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Exploration and Thinking on the Information Construction and Management of the Military Key Laboratory

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Informatization is the core of modern military development. It is necessary to pay attention to and strengthen the informatization construction of military key laboratory to win the information war. Based on the analysis of the traditional management mode of laboratory and its disadvantages, combined with the practice and exploration of information construction and management of military key laboratory of military underground construction engineering in recent years, this paper comprehensively analyzes and deeply discusses the achievements and experience of laboratory in information construction and management, as well as the existing problems and lessons. Practice shows that the laboratory has made significant progress and benefits in the information construction and management, but there are still some contradictions and problems to be solved.

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1. INTRODUCTION

The construction level of laboratory is one of the important evaluation indexes of teaching and scientific research level in military colleges and universities, and its informatization construction is just the scientific research guarantee for the current military to vigorously develop the information war [1]. Therefore, in the evaluation standard of military key laboratory [2], there is a special three-level index of "informatization management", and it can be seen that its importance is indispensable.

Relying on the "Military Key Laboratory of military underground construction engineering" (hereinafter referred to as "MKL") of the Army Logistics Academy, it mainly carries out scientific research and teaching in four main directions: engineering repair and construction technology and equipment, national defense engineering camouflage and protection, geotechnical mechanics and underground engineering, special soil and foundation treatment. However, in 2009 a, the academy mainly focused on the overall relocation of the new campus in the university area of Chongqing city of China and paid insufficient attention to the laboratory evaluation preparation (especially the information construction), resulting in the unsatisfactory evaluation results in 2010. In 2011 a, with the high attention of the leaders of the standing committee of the academy, the leaders at all levels of the department of civil engineering and all the laboratory staff overcame difficulties after careful preparation, we finally succeeded in keeping the brand of "military Key Laboratory" which was hard to obtain at the most critical moment.

For many years, the construction and management of military key laboratories are restricted by the need for confidentiality, relatively closed operation, and the influence of traditional management thinking. They are used to following the traditional mode for many years, its construction and management is more and more not adapt to the point of the higher education law and characteristics of the resulting laboratory management efficiency, effect and low benefit, resource closeness of highlights, the laboratory has started to research and develop information management system (LIMS) for military key laboratories [3-8]. By using modern management concepts and information network technology, the laboratory has actively explored and practiced in laboratory information construction and management to achieve the goals of efficient operation, resource opening and sharing, serving the army and economic and social development [6].

With the rapid development of information technology, the information construction and management of military key laboratories of Chinese military academies have attracted more and more attention [9-33]. However, due to the constraints and restrictions of various confidentiality provisions, its information construction and management level need to be greatly improved. Therefore, the Military Key Laboratory managed by the author has made some beneficial practice and exploration in the past 10 years. We have taken the initiative to get rid of the influence of the traditional way of thinking, vigorously reformed the management mode, and achieved some remarkable laboratory construction and management benefits. However, there is still a big gap from the target, and it is necessary to continue to strengthen the reform, this paper summarizes and reflects on this, in order to point out the direction for the future laboratory information construction and management.

2. TRADITIONAL MANAGEMENT MODE AND EXISTING PROBLEMS OF MILITARY KEY LABORATORY

2.1 Traditional Management Mode of Laboratory

For a long time, the traditional management mode of military academy laboratories has been adopted in the archives, personnel information, scientific research projects, experimental teaching, experimental equipment (software) and other aspects, such as the Military key laboratory of military underground construction engineering. Until the overall relocation of the new campus of the university town in 2009, the traditional construction and management mode has been adopted. The traditional management mode, for the need of confidentiality, based on the relatively rigid, closed and conservative management idea, mostly adopts manual or stand-alone operation, and its efficiency and benefit can be imagined. It can be said that it has been staying at a low level, greatly affecting the

improvement of laboratory management and operation ability.

2.2 Major Problems Exist

(1) The basic information is not updated in time or lags behind

Laboratory management is facing the problem of information explosion. Various types of data and information accumulate over time. These data and information are extremely complex, and the cost of maintaining human, material and financial resources becomes more and more unbearable. In the past, the laboratory mainly relied on manual statistics to grasp the relevant information, and the change of information is real-time, which inevitably leads to the problem of information lag. At the same time, manual statistical processing of information, there are low efficiency, error prone, difficult data analysis and other issues. It can be seen that the traditional management mode of the laboratory can hardly grasp the real-time dynamics of the laboratory, and it is difficult to achieve an efficient laboratory management level.

