical Laboratory, Heilongjiang Agricultural Reclamation Vocational College, Haerbin 150025, Heilongjiang, China
Correspondence Author, zhangruity12@163.com

Abstract: ***Background**: To explore the reasonable orientation of talent training for medical laboratory technology (MLT) at the vocational undergraduate level, this study has conducted a thorough survey and analysis of the talent market demand in multiple aspects, including the total MLT talent market demand, talent demand changes and expectations, and changes in industry development. **Methods**: Based on a literature search, this study collected statistics on the number of MLT professionals in China over the past decade. Questionnaires were distributed to 128 employers in 14 provinces nationwide. A survey was conducted on the overall industry development and the requirements of enterprises for the abilities of talent on the market, and 26 doctors and nurses with senior technical titles were interviewed. Another survey was carried out among 17 higher vocational colleges and 8 general undergraduate universities nationwide, focusing on vocational abilities that are highly regarded by teachers. **Results**: As reflected by the results of this study, the market requires a higher level of educational background for talent, and self-directed learning ability is rated as the most essential vocational ability by enterprises. Moreover, the ability to use information technology and the communication and expression ability are necessary personal abilities in the opinion of enterprises. However, the vocational abilities specially developed by teachers are not always the same as those required by enterprises. The results of this study show that the latest progress of information technology in the industry must be integrated into talent training, and priority should be given to developing innovation ability, self-directed learning ability and interpersonal communication ability to develop talent that precisely meets market demand. **Conclusion**: Based on a thorough survey and analysis of market demand, this study recommends upgrading traditional teaching thought, focusing on specific market demand, accurately determining talent training and ensuring that talent can better meet market demand.*

Keywords: Talent market demand, Orientation of talent training, Medical laboratory technology education.

1. Background

Vocational education is a gateway to the training of high-skill professional talent and a critical path to the reproduction of labor power. With the changing demand of the labor market, vocational education should reform itself now and then, thus empowering laborers with the technical level and vocational quality necessary for the labor market and ensuring the effective continuous operation of the vocational education system [1]. With the establishment and consummation of the market economy system, the market regulates not only economic life but also the development of education. In particular, with distinct vocational characteristics, vocational education is most closely related to the labor market. Therefore, the ability to meet the demand of the labor market is a significant indicator measuring the development level of modern vocational education and the degree of adaptation to social demand.

Talent market demand is highly instructive and incentivized for the specialty construction of higher vocational schools by guiding these schools to upgrade ideologies, build up the education philosophy under the market economy and strengthen the understanding of the attributes of higher vocational education. "Employment-oriented, and constantly fit the development of the industry" is the fundamental guiding ideology for the current development of vocational education [2]. The implementation of this ideology in practical vocational education is decided by the degree of meeting the talent market demand, the compliance of higher vocational schools with market rules in practice, the application of scientific technical methods to improve and strengthen management and the realization of optimum resource allocation to achieve the coordinated and steady development of talent training in higher vocational education. Higher vocational education can meet the demand of different enterprises in the industry and achieve scientific and sustainable development only by coordinating with the talent market demand and improving the scientific level of talent training planning, organization, control and implementation.

1.1 Current Status of Higher Vocational Education Reform in China

As shown by the development trend of the world's higher vocational education, the educational level is inevitably becoming increasingly higher. The vocational and technical education of many foreign countries and regions has reached the undergraduate and postgraduate levels. Meanwhile, higher vocational education has constituted an intercommunicated and interconnected system with regular higher education. However, there are insufficient communications and connections between vocational and technical schools and regular colleges in China. It is difficult for vocational and technical education to achieve high-level development, thus failing to meet the demands of social and economic

development [3].

According to the specialty adjustment of higher education, China is working hard to promote the integration of specialty structures between vocational colleges and general undergraduate universities. With regard to national macroscopic policies and higher vocational college development planning, China is encouraging higher vocational colleges to accelerate the construction and development of professional undergraduate levels and build new undergraduate colleges. In addition, colleges with industry characteristics are encouraged to develop professional education integrating professional curriculum with undergraduate curriculum, spare no effort to establish a complete specialty structure covering secondary vocational education, higher vocational education, undergraduate education and graduate education with professional degrees, steadily achieve the development of integrating professional curriculum with undergraduate curriculum and featured vocational education and finally establish a relatively stable vocational education specialty system structure. After being authorized and approved by the Ministry of Education, 32 colleges have been officially renamed as "vocational universities" by the end of June 2023 in China to pilot undergraduate-level vocational education [4]. Thirty-two undergraduate-level vocational colleges, as the first batch of participants in the pilot program, have set the goal of developing high-tech skilled talent for regional social and economic development and are characterized by higher-level and stronger vocationalism.

With a wider range of acceptance from higher education, people express higher expectations for higher vocational education. It is extremely important to maximize the benefit of limited resources. As proven by human capital theory, education will yield the highest rate of return on investment only when educatees obtain a job corresponding to their educational levels. To maximize the benefit of higher education resources, educated talent must meet the demand of the labor market. In other words, the talent training of higher vocational education should be coordinated with the demand of the labor market.

A study on the coordinated development between talent market demand and talent training orientation is helpful for the scientific and healthy development of vocational education. With fiercer employment competition and increasing education costs, people become increasingly rational and aware of benefits while "investing" in higher education. In other words, people will think about the return on "investment", yield and risk more or less while making decisions on universities and specialties [5]. It will be very difficult for higher vocational education to achieve sustainable development if the conflicts between vocational education and labor market demand in talent quantity, structure and quality cannot be eliminated and the return on "investment" continues to decrease. Some social problems will even occur if graduates cannot be employed successfully [6].

In terms of training objectives, vocational undergraduate education is a type of education that simultaneously meets the talent training demand of vocational education and undergraduate education [7]. It is committed to developing high-quality undergraduate-level technical and skilled talent with a profound technical and theoretical foundation, cross-disciplinary knowledge integration ability, comprehensive application and technical integration ability, practical innovation ability, job flexibility, sustainable development ability, technical ethic quality, strong general educational background and other abilities. This type of education should allow students to know about their personal career planning more clearly and focus on the modelling of occupational identity from a beginner to a veteran in a certain field rather than ensuring basic survival by simply obtaining a certain professional ability, promoting overall personal development, and ultimately improving the personal socialization process and achieving social integration [8].

