

Establishment and Consideration of Large-scale Instrument Innovative Sharing Platform

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Abstract: The large scientific and innovative instrument sharing platform is an important support platform for the construction of first-class universities and talent cultivation. Instrumental analysis center of Qingdao University is a sharing service platform for advanced instruments, which integrates testing inside and outside the university, training of high-end testing talents, demonstration construction of modern laboratory culture and integration. In view of the previous platform management problems and characteristics of large instruments, platform construction and practice work have been carried out, an intelligent management system has been established, and multiple measures have been taken to improve the efficiency of the instrument and the management. The university will comprehensively improve its scientific research capacity and the ability to produce original results, promote talent cultivation, and contribute to the construction of Qingdao University.

Key Words: large-scale instruments; sharing platform; management system; efficiency

1 Introduction

As a powerful support and hardware guarantee for scientific research work in universities, the construction and management of large-scale instrument sharing experimental platforms have always been a key focus of major universities, and have now become an important part and necessary condition for the construction of first-class universities^[1-2]. However, large high-precision instruments have the characteristics of high precision, strict operation, high environmental requirements, and difficult maintenance. Therefore, in addition to investing a large amount of funds to purchase large instrument equipment, it is also necessary to build a high-end platform environment and a scientifically standardized management system to effectively ensure the smooth operation and development of the large-scale instrument sharing platform^[3-4].

In recent years, Qingdao University has established a three-level scientific research platform system consisting of schools, colleges, and research teams to improve laboratory construction and management, promote the sharing and

utilization of valuable instruments and equipment, and effectively reduce duplicate purchases of instruments and equipment. The Analysis and Testing Center is an important part of the construction of our university's innovative three-level scientific research platform system. With the design concept of "technological fashion and people-oriented", we have created a first-class large-scale instrument and equipment public service center, a high-end testing talent training center, and a modern laboratory culture construction demonstration center. The Analysis and Testing Center of Qingdao University was established in 2017. The main construction of the laboratory was basically completed in September 2021, and trial operation began in October. It is located on the first floor of the library at Fushan Campus of Qingdao University, covering an area of over 5600 square meters. It currently has more than 50 sets of large instruments and equipment, with a total value of over 80 million yuan. The Analysis and Testing Center is a high-end testing sharing platform at the school level, with four major testing platforms: electron microscopy analysis, microstructure analysis, composition analysis, and physical property analysis. It

focuses on material surface morphology analysis, microstructure analysis, composition content analysis, and physical performance analysis, and is open for sharing both inside and outside the school, providing testing services. Its goal is to build a large-scale instrument sharing platform that is internationally first-class, domestically leading, and characteristic of Tsinghua University, providing high-level base support for the development direction of our university's advantages and key areas, promoting the construction of first-class disciplines, accelerating interdisciplinary research and the transformation of original high-level research results. However, the construction of the platform is still in its early stages, and its management and maintenance still need to be further improved. Therefore, based on the characteristics of large high-precision instruments, this article takes the Analysis and Testing Center of Qingdao University as an example to explore the construction and management of a large-scale instrument sharing experimental platform.

2 Construction measures for a large-scale instrument innovation sharing platform

2.1 Reasonable layout of instrument procurement and environmental construction

The main task of building a shared platform is to select precise and efficient large instruments and equipment. However, the purchase price of large instruments is expensive and they are updated quickly. Only by establishing a reasonable system and process for instrument procurement can we avoid the dilemma of resource waste or shortage in later applications, and lay a solid foundation for platform construction and operation. Therefore, the selection and purchase of large instruments are key links in platform construction. In order to avoid the problems of low instrument usage or crowded instrument reservation in the construction of shared platforms in the past, and to better build the analysis and testing center, Qingdao University referred to the construction experience of universities such as Tsinghua University, Peking University, Xiamen University, Shanghai Jiao Tong University, and Xi'an Jiaotong University, and also hired Academician Li Jinghong from Tsinghua