Taking the management of laboratory archives as an example, it has the characteristics of wide variety, large quantity and complex content, including 4 items, 10 sub items and 30 sub items of laboratory evaluation index system. The first-class laboratory is indispensable for the first-class military school, and the first-class laboratory largely depends on the systematic accumulation, sorting and filing of laboratory archives. Information processing and scientific management of archives play an important role in the efficient operation of laboratories and the evaluation of key military laboratories. However, the traditional management mode is difficult to realize the informationization, dynamic construction and management of archival data [9,25-30].

(2) Missing dynamic management of instruments and equipment

There are many types and quantities of instruments and equipment, but they are still in stand-alone operation mode, without intelligent automation functions, and their utilization rate and experimental efficiency are low [10]. This is far from meeting the development requirements of information technology. The use efficiency of large-scale equipment is low, similar equipment is purchased repeatedly, the maintenance of equipment lags behind, the distribution of maintenance funds is unreasonable, and the funds are not spent on the blade and so on [11].

(3) Lack of dynamic management of personnel

The degree of refinement of the laboratory is too high, the staffing structure is unreasonable, and the technical personnel lack effective communication, which limits the development of their business level. At the same time, the degree of informatization cognition of laboratory personnel is uneven, the enthusiasm of the laboratory information construction is not high [6,11].

The traditional management mode of laboratories makes it difficult to grasp the specific conditions of the experimenters, such as the time of the experiment, the location of the experiment, and the usage of the experimental equipment. Especially for some large-scale experiments, the operating costs of experimental materials and equipment are high. At this time, the traditional personnel management mode cannot dynamically grasp the experimental time and equipment usage, and it is difficult to manage the experimental cost rationally, and it is easy to cause unnecessary waste [11].

Therefore, it is necessary to establish the dynamic information management of the personnel, to grasp the experimental status of the laboratory personnel in time, so as to further improve the overall operating efficiency of the laboratory.

(4) The experimental teaching mode is mainly "hand in hand"

At present, the "hand-in-hand" nanny-style experimental teaching is mainly conducted by teachers, which imbibes students' creative thinking and exploration spirit. There is a disjointed phenomenon in time and content between theory course teaching and experimental course teaching. Most of the experimental projects are for verification, while the comprehensive, independent and innovative design experiments are not enough. The experimental practice projects cannot keep up with the development of modern science and technology application, weapons and equipment and protection technology.

The laboratory operation management model is outdated. The current operating mode of the laboratory is mainly based on planned experimental teaching, and the courses are

arranged in "one pot" in units of period or classes, ignoring individual differences such as the knowledge base and accepting ability of the students; Although the open operation can be achieved in some periods of time, the form of open operation is greater than the actual effect because the characteristics of centralized management of military students are not considered. In terms of experimental equipment management, the application of components and equipment, storage and warehousing are still mainly managed by manual paper, which greatly reduces the use efficiency and teaching benefits of experimental instruments and equipment.

(5) The effect of website construction is not obvious

At present, the laboratory's website is static webpage and mainly used to display laboratory information, and the connection of information at the upper and lower levels has not yet been achieved. The website information has hardly been updated, for example, it is impossible to display equipment occupation information in real time on the website. Dynamic management function is a key function that must be considered in the construction of information laboratories, especially for open laboratory [12,13,33]. Equipment conditions and experimental items are placed on the internet, and the equipment occupancy status is updated online in real time, so that students (or users) can understand the situation of the laboratory, so as to be well prepared, orderly and open without disorder. Otherwise, the opening will only make the laboratory work in chaos or become a piece of paper. Because the functions of university laboratory are complex and there are many kinds of information, this paper takes university laboratory website as an example to discuss the construction requirements for reference.

3. PRACTICE AND EXPLORATION OF LABORATORY MANAGEMENT INFORMATIZATION

In the face of the problems existing in the traditional laboratory management mode, we must deeply analyze the problems from the source, combine with the information technology of the new era, and use the idea of reform and innovation to open the management and construction path of the laboratory in the new era [12], aiming to build a Military Key Laboratory with distinctive professional characteristics, reasonable structure of experimental talents, rich and shared experimental resources in military colleges and universities.