1.2 Problems Faced During Specialty Construction.

With the new requirements of new business, new industry and new economy for talent, systematic investigation and research during specialty construction is of great value and significance for the talent training of vocational undergraduate education. With the rapid development of information technology, the talent demand on the market continues to change. At present, the structural unemployment caused by the lower utilization ratio of graduates' specialties is the main problem [9]. The lower utilization ratio of graduates' specialties is manifested in the lower adaptation of supply-demand quality.

Before starting specialty construction and preparing talent training plans, most colleges and universities conduct different levels of market demand surveys. Limited by the information on hand and the survey area, they cannot obtain complete information during the survey. With the development of big data and information technology, professional post groups have seen great changes in skill demand. However, teaching process design, teaching methodology and course design are not reformed in a timely manner, and the teaching thoughts of teachers remain unchanged. Instead, they are still using traditional methods to pass on their knowledge and skills to students. Moreover, teachers have not gained a clear understanding of external changes, resulting in a lower compatibility between graduates and actual market demand.

1.3 MLT Education Situation

Medical examination is the combination of modern laboratory technology and clinical applications, which is an important part of clinical medicine. In clinical medical services, medical examination provides important information for disease screening, prevention, diagnosis and management. In health management, medical examination is crucial to etiological diagnosis, as well as epidemic monitoring, prevention and control. Medical examination plays an increasingly important role in clinical diagnosis, treatment and prognosis. Its continuous progress and the application of new achievements and technologies have become the main drivers for the overall medical level in various countries [10].

The MLT talent training in China includes vocational education and regular higher education. Vocational education

consists of three years of secondary technical education, three years of higher vocational education and two years of higher vocational education for further undergraduate education, while regular higher education consists of four years of undergraduate education and five years of undergraduate education. Four-year vocational undergraduate education was added after the catalog of disciplines and specialties was updated in 2021. Therefore, the MLT specialty has two-year, three-year, four-year and five-year education systems. Only the model in which practical talents that meet the actual market demand are trained and the structural unemployment of skilled talents is avoided is an acceptable talent training model.

The structural unemployment of skilled talent is a wicked problem, and the mismatch between labor supply and market demand is a primary cause of unemployment for young people [11]. The delayed supply of skills for students is also one of the primary causes of structural unemployment [12]. The gap between the skills mastered by students and the skills required by professional posts, especially the lower ability of skill transfer, will worsen the unemployment caused by insufficient education.

Vocational undergraduate education is known as a new type of education. We hope to accurately learn about the market demand at the beginning to build a teaching system that meets the talent demand and train the talent that better meets specific post requirements. For the above reason, this study explores the MLT talent market demand by investigating three aspects, including talent level demand of enterprises, vocational ability appeal and vocational college teachers, and taking the MLT specialty of the vocational education system as the object. It aims to lay a foundation for setting up undergraduate specialties that better meet market demand and have a reasonable talent training system.

2. Method

2.1 Participants

By means of a big data platform and information technology, this study performs a statistical analysis of total talent demand, deeply investigates the requirements of professional posts in this specialty for talent abilities and summarizes the characteristics, trends and future priorities of talent demand. To obtain typical results from the investigation and research, 128 representative medical and health organizations from 14 provinces (municipalities) in the eastern, central and western regions were selected to carry out research on tasks and projects of medical examination posts according to the regional division in the Chinese Journal of Health Statistics (2021) [13]. The specific regional distribution and classification of the investigated medical and health institutions are shown in Table 1.

In this study, interviews were conducted in situ and by telephone. A total of 18 doctors or nurses with senior titles and 8 managers of the information center were interviewed. They were from the First Affiliated Hospital of Medical School of Zhejiang University, The First Affiliated Hospital of Xi'an Jiaotong University, Air Force Medical University of PLA (the Fourth Military Medical University), Xi'an Tumor Hospital, Xi'an Hospital of Traditional Chinese Medicine, and Xi'an Honghui Hospital. Trained researchers asked questions according to the interview outline. After obtaining informed consent from the interviewees, the interview results were sorted according to the audio recording.

In this study, we also investigated the talent training plans of talent suppliers (colleges and universities responsible for talent training) and the attitudes of teachers towards the training of vocational abilities. We selected some higher vocational colleges and regular undergraduate colleges for the investigation and research. According to the regional division in the Health Statistical Yearbook of China, 17 higher vocational colleges and 8 regular undergraduate colleges in the eastern, central and western regions were selected to carry out research on teachers and students. In total, 112 front-line professional teachers from 25 colleges participated in this event. See Table 2 for details.

Table 1: Distribution of medical and health organizations

Region	Province (municipality)	Number of medical and health institutions	Proportion (%)
Eastern region (58)	Beijing	4	3.13%
	Tianjin	6	4.69%
	Zhejiang Province	15	11.72%
	Jiangsu Province	15	11.72%
	Fujian Province	10	7.81%
	Hainan Province	8	6.25%
Central region (34)	Heilongjiang Province	6	4.69%
	Jiangxi Province	7	5.47%
	Jilin Province	8	6.25%
	Hubei Province	4	3.13%
	Henan Province	9	7.03%
Western region (36)	Yunnan Province	9	7.03%
	Guizhou Province	6	4.69%
	Chongqing	4	3.13%
	Shaanxi Province	17	13.28%
Total	14 (provinces/municipalities)	128	100.00%

Table 2: Basic information of the schools involved in the investigation and research

School type	School category	Eastern region	Central region	Western region	Subtotal
Higher vocational college	National demonstration school	1	2	1	4
	Provincial demonstration school	1	1	1	3
	College of national featured high-level higher vocational education and specialty construction program	1	1	1	3
	College of provincial featured high-level higher vocational education and specialty construction program	2	2	3	7
Regular education	Regular undergraduate college	3	2	3	8
Total		8	8	9	25

2.2 Measure

2.2.1 Literature search

Based on a literature search and statistical yearbook data query, this study collected statistics on the number of MLT professionals in China over the past decade.