University as the director of the academic committee of the analysis and testing center, providing many professional opinions for the center's construction. At the beginning of the platform construction, a demand survey was conducted among the user group to comprehensively consider the needs and practicality of instrument procurement. Experts were organized to demonstrate the necessity of instrument procurement, establish a scientific and reasonable procurement system, investigate the purpose of instrument procurement, applicable objects, model parameter selection, etc., and make records for planned procurement. At present, the shared platform of Qingdao University's Analysis and Testing Center has four major testing platforms: electron microscopy analysis, microstructure analysis, composition analysis, and physical property analysis. It can support the scientific research and testing needs of engineering colleges and various research institutes such as the School of Chemistry and Chemical Engineering, the School of Textile and Clothing, the School of Physical Sciences, the School of Materials Science and Engineering, the School of Environmental Science and Engineering, and the School of Life Sciences. It can conduct comprehensive analysis, testing, and characterization of the morphology, structure, properties, composition, content, and application of chemical materials, energy and environmental materials, functional textile materials, biomedical materials, sensing materials, etc. At present, there are more than 50 sets of large-scale instruments and equipment, including field emission scanning electron microscopy, transmission electron microscopy, atomic force microscopy, XRD single crystal diffraction analyzer, XRD powder diffraction analyzer, nuclear magnetic resonance spectrometer, gas chromatography-mass spectrometry, liquid chromatography-mass spectrometry, electrochemical analyzer and other professional equipment, providing high-level technical support for all teachers and students in the school, promoting the output of high-level original achievements, and also providing strong scientific research guarantee for the construction of "double high". In addition, high-precision large

instruments often require special environments to ensure stable operation, such as controlling temperature and humidity, cleanliness, dust, static electricity, voltage, etc. This requires hiring a professional laboratory design team for specialized design work. Therefore, in order to build a "fashionable, environmentally friendly, and safe" laboratory, provide personalized operating environments for each large instrument and equipment, maintain cleanliness and temperature and humidity, it is necessary to establish a comprehensive and complete platform layout and environmental system design concept from the beginning of platform construction. The Qingdao University Analysis and Testing Center platform has arranged the placement of pre purchased instruments in a reasonable manner based on the distribution of sub platforms and instrument classification. The platform is divided into three zones A, B, and C from the outside to the inside, and the office and data processing area, sample pre-processing area, and large instrument placement area are arranged in sequence from zone A to zone C. This layout effectively controls the flow of people in the large instrument area and improves usability. At the same time, the platform sets up the environmental system based on the characteristics of the instruments and establishes a high standard intelligent laboratory system. The system includes an air-cooled heat pump monitoring system, a gas monitoring system, and a pure water monitoring system, which can monitor the temperature, humidity, gas pressure and leakage situation, pure water data, etc. of each large instrument room in real time. Good environmental protection not only maintains the instrument in good operating condition and enhances user experience, but also reduces the risk of damage and maintenance costs.

2.2 Strengthen the platform's external publicity work

The establishment of a large-scale instrument sharing platform in universities has incurred huge costs, but many students and teachers are often unclear about the services that the platform can provide or even unaware of its existence, and are still struggling to find resources outside the campus. This

problem often stems from insufficient publicity work. At the time of rapid development of informatization construction, the large instrument sharing platform of the Analysis and Test Center of Qingdao University adheres to the concept of open sharing, actively publicizes the construction and development of the platform and bookable instrument information^[7] by using the analysis and test center platform website, WeChat communication group, official account and other media means, and continuously updates the technical training lectures, original major achievements, and technological frontiers to promote zero distance communication between the platform and users, so that more students and teachers can understand the instruments and technical support that the platform can provide, better help scientific research needs, and maintain the smooth operation of the sharing platform. A stable user base is the finishing touch of platform operation. Without a continuous stream of users, platform instruments will ultimately become cold instruments, resulting in resource waste. The Analysis and Testing Center of Qingdao University actively promotes itself to the outside world. Currently, it has received visits and exchanges from 18 colleges and research institutes of science, engineering, and medicine on campus, as well as government agencies and institutions such as the Qingdao Science and Technology Bureau, peers from universities such as Ocean University of China, Qingdao University of Science and Technology, Shandong University of Science and Technology, and high-tech enterprises such as Shandong Jingbo Petrochemical Co., Ltd. and Qingdao High tech Testing Technology Co., Ltd.