In order to ensure the effectiveness of laboratory information construction, it is necessary to combine with the actual situation of the Military Key Laboratory, from the aspects of personnel training, experimental research, system mode innovation, rational use of resources and so on, to carry out laboratory information construction and improve the operation efficiency of the laboratory.

3.1 Target Traction and Functional Requirements

Set the goal and the direction of efforts, that is, the introduction of modern management concept, the implementation of the Military Key Laboratory information construction and management strategy, to maximize the efficiency and benefit of the laboratory construction and management. In order to achieve this ambitious goal, it is undoubtedly necessary to make full use of modern information technology conditions, build a military underground construction engineering Military Key Laboratory information management system based on the campus network of the academy, and conduct network management of laboratories, instruments and equipment.

3.2 Construction of Laboratory Information Management System

The laboratory information management system is a set of system which combines information technology and laboratory management and relies on database operation. It mainly includes human resource and organization management, instrument and material management, quality and safety management, information and data management.

The information management system of military key laboratory of military underground construction engineering is developed based on. Net platform (three-tier system architecture). In order to realize the purpose of information-based experimental teaching, real-time status feedback of experimental instruments, and automatic generation of various experimental report statistics, three modules (Fig. 1) are mainly designed, namely teaching module, instrument module and laboratory management module [8][14]. Through the information connection and linkage management in the module, a more comprehensive LIMS was established, and the laboratory resources were fully utilized.

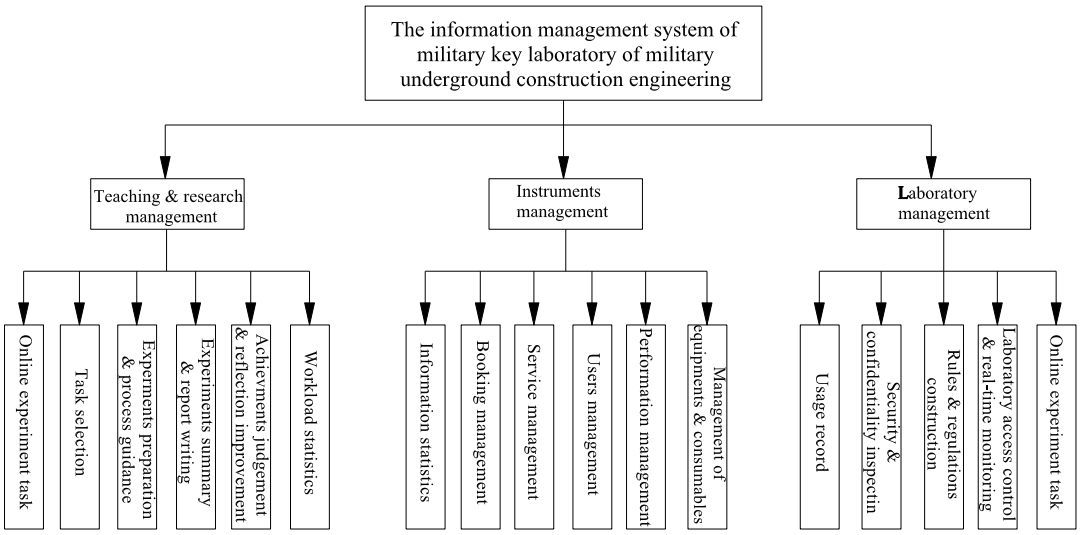


Fig. 1. The structure chart of the information management system of military key laboratory (Modified of [14])

3.3 Build a Large-scale Instrument and Equipment Informatization Sharing Platform

On the one hand, the resource sharing of large-scale instruments and equipment is to open the high-quality, precise and cutting-edge instruments and equipment owned by the laboratory to China through certain paid use; On the other hand, the related information of instruments and equipment is released on the Internet. The purpose of resource sharing of large-scale instruments and equipment is to improve the use efficiency, allocate scientific and technological resources reasonably, and establish a shared operation mode.

In order to strengthen the information management of large-scale instruments and equipment, make full use of the existing instruments and equipment resources of the Military Key Laboratory, avoid repeated construction and decentralized investment, strictly control the source of large-scale instruments and equipment purchase, improve the multi-party benefits of large-scale instruments and equipment, and realize the sharing of scientific and technological resources, after the deliberation of the laboratory working committee, the "management measures for large scale instruments and equipment (Trial)" [15] was adopted, and all laboratory instruments and equipment information meeting the sharing conditions were included in the supporting unit and Chongqing large scale instruments and equipment resource sharing platform for opening to the outside world.