2.2.2 Questionnaire

An online survey was implemented via questionnaires. Electronic questionnaires were sent using the WJX app to ask the leaders of the surveyed employers and the core personnel of the surveyed departments to answer relevant questions. Questionnaires were sent to the 128 employers selected in the previous step, and 97 valid questionnaires were collected in total. With these questionnaires, we investigated the most needed types of MLT talents, the employment of these talents in the past three years, the planned employment of MLT talents in the next five years, and specific ability requirements. Another survey was carried out by sending questionnaires to the front-line teachers of 17 higher vocational colleges and 8 general undergraduate universities nationwide, focusing on vocational abilities that are highly regarded by teachers. A total of 112 valid questionnaires were collected. All the questionnaires were edited using a 5-point Likert scale from 1 indicating “Not essential” to 5 indicating “Most essential”.

Interviews with the doctors and nurses from Grade II or Grade III hospitals with senior technical titles,

Interview outline: 1) What aspects are you satisfied with for medical laboratory technicians? What aspects are weak and should be improved for medical laboratory technicians? 2) What aspects should be improved by medical examination departments for clinical diagnosis and treatment services?

Interviews with the management personnel or leader of the hospital information management department.

Interview outline: What knowledge and technology do you think medical laboratory personnel need to strengthen in information management, application and maintenance?

3. Result

3.1 Investigation and Research on the Total Talent Demand and Expected Talent Demand

According to the Health Statistical Yearbook of China (2012-2022), the number of MLT professionals rose from 238,800 in 2011 to 457,600 in 2021, a growth rate of 91.6%. The scale of MLT talents became notably larger (see Figure 1). The overall growth trend is steady. However, greater fluctuations occurred in 2021 than in 2020 because of the COVID-19 pandemic. The data do not contain other professionals on the industry chain relating to medical examination and only include the MLT professionals working at clinical medical institutions. As estimated, the growth rate of professionals on the entire industry chain will be much higher.

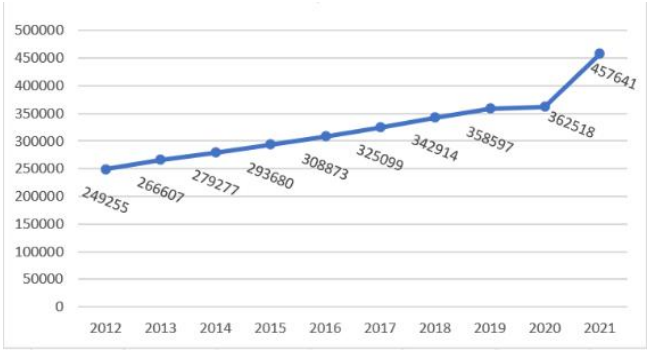

Figure 1: Increase in the number of medical laboratory technicians from 2011 to 2021

According to the data collected from 128 medical health institutions involved in this study, 984 employees were enrolled in the last three years, and most of them were undergraduates, followed by postgraduates. The proportion of students from technical secondary school was the lowest (see Figure 2). Among all the employers involved in this study, 13 employers had no talent recruitment plans for the next five years, and the remaining 115 employers planned to recruit 756 persons in the next five years. Most of the persons to be recruited had undergraduate and postgraduate degrees, accounting for 89.0% (see Figure 2). The employment in the past three years and the planned enrollment for the next five years reveal that the expected educational background of employees is rising as a whole, which is consistent with the overall development trend of vocational education.

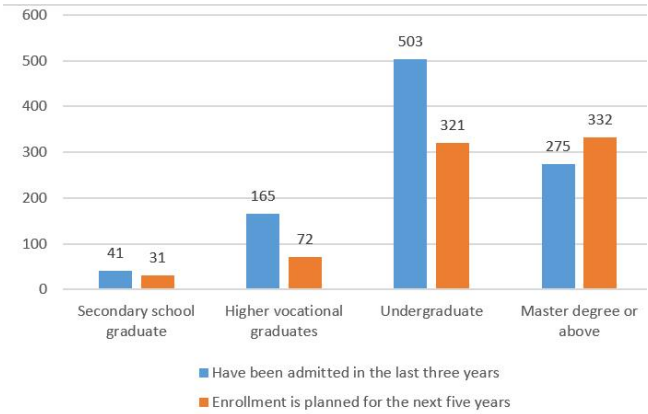

Figure 2: Employment in the last three years and employment plan for the next five years

At present, higher vocational graduates are still mainly part of MLT, and there are 217 higher vocational colleges, 177 undergraduate colleges and 74 enrollment points for master's students on a national scale [14]. Vocational undergraduate education is a new type of education established after the revision of the enrollment catalog in 2021. Therefore, the colleges of this type have enrolled fewer students and provided no graduates. According to the number of recruitment colleges in the statistical data and the fact that the number of students enrolled by a single higher vocational college is larger than that of students enrolled by a regular undergraduate college, it is concluded that there are more graduates from higher vocational colleges than from undergraduate colleges in the MLT specialty.

By comparing the employment of 128 surveyed employers in the past three years, we found that the number of employed undergraduates (503) was far greater than that of graduates (165) from higher vocational colleges. According to the employment plans for the next five years, the number of undergraduates (321) is far greater than that of graduates (72) from higher vocational colleges. These employers even need a large number of postgraduates (332). With reference to the above data, we can easily conclude that improving the educational level for industrial development is crucial to the future of vocational education.