The large-scale instruments and equipment are opened according to the appointment mode, and the workflow [15] is as follows: the applicant puts forward the application → the instrument management unit accepts the application → arranges the time and place of use → the applicant sends the sample for testing or operates by himself → issues the test data → the management personnel confirm the completion of the experiment.

The "Instrument and equipment management system" (Fig. 1) is established in LIMS. The laboratory should fill in the basic information of the instrument and equipment within 10 days after the equipment is put into use, and report it to the large-scale instrument and equipment management center for entry into the management system. When applying for the use of large-scale instruments and equipment, the user shall make an appointment application through the management information system, and after acceptance, the user shall use the instruments and equipment at the agreed time.

At the same time, we also set up an open fund for large-scale instruments and equipment [9][16], which is mainly used to subsidize the test cost of large-scale instruments and equipment in the Academy when they are open to use.

4. ACHIEVEMENTS OF INFORMATIZATION CONSTRUCTION OF MILITARY KEY LABORATORIES

4.1 Significantly Improve the Efficiency of Laboratory Management and Operation

In the past few years, the information construction of Military Key Laboratory, through several years of experimental teaching and the practice of scientific research personnel engaged in experiments, it is found that the construction of laboratory information management system has many advantages that the traditional laboratory management mode does not have. It is embodied in the following aspects:

(1) It can effectively improve the accuracy of experimental data statistics and avoid the error prone problems of manual statistics;

(2) The real-time performance of experimental data can be effectively guaranteed, and the real-time monitoring and metadata modification can be carried out in the experimental management system, which greatly improves the experimental efficiency [3];

(3) It replaces manual operation in many ways to improve efficiency, and at the same time, it makes use of the advantages of information technology to open and share experimental resources and data, so as to eliminate the unreasonable allocation and waste of human and material resources [17];

(4) Multi-dimensional improvement of laboratory management ability, real-time control of experimental resources, rationality of work decision-making, high quality of teaching and scientific research services, and accuracy of financial check accounts are quite effective, which makes the Military Key Laboratory more standardized and scientific [17].

(5) Dredge the user communication channel of experimental instruments and equipment. When the user has used the instruments and equipment, the system will authorize the user to add the function of using experience, so as to facilitate the user to understand the important information such as the precautions of using the instruments and equipment as soon as possible, and provide a targeted communication platform for the user. The utilization rate of large-scale instruments and equipment has increased from 35.8% in 2010 to 68.3% in 2020, nearly doubling.

To sum up, the laboratory information management system makes the structure of experimental resources optimized, the degree of opening and sharing high, and significantly improves the laboratory management level and operation efficiency [6].

4.2 Joint Dynamic Management of Experimental Operators and Experimental Equipment

The time parameter is introduced into LIMS to establish the dynamic relationship between the experimental operator and the experimental equipment. The first is to determine the physical space of experimental operators and experimental equipment at the same time, so as to determine the relationship between them and master the laboratory dynamics more comprehensively; The second is to determine the operating instructions of the experimental operators and the real-time data of the experimental equipment at the same time, so as to facilitate the review of the experimental results after the experiment; The third is to establish real-time laboratory management combining dynamics and statics, in order to improve the efficiency of laboratory management and operation [11].

4.3 Strengthening Laboratory Management Based on Data Analysis

(1) By sorting and analyzing the data of the laboratory information management system over the years, we can master the operation law of the laboratory and the change law of the state of the experimental equipment. It is convenient to plan the future operation direction and focus of the laboratory, so as to effectively improve the management and operation efficiency of the laboratory [11].

(2) The continuity of data management in laboratory information management system makes up for the shortcomings of incomplete data management and easy loss and omission in traditional laboratory management mode. The integrity and continuity of the data provide a strong guarantee for the meticulous and efficient management of the laboratory [11].

(3) Provide efficient and benefit evaluation. Through the statistics and common functions of the utilization rate module of large instruments and equipment, and the statistics of the papers,

patents and awards related to large instruments and equipment, it provides basic data for the reporting of the use data of large instruments and equipment. Scientific statistics on the benefit of instruments and equipment will stimulate the enthusiasm of administrators and further improve the sharing degree of instruments and equipment [4].