3.2 Appeals of Enterprises for Talent Abilities

To gain an in-depth understanding of the vocational abilities and qualities of graduates highly regarded by employers, the study group conducted an in-depth survey. We implemented the questionnaire survey on the importance of ten abilities, such as scientific research and innovation ability, self-directed learning ability, and communication and expression ability. We performed a reliability analysis of the questionnaires using Cronbach's alpha coefficient in SPSS 23.0. The coefficient was 0.9, indicating that the questionnaires had excellent internal consistency and met the reliability criteria. All answers were scored using a 5-point Likert scale with 1 indicating "not essential" to 5 indicating "most essential". Ninety-seven valid questionnaires were collected from 128 employers. Then, the scores were totaled and averaged for statistical analysis. See Figure 3 for the results.

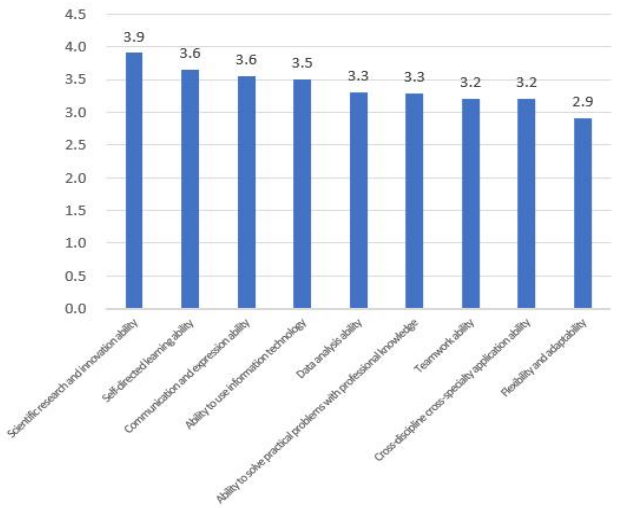

Figure 3: Score ranking of abilities required by enterprises for talent training

According to the above results, the abilities and qualities that are highly regarded by employers during recruitment are scientific research and innovation ability, self-directed learning ability, communication and expression ability, ability to use information technology, data analysis ability, ability to solve practical problems with professional knowledge, cross-discipline cross-specialty application ability, teamwork ability, and flexibility and adaptability.

3.2.1 Scientific research and innovation ability and self-directed learning ability

We could not distinguish the appeals of employers for the abilities of employees (postgraduates, undergraduates or graduates of higher vocational colleges) through questionnaires. However, "scientific research and innovation ability" ranked at the top according to the feedback. Postgraduates have scientific research abilities because they have experienced scientific research training. Therefore, they take a large proportion in the employment plan of enterprises for the next five years, which is consistent with the above results.

MLT is a highly practical discipline integrating multiple modern technologies. We should avoid turning students into professional technicians on instrument lines but work hard to develop them into multiskilled practical talent proficient in daily work and capable of scientific research and innovation. In this process, scientific research and innovation ability are extremely important. Innovation ability is always the aim of education, and educational workers are exploring how to develop the innovation ability of students. However, innovation ability is an unmeasurable soft skill, and the evaluation criteria of technical abilities are objective and direct. According to the survey on front-line teachers, they agreed on the importance of scientific research and innovation ability, but such ability was not reflected in the specific talent training plans of the surveyed colleges. In addition, it was not measured and considered. Innovation ability decides career breadth and depth. It is reflected in different work steps and plays a basic role in the training of other abilities [15]. As a weakness of vocational education, innovation ability should be fully recognized.

3.2.2 Communication and expression ability

In the questionnaires, the appeal of enterprises for "communication and expression ability" ranked second, which differs greatly from previous understandings. This situation may be caused by the following factors:

The extensive application of automatic instruments leads to changes in ability requirements.

To learn about the application of automatic instruments in clinical practice, the prescribing rate of 342 examination items (including combined examination items) commonly used in 128 medical health institutions was investigated, and the results are shown in Table 3.

Table 3: Mean prescribing rate of 342 common examination items in 128 medical and health institutions

Examination item	Number of examination items	Mean prescribing rate (%)
Basic examination for clinical diagnosis	35	79.98
Microbiological examination	77	78.46
Biochemical examination	86	75.7
Immunology examination	56	62.52
Hematological examination	80	54.35
Molecular biological examination	8	51.90

According to the preliminary survey, approximately 70% of the examination items are completed by automatic examination instruments. At present, 30 kinds of automatic examination instruments are widely used. Some of them are subjected to frequent upgrading and generation change. For example, the full automatic three cent blood cell analyser is mostly replaced by the more accurate and rapid analyser for five kinds of blood cells. Some instruments have multiple sets

in one department. Some sophisticated instruments are not used in primary health institutions or specialized hospitals because they are expensive and designed for complex examinations. The types and number of automatic instruments applied in medical and health institutions are listed in Table 4.

Table 4: Application of automatic instruments in 128 medical and health institutions

Type of instrument	Number of instruments					
	0	1	2	3	4	5
Full automatic five cent blood cell analyser	6	20	22	25	24	31
Automatic biochemical analyser	7	21	31	26	21	22
Microbial identification and drug sensitivity analysis system	8	49	31	14	14	12
Blood coagulation analyser	9	22	40	23	16	18
Immunochemiluminescence apparatus	9	20	27	21	18	33
Urine analyser	10	21	31	25	22	19
Automatic blood cultivator	10	38	33	19	15	13
Urine sediment analyser	11	25	36	27	14	15
Nucleic acid extraction and purification instrument	11	15	29	23	20	30
Nucleic acid amplification analyser	11	14	22	23	23	35
Erythrocyte sediment rate analyser	14	38	29	18	15	14
Blood gas analyser	15	35	31	21	13	13
Automatic microplate reader	17	40	25	20	13	13
Fluorescence microscope	19	39	24	14	16	16
Blood group analyser	20	46	21	15	15	11
Electrolyte analyser	22	26	28	17	19	16
Excrement analyser	27	38	22	18	12	11
Special protein tester	28	27	28	18	14	13
Blood analysis system	32	38	17	15	12	14
Biochemical immunization system	33	37	18	13	14	13
Thrombelastography instrument	35	25	22	18	15	13
Blood cell morphology analyser	36	31	22	14	13	12
Flow cytometry	37	34	17	16	12	12
Microbial mass spectrometer	41	36	12	13	15	11
Fully automatic sample processing system	42	29	18	15	13	11
Protein electrophoresis apparatus	42	30	17	14	13	12
Mass spectrometer	42	32	13	16	12	13
Semen analyser	44	33	13	14	13	11
Time-resolved fluorescence immunoanalyzer	47	26	15	14	14	12
Full automatic three cent blood cell analyser	59	10	18	13	13	15

This survey conducted a preliminary investigation on the use of POCT instruments in medical institutions, but mainly focused on laboratory departments. In fact, POCT is widely used in primary hospitals, mainly used by clinicians and nurses. In this survey, however, Grade II, Level A hospitals or above accounted for 82.8%, so the collected questionnaire data was not representative.