5. REFLECTION ON LABORATORY INFORMATION CONSTRUCTION AND MANAGEMENT

5.1 Reflection No. I: the Problem of Informatization for Informatization's Sake

(1) The necessity of laboratory information construction

The construction of laboratory informatization not only promotes the change of laboratory management methods, but also enriches the work contents and forms of laboratories. After the establishment of information management system in Military Key Laboratory of military underground construction engineering, its advantages of network combination, open sharing and modern management have effectively improved the management level and operation efficiency of the laboratory [18].

(2) The purpose and means of laboratory information construction

The purpose of laboratory information construction is to achieve efficient and standardized laboratory management, grasp the dynamic data of the laboratory, understand the law of laboratory development, and improve the utilization rate and openness of instruments and equipment [19]. The innovative spirit and subjective initiative of experimental operators should be mobilized fundamentally to improve the academic research ability of teachers and students in military underground construction engineering [20].

The information management system platform of Military Key Laboratory has been built into a powerful and interactive dynamic website composed of "laboratory course selection system", "inquiry system", "integrated management system" and "learning garden" from the initial static website. The interactive dynamic website realizes network management and improves laboratory management and operation efficiency [19].

(3) The content of information construction

The information construction of military key laboratories has a wide range of contents, including at least eight elements: the application of information technology in laboratories, laboratory information resources, laboratory information network, laboratory information technology development, laboratory information policies, regulations and standards, innovative laboratory theory, establishment of laboratory system adapted to information technology, and establishment of laboratory information system Laboratory construction, information technology talents, etc. [5][6][21].

The key of laboratory information construction is mainly talents and infrastructure. Regarding the construction of infrastructure, only by earnestly implementing the deepening application of military laboratory information system and using advanced software system to make the laboratory information system easy to operate, easy to manage and easy to maintain can the laboratory management and operation efficiency be effectively improved. It is necessary to recruit high-quality laboratory technicians, train the existing laboratory personnel, and improve the rationality of personnel structure.

In the information platform of instrument and equipment, it should also be incorporated into the functional modules of instrument and equipment condition maintenance and repair according to the actual situation, so as to effectively contact the person in charge of instrument and equipment, the administrator of instrument and equipment, the director of laboratory, the personnel of maintenance management unit, and the repairer.

(4) Informatization standard of Military Key Laboratory

The establishment of laboratory information standard is the key point of laboratory information construction and management [21]. Only by establishing a unified and perfect standard can we provide strong technical support for the realization of laboratory information management, thus improving the management efficiency of the laboratory and the openness and sharing degree of experimental equipment.

Based on the experience of the traditional management mode of the laboratory, the information construction is carried out in a

targeted way and the unified standard of information construction is standardized.

5.2 Reflection No. II: How to Evaluate the Benefits of Informatization Construction and Management

Taking the benefit evaluation of large-scale instrument and equipment sharing platform as an example, the benefit management module was added in the process of building the platform. It can realize convenient and dynamic understanding of the use efficiency (see Fig. 2) and benefits (see Fig. 3) of instruments and equipment at any time, such as papers, patents, awards based on large-scale instruments and equipment, equipment use time, equipment status, equipment maintenance, etc. Utilization rate is one of the main indicators to evaluate the management level of large-scale instruments and equipment. The academy should also evaluate the performance of units and individuals according to the utilization rate, so as to promote the sustainable development of the sharing platform. The main functions of benefit management module of large-scale instrument and equipment sharing management platform include benefit basic information management and benefit information statistics management.

5.3 Reflection No. III: Development of Laboratory Information Construction and Management

(1) Introduction of modern enterprise management concepts

The construction of Military Key Laboratory information management focuses on learning from modern enterprise management ideas and processes, adjusting resource allocation structure, combing and analyzing experimental teaching mode, experimental equipment management mode and experimental personnel training mode, strengthening the control of laboratory management nodes and establishing relevant requirements and regulations. Through the implementation of management methods such as experimental duty, experimental log, and experimental inspection, the management and operation efficiency of the laboratory has been effectively improved [20].