The extensive application of large-sized automatic instruments and small-sized bedside diagnostic instruments and reagents has greatly increased the number of medical examination items. Under such circumstances, much stronger abilities are required to analyse examination items and communicate with clinical patients. Moreover, the application of POCT (point-of-care testing) allows patients to better involve themselves in the medical process, thus highlighting the communication ability of MLT personnel. POCT has the advantages of a short examination cycle, great convenience and high practicality. However, tests are scattered. If operations are not standardized and examination quality is not controlled properly, the accuracy of examination results will be greatly affected [16]. The extensive application of POCT and networks and other factors allows patients to participate in the whole medical process. Both medical care services and responsibilities are changing.

3.2.3 Interviews with doctors and nurses with senior technical titles.

By interviewing doctors and nurses with senior technical titles, we summarized their satisfaction with medical examinations and the following problems.

They are satisfied with 1) a good attitude towards patients and a reasonable service process. 2) Timely processing of specimens, high testing speed, scheduled release of testing results and timely reporting of critical values. 3) More new examination items that basically meet clinical requirements.

Aspects to be improved: 1) Strengthen the clinical sense and clinical thinking, be active to communicate with clinicians, for example, attend ward inspection and examination report, especially interpret abnormal results to ensure medical examination plays a bigger role in diagnosis and treatment, and strengthen acceptance and mutual trust (communication ability is essential here). 2) When starting any new examination item, strengthen clinical promotion and help more doctors and nurses learn about its clinical application value (communication ability is essential here). 3) Strengthen the training of ability and personnel to read morphological analysis films of bone marrow aspiration and peripheral blood smear cells and improve the level of diagnosis. 4) Synchronously adjust the range of indicator reference for examination items with the new guide; keep improving the accuracy of examination items used as disease diagnosis and classification criteria; once the results are not consistent with the clinical diagnosis, keep an active contact and require reexamination timely (communication ability is essential here).

3.3 Requirements for the Ability to Use Information Technology

“Ability to use information technology” is an important ability in the opinion of the surveyed employers. Network information technology has been widely applied in various medical fields because of its convenience and accuracy. Various automatic analysers in the laboratory department are connected to the laboratory information system (LIS), which is connected to the hospital information system (HIS). These technologies, together with the electronic medical record (EMR) system, are of great assistance to laboratory technicians, doctors and patients. During the investigation and research, the employers commonly believed that the ability of students to use information technology should be strengthened at school.

We conducted the corresponding data statistics on the application of network information digital technology during the investigation and research on enterprises. The Standard for Grading Evaluation of Application Level of Electronic Medical Record System (Trial) [17] divides the application

level of EMR system into 9 levels, detailing the requirements of each subsystem of EMR and the whole EMR system of medical institutions. Specifically, level 3 is data exchange between departments; level 4 is information sharing across the whole hospital, which provides support for primary medical decisions; and level 5 is unified data management, which provides support for secondary medical decisions.

The survey shows that the majority of medical institutions at all levels use laboratory information systems (93.2%), hospital information systems (80.8%) and EMR systems (76.7%), which greatly improve medical service ability and are widely recognized by the public (see Table 5).

Table 5: Application of network information digital technology in 128 medical health institutions

Network information digital technology	Number of medical institutions equipped with this system	Proportion (%)
Laboratory information system (LIS)	120	93.75
Hospital information system (HIS)	103	80.47
EMR system with application level 3 and below	34	26.56
EMR system with application level 4	41	32.03
EMR system with application level 5 and above	25	19.53

By interviewing the management personnel of hospital information centers, the following suggestions are proposed for MLT personnel: 1) Strengthen and improve basic computer operation skill training; 2) Propose MLT personnel to better connect the examination business with information systems; and 3) Strengthen education on network security.

With the continuous progress of AI technology, applications of AI services and AI-assisted morphological examination in clinical medical examination are increasing, which significantly enhances work efficiency. Table 6 shows the current applications ready to provide or upgrade AI services in medical health institutions.

Table 6: Application of AI services in 128 medical health institutions

Application of AI technology	Number of medical institutions equipped with this technology (%)	Ready to provide or upgrade (%)
Intelligent selection system of medical advice or clinical decision support	54 (42.19%)	13 (10.16%)
Intelligent sample management	50 (39.06%)	18 (14.06%)
Middleware (Laboman, DM2, Cobas IT3, etc.)	51 (39.84%)	14 (10.94%)
Intelligent interpretation of examination results	48 (37.50%)	19 (14.84%)
Automatic sample sorting line	42 (32.81%)	19 (14.84%)
Automatic check of examination results	42 (32.81%)	12 (9.37%)
Intelligent blood collection management system	37 (28.91%)	18 (14.06%)
Intelligent sample transfer system	33 (25.78%)	14 (14.02%)
Intelligent examination based on graph	33 (25.78%)	15 (11.72%)
AI+ laboratory management (intelligent quality control and patient service)	28 (21.87%)	18 (14.06%)
Development and utilization of big data intelligent scientific research platform	23 (17.96%)	21 (16.40%)

At present, the clinical laboratory relies on manual microscopy for cell morphological analysis. However, manual microscopy is affected by various subjective factors and requires professional laboratory technicians to operate [18]. Moreover, it is often tedious and time-consuming, which is not suitable for large-scale screening. The advent of AI has given a favorable turn to morphological examination. This study conducts a questionnaire survey on the application of AI in morphological examination in 128 medical and health institutions. The results are shown in Table 7.

Table 7: AI-assisted morphological examination items in 128 medical health institutions

AI-assisted morphological examination services	Number of medical institutions providing this service (%)	Ready to provide or upgrade (%)
Analysis of visible components of urinary sediments	77 (60.16%)	7 (5.47%)
Analysis of visible components of excrement	56 (43.75%)	7 (5.47%)
Morphological analysis of peripheral blood cells	53 (41.41%)	16 (12.50%)
Analysis of visible components of vaginal secretions	53 (41.41%)	16 (12.50%)
Analysis of visible components of liquid-based thin layer cells	42 (32.81%)	16 (12.50%)
Semen quality analysis	40 (31.25%)	14 (10.94%)
Morphological analysis of bone marrow cells	37 (28.91%)	18 (14.06%)
Karyotype analysis	35 (27.34%)	14 (10.94%)

The above data reveal that artificial intelligence-aided diagnosis, intelligent morphological recognition, intelligent examination equipment and automatic quality control are being improved and consummated in the field of medical examination against the background of greatly promoting the AI industry. AI has been applied to microbiological examination, chromosome analysis, intelligent cellular morphology recognition, automatic specimen transfer, automatic examination result review and so on. Meanwhile, automatic blood collection robots and automatic examination lines from bacteria isolation to bacteria culturing, staining and recognition. For individual diagnosis, intelligent management and examination data analysis are performed using systems to generate the reference range of individual examination indicators, which helps observe the variation trend of individual examination indicators anytime and provide early warning and intervention [19]. The development and broadened application of AI provide new drivers for medical examinations and boost medical examinations into the new era of "fully automatic equipment + AI". It is recommended to add teaching content relating to the "intelligence" industry into the talent training system, pay more attention to the integration of knowledge from different disciplines and the integration between discipline systems and organize students for relevant practical operations to meet possible changes in the future.

3.4 Vocational Abilities that are Highly Regarded by Teachers

Education shoulders the mission of nourishing and promoting human development, which is also the mission of vocational education. Higher vocational education inherently pursues talent with all-round abilities and harmonious development. It has the specific nature of "high skill training", which is achieved jointly by higher vocational colleges and teachers. Therefore, the philosophy followed by vocational colleges

and teachers when developing the vocational abilities of students is the core of "high skill" talent training. The study group also conducted a survey on the understanding of teachers from vocational colleges towards the importance of related vocational abilities to fully learn about the vocational abilities highly regarded by vocational college teachers. According to the statistical results of the special questionnaire survey, "ability to solve practical problems with professional knowledge" takes the largest proportion among all the abilities and qualities to be developed by the students of MLT specialty in the opinion of front-line professional teachers (see Figure 4). The teachers from both higher vocational colleges and undergraduate colleges believe that professional knowledge plays the most important role in talent training.

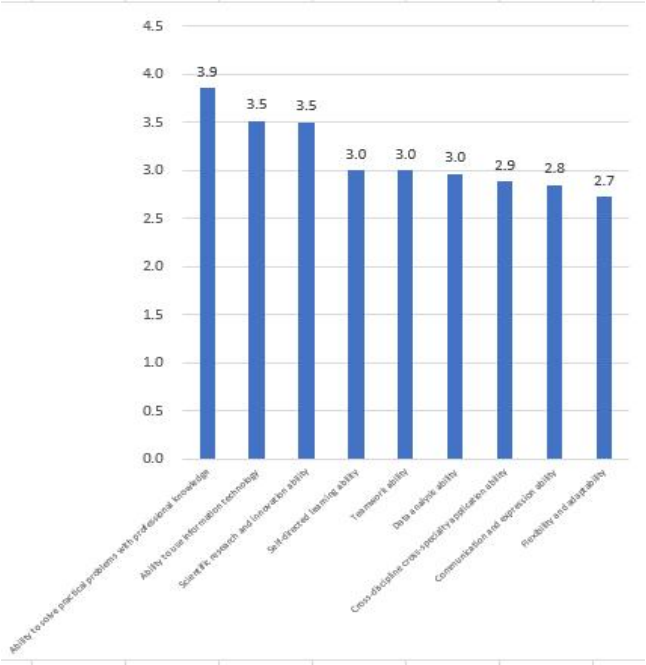

Figure 4: Abilities highly regarded by teachers during talent training

Scientific research and innovation ability is regarded as an important ability. However, the details on how to develop the ability are not given in the talent training plans made by the 25 surveyed colleges. Innovation ability and the design of relevant courses or practical activities are not mentioned in these plans. According to the results of the T test for independent samples, the teachers from undergraduate colleges and the teacher from higher vocational colleges gave different scores in three aspects, including "self-directed learning ability", "data analysis ability" and "cross-discipline cross-specialty application ability". With regard to the understanding of the requirements for these three abilities, the teachers from higher vocational colleges hold significantly different attitudes than the teachers from undergraduate colleges, which may arise from the significant difference in the basic quality of students that the teachers are faced with (Table 8).

Table 8: Different understandings of the teachers towards the training of vocational abilities

	Mean value		Standard deviation		F	P
	Higher vocational college (n=85)	Regular undergraduate college (n=27)	Higher vocational college	Regular undergraduate college		
Cross-discipline cross-specialty application ability	2.752	3.296	5.292	0.548	20.155	0.006*
Self-directed learning ability	2.582	4.296	13.077	3.847	6.895	0.07*
Data analysis ability	2.894	3.185	6.745	2.074	10.793	0.09*
Ability to use information technology	3.623	3.185	5.431	1.817	7.429	0.26
Ability to solve practical problems with professional knowledge	3.870	3.814	8.746	2.881	5.159	0.53
Innovation ability	3.235	4.333	6.403	2.608	2.882	0.128
Teamwork ability	2.918	3.259	5.788	6.148	0.316	0.589
Communication and expression ability	2.753	3.148	6.205	6.189	0.004	0.952
Flexibility and adaptability	2.635	3.000	5.339	2.966	0.468	0.513

Note: ** and * represent the significance level of 5% and 10%, respectively.