(2) Establish regional laboratory alliance or professional laboratory alliance

The laboratory alliance is based on the purpose of promoting innovation-driven development, based on the development needs and common interests of key laboratories, with the goal of promoting mutual coordination and supporting and leading roles, and building a high-level exchange and cooperation and open innovation service platform. The main body, guaranteed by contract, is an open consortium of non-profit and unincorporated nature, a scientific and technological innovation cooperation organization that shares resources, complements each other's advantages, collaborates and seeks mutual development. Its composition is not limited to military key laboratories, but can be expanded to include national laboratories, key laboratories, national engineering centers, provincial and ministerial key laboratories, engineering technology centers, collaboration centers and other units to form regions (such as university towns) Laboratory alliances, similar professional and interdisciplinary (field) laboratory alliances, promote resource sharing, complementary advantages, exchanges and cooperation. It is the strategic positioning of the laboratory alliance to provide a multi-disciplinary and multi-level innovation platform for the laboratory in the professional field of underground engineering to promote the vigorous development of the professional field.

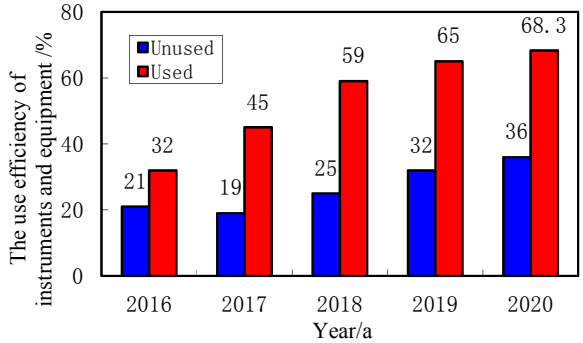
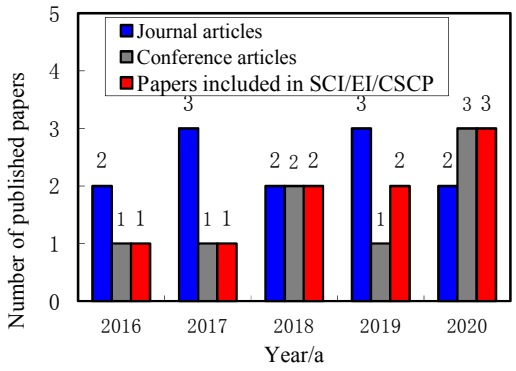
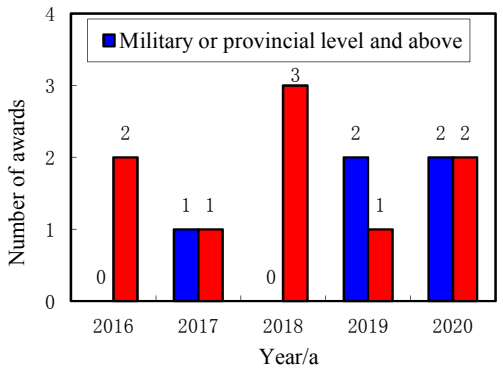


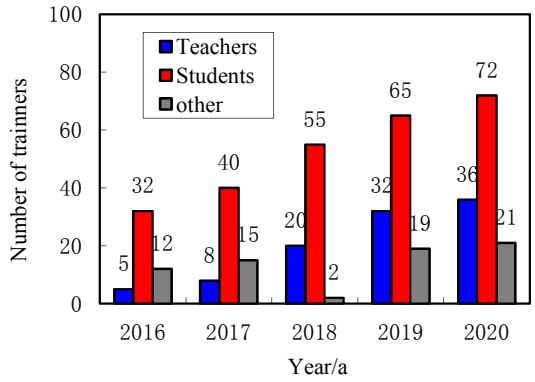
Fig. 2. The use efficiency of large-scale instruments and equipment



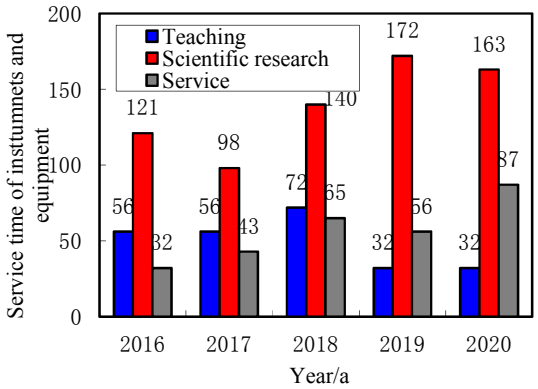
（a）Number of published papers



（b）Number of awards



（c）Number of trainers



（d）Service time of instruments and equipment

Fig. 3. Benefit of Representative Instrument and Equipment (SHPB)