By comparing the relevant data, we can easily find the gap between the appeals of enterprises for talent abilities and the vocational abilities highly regarded by teachers during the teaching process. See Figure 5 for details.

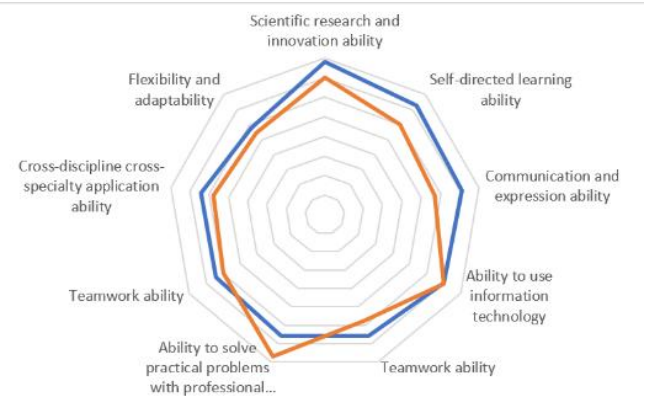

Figure 5: The gap between the appeals of enterprises for vocational abilities of talent and the vocational abilities highly regarded by teachers

4. Discussion

External professions are full of complicated, differentiated and diversified demands, which shows some new requirements for the training of professional talent. The whole industry is changing increasingly faster, and the industry restructuring cycle is becoming increasingly shorter. Technological progress has improved the automation of the medical examination industry, and many posts have been replaced by intelligence. Fundamental changes take place in the types of skilled talent in need. In the adaptation and interaction between higher education institutions and the industry, the integration and matching of their goals will be the foundation of cooperation. We found a difference between the appeals of enterprises for talent abilities and the abilities highly regarded by teachers during the investigation and research. In this sense, the talent training of higher education institutions cannot fully adapt to the actual demand of the industry.

By summarizing the results of the investigation and research, we have thought about the changes in industry development, the problems faced by the current talent training of medical examination vocational education and the abilities to be strengthened during talent training.

4.1 Changes in Industry Development

4.1.1 Trend of building modern comprehensive laboratories

High-grade hospitals, including Grade III Level A and Level B hospitals, are building modern comprehensive laboratories at a very high speed. A large number of automatic instruments and equipment and examination lines have been applied to these modern laboratories, thereby posing a severe test to the education and talent training orientation of MLT specialty. Fewer professionals are needed by examination assembly lines, but the personnel quality will be increasingly higher.

4.1.2 Medical examination equipment shows the development trend of polarization

On the one hand, the construction of large-sized equipment or examination lines is being accelerated to achieve the full automation and high-flux development of the proposed projects. On the other hand, the scope of using small-sized equipment, portable equipment, bedside examination equipment and efficient diagnostic reagents is becoming increasingly wider. High-end examination lines and small-sized household equipment are developing in the same trend, allowing laboratory medicine to provide better services for patients during relative risk evaluation disease diagnosis, disease surveillance, efficacy judgment and prognostic evaluation and transform from treatment to the four functions of prevention, health care, treatment and rehabilitation. These changes lead to higher requirements for the talent structure of MLT specialty and inspire the talent training model of MLT specialty.

4.1.3 Trend of transforming from “passive examination” to “active examination”

With the development and introduction of computer and molecular biology technology, medical examination will transform from the “past” to the “future”. In other words, it will develop from a “passive examination” after the outbreak of disease to an “active examination” for early discovery at the molecular level. Medical examination will explore the early discovery of diseases at the molecular level and start more individualized treatments and individualized drug effect evaluation after treatment. However, these examination items require that MLT professionals have stronger scientific research and innovation ability, communication and expression ability, cross-discipline cross-specialty application ability, etc.

4.1.4 The MLT specialty has become a discipline integrating multiple disciplines

The MLT specialty has become a comprehensive technical discipline integrating the new achievements and new technology applications of immunology, molecular biology, material science, information science and computer technology. “Technology” in the MLT specialty does not simply mean a single discipline; it refers to a combination of multiple disciplines. AI technology has been increasingly used in the medical examination industry. It is an inevitable trend to explore the integration between medical technology and AI during medical education.

4.2 Problems Faced by the Current Talent Training During MLT Vocational Education

The MLT specialty is a traditional medical specialty and has a long education history for technical secondary schools and higher vocational colleges. People prefer to organize courses by taking a discipline as the logic. In the process of talent training for MLT vocational undergraduate education, courses are set by continuing the logics. Therefore, the current curriculum system has many problems in ensuring adaptation to specific posts. The details are given as follows:

4.2.1 Focus on the integrity of disciplines but ignore the adaptation to posts

During the investigation and research, we found that all the schools, including higher vocational colleges and regular undergraduate colleges, have a complete discipline system and relatively sound talent training plans and suffer a very small difference from each other. The teachers preferred to use the designated teaching materials and give lessons according to the relevant regulations. They will not adjust themselves even if some changes take place in the industry. Have the current curriculum system, training objectives and training specifications met the job requirements? Any change, for example, the application of automatic instruments and AI technology in the industry, is not involved in the teaching content. Attention should be given to this aspect during the preparation of MLT undergraduate talent training plans.

4.2.2 Focus on practical training and internships and ignore the deep integration between industry and education

MLT specialty is a special kind of technology that takes operations as the dominant trait and organically combines professional tools and technologies with the application of tools to complete tasks. In this sense, it is the whole process of coordinating technologies, projects, processes and qualities.

Automatic instruments have been increasingly used by the surveyed employers, and intelligent information technology has been spread to various medical institutions at different levels. Under such circumstances, employers have expressed some new requirements for talent training. However, neither higher vocational education nor undergraduate education has attached importance to these new requirements. Most of the practical training courses arranged by the surveyed colleges are still manual operations and verification experiments. It is very difficult for practical training courses on campus to synchronize with new clinical technologies and methods due to limited education spending. To solve this problem, the international practice of strengthening the deep integration between schools and enterprises and transferring some courses from campus to production practice is recommended. Many vocational colleges have established industry colleges nationwide in recent years. However, the integration between

colleges and enterprises is still very loose. In most cases, such integration can only be called an "enterprise practice base". Enterprises have not achieved deep integrations with colleges. For the root cause, enterprises cannot obtain direct benefits from cooperation but must bear the time cost and human cost brought by the internships of students. As a result, enterprises are not active enough to cooperate with colleges. Vocational undergraduate education is a new type of vocational education. We are now faced with the great challenge of ensuring an appropriate connection with this type of vocational education.

4.3 Strengthen the Corresponding Ability Training and Improve Adaptation to Posts During Talent Training

4.3.1 Reform the teaching method of practical training courses and attach importance to the training of scientific research ability and self-directed learning ability

Rapid industry development shows increasingly higher requirements for the vocational abilities of medical examination technicians. According to the analysis of questionnaires and interview results, "scientific research and innovation ability" and "self-directed learning ability" to efficiently learn about and master new technologies and new methods are the top abilities required by enterprises for talent.

The survey on teachers obtains the same results. However, there are no appropriate criteria to measure the training of innovation ability. As reflected by the actual implementation of practical training courses in colleges (with the results not revealed), most practical training courses are still verifications and lack exploratory content, which is an unfavorable factor for developing the innovation ability of students. As a result, students cannot complete conventional operations during practical work and feel confused when facing new technologies and new methods at work.

All vocational education teachers should gain a full and deep understanding of the current changes in the industry and adapt themselves to the new situation by updating the teaching content, mode, method and means for talent training. Personal quality training is a comprehensive and complex process, and personal comprehensive quality cannot be improved only by giving theory lessons and learning more professional knowledge.

Medical examination is a comprehensive specialty. Therefore, students should be provided with more opportunities for practice, and more exploratory practical training programs rather than verification practical training programs should be designed in the curriculum system to steadily improve the ability of students to solve problems. The training of scientific research ability cannot be completed in a single effort. It is recommended to design some small study tasks, guide students to participate in these tasks, inspire their interest in scientific research and imagination, direct them to develop the thinking of scientific research step by step and finally improve the adaptation of talents to posts. In the process of talent training, efforts should be made to improve the self-directed learning ability of students. While giving lessons, teachers should scale up self-directed learning. Different teaching media, such as microlectures and MOOCs, are recommended. In addition, conductive teaching, problem-based teaching and interactive teaching can be used to guide students to fully absorb and understand knowledge and develop their self-directed learning ability, comprehensive analysis ability and problem-solving ability. Furthermore, we should heighten the principal status of students in the process of learning, reform the traditional teaching evaluation system and guide students to independently monitor and evaluate the effectiveness of self-directed learning. It is essential to achieve self-directed learning and improve self-directed learning ability with the help of teachers.

4.3.2 Focus on the training of interpersonal communication ability

"Being patient-centred" is the advanced philosophy of the health field in the 21st century, which is marked as a great breakthrough for the "specimen-centred" laboratory model [20]. Medical examination requires examination technicians to not only communicate with clinicians but also directly interact with patients, tangibly realizing the humanized medical model. According to the results of the investigation and research, the ability to communicate with clinicians and patients is regarded as an important ability for medical examination technicians based on questionnaire feedback and interviews. The patient-centred medical service philosophy is being recognized by the world. Patients shoulder a heavier responsibility for their own health and involve themselves in making decisions on disease diagnosis and management [20]. Laboratory medicine must accept such changes and realize three-party cooperation with patients and clinicians using clinical laboratory services. Both the questionnaire feedback and interview results reveal that the interpersonal communication ability of students is highly regarded by enterprises. Three of the four problems that should be solved according to the interview information are related to "interpersonal communication". However, teachers have not taken it as an important vocational ability according to the feedback of the survey on front-line teachers. By sampling the relevant talent training plans, we found that the training of this ability is not reflected in these talent training plans. We have not discovered any corresponding course or corresponding practical activity in the process of talent training. More attention should be given to this aspect in subsequent course reform.

Some courses on medical humanity, such as Medical Ethics, Medical Psychology, Philosophy of Medicine, Medical Sociology and Medical Logic, should be added to the process of talent training. Meanwhile, priority should be given to the training of interpersonal communication ability. It is also recommended to cooperate with the industry, accept clinical examination professionals to jointly create teaching scenes with course teachers, make every teaching step as real as the actual work process, help students deal with practical work as early as possible and achieve an effective connection between the teaching process and production process. "Role play", case analysis and other methods can be used to help students simulate clinical applications based on actual clinical problems and teach students how to solve problems in a timely and effective manner.

5. Conclusion

Vocational undergraduate education is a new educational level in China. The MLT specialty is a traditional medical education specialty. With the rapid development of the medical examination industry, all educational workers should carefully study how to make better use of vocational education in the new teaching form and train eligible and suitable personnel for the industry. To make progress in a new type of education, we must obtain a comprehensive understanding of market demand, reform some traditional teaching philosophies, focus on market demand, ensure that talent can better meet market demand and reduce structural unemployment during employment.

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Authors' Contributions

NNZ and RZ designed the trial and drafted the article. ZZL obtained research funding and organized the interview. WQ analyzed the data and organized the data records. LM and DZ organized the interview and the data records. RCL provided design ideas and supervised the overall trial process. All authors proofread and approved the manuscript.

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Declarations

Ethics approvals and consent to participate

This study was approved by the Ethics Committee of Guiyang Healthcare Vocational University. All methods were carried out by related guidelines and regulations. All participants provided the informed consent form before completing the questionnaire.

Consent for publication

Not applicable.

Competing interests

The authors declared no conflicts of interest.

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