(3) The concept of refined and digital (quantitative) management

Everything in the world must be done in detail. The so-called quality comes from delicacy, and the details can reflect the management advantages of the laboratory. Therefore, the improvement of laboratory construction and management efficiency comes from fine management, especially for information construction, because of the accuracy of information requirements, it is urgent to introduce the concept of refined management [22]. The data management of laboratory information management system is reliable and efficient, which can greatly improve the fairness of laboratory evaluation. The long-term accumulated database of the laboratory can achieve quantitative management, thus improving the management and operation efficiency of the laboratory.

(4) Virtual simulation laboratory

The application of virtual simulation technology in the laboratory information construction is becoming more and more mature, which greatly enriches the traditional experimental teaching and provides certain convenience for scientific research and academic work. Through virtual simulation, students can have a more intuitive and clear understanding of the relationship between theoretical difficulties and experimental practice in the experimental classroom, so as to master the theoretical difficulties through experiments [23].

(5) LIMS based on Internet of things and cloud computing

The combination of laboratory information construction with Internet of things and cloud computing, using the excellent computing speed and capacity of cloud computing technology, can provide a powerful backstage guarantee for the data management of the laboratory [10], at the same time, it can reduce the system hardware investment of the laboratory, strengthen the opening and sharing of experimental information resources, improve the security of laboratory management data and equipment operation data, and improve the experimental teaching management and students' experimental practice effect [24].

5.4 Reflection No. IV: How to Implement Laboratory Informatization Construction Strategy in a Practical and Realistic Way

Strategy is to solve a certain problem or achieve a certain goal with overall and fundamental ideas, decisions, approaches, methods and steps. The reason why laboratory information construction and management are raised to the height of strategic thinking here is a profound consideration. That is to adapt to the changes of the information age and the information requirements of the progress of science and technology as much as possible, instead of informatization for the sake of informatization, closely combine the characteristics of the military laboratory, find out the direction of laboratory management and development, formulate scientific and reasonable information construction and development strategy, and based on the information thinking concept and information technology, incorporate information technology into every detail, step and key point of laboratory construction and management, formulate a complete and scientific series of measures, plans, methods and means according to local conditions, incubate and construct the core culture of the laboratory, and realize the sustainable development of laboratory information construction and management [22].

6. CONCLUSION

In the era of digitalization, network and information, the information construction and management of Military Key Laboratory is the premise of realizing modern laboratory teaching, scientific research and military or services social service. To a great extent, the informatization level of laboratory can reflect the innovation standard and management operation ability of laboratory.

(1) The laboratory portal website has been established to integrate information release, collection, management, sharing and other functions to meet the needs of information management. It realizes the information management of teaching, scientific research and daily office, such as document information release, postgraduate information collection, scientific research and academic information collection, laboratory equipment management, etc. Through the laboratory portal website, as well as the linked military, college digital library website, professional website of various disciplines,

we can realize the sharing of literature resources, scientific research data resources, experimental data resources, online booking of experimental arrangement and other functions. Combined with the construction of digital campus, the information management system was upgraded in time.

(2) Through the construction and practice of the management information system of the Military Key Laboratory based on the campus network, the utilization rate and openness of the experimental equipment are improved, the students' sense of experience in the experimental classroom is enhanced, and the laboratory management efficiency and benefit are improved, It basically realized the sharing of large-scale equipment resources, saved the cost of laboratory management and maintenance, trained the laboratory management team, and realized the leap forward development of laboratory information construction and management. These beneficial exploration experiences are worthy of reference by the National Engineering Center and other key laboratories of the Army Logistics Academy.

(3) Since the start of laboratory informatization construction, although some achievements have been made in laboratory informatization construction and management around experimental classroom, equipment opening, scientific research innovation, army (or social) services, team construction and other aspects, there are still some problems, which need further research countermeasures and measures. At the same time, we also deeply realize that the information construction and management of military key laboratories need long-term unremitting persistence and efforts.

(4) We need to deeply realize that informatization is the informatization based on scientific management, otherwise it can only be water without source and a tree without roots.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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