In order to better cultivate the skills of technical teams and users in operating large instruments, stimulate interest and innovation ability, the Analysis and Testing Center and Graduate School cooperated with Qingdao Shenghan Chromatography Technology Co., Ltd. to hold the "Shenghan Cup" Qingdao University First Graduate Large Instrument Skills Competition and Qingdao University Experimental Teachers First Large Instrument Operation Skills Competition. In addition,

the platform should regularly organize user communication meetings to listen to user feedback, improve platform quality, and promote the smooth operation of the platform. At the same time, in terms of international exchanges, Professor Alexander from the University of Houston in the United States was invited to our university's Analysis and Testing Center for exchange visits and academic presentations on photoacoustic imaging technology; Hitachi Scientific Instruments (Beijing) Co., Ltd. has established a joint laboratory with the Analysis and Testing Center of Qingdao University, and conducted specialized training on electron microscopy applications at the center.

2.3 Establishing a professional technical team

Large instruments are highly specialized and complex, and in order to maintain their good operation and use, they must be managed by professional personnel. Therefore, building a high-quality and specialized technical service team is the core to ensure the smooth operation of the open sharing platform for large instruments. At present, the platform team has teachers from different colleges and disciplines, and the crew leaders are all doctoral students with certain research and instrument usage foundations. The technical team members not only complete instrument maintenance and operation skills training, but also assist users in better applying large-scale instruments to complete research projects, improve experimental methods, and promote the output of innovative and original results. Each team member is responsible for fixed large instruments and equipment, and each large instrument and equipment is jointly supervised by three team members. At the same time, the skill level of the team's technical personnel is crucial for the development of the platform. Therefore, the platform attaches great importance to the skill improvement and training of technical personnel, requiring them to be familiar with the principles and cutting-edge applications of the instruments. Relevant personnel are organized to take turns visiting large-scale instrument sharing platforms in various universities to learn successful experiences and solve development

bottlenecks.

Although the technical team is facing the problem of insufficient staffing with the expansion of the platform scale and the increase of large-scale instruments and equipment, the platform is actively recruiting and trying to introduce outstanding teachers from schools as part-time management platforms to assist the platform in completing training, management, and testing work, maintaining the effective operation of the platform, and has achieved initial results.

3 The management system and practical effectiveness of the innovation sharing platform for two large instruments

3.1 Training and Assessment Management

Large high-precision instruments have strict operating requirements due to their high precision, so it is necessary to ensure that users have the qualifications to operate them. Firstly, the platform technology team has developed the "Standard Operating Procedures for Instruments of Qingdao University Analysis and Testing Center" for users to learn and refer to. Large instruments generally have multiple operating steps and precautions during use. If not taken seriously, it can result in experimental failure or even damage to the instrument or personal injury. Therefore, compiling a concise and easy to understand manual with strong operability can not only be used for training and teaching, but also help users avoid mistakes during daily use. Secondly, the platform has established a training and assessment system to train and assess users, and to authorize qualified users to make appointments, ensuring the effective and safe use of the instrument and the smooth operation of the platform. In addition, the central platform also enhances the analytical and testing skills of professionals through special lectures and organizing specialized training. Since its opening, the platform has organized over 1000 free training sessions, covering more than 15000 teachers and graduate students from 7 colleges of the school. After training, teachers and graduate students from dozens of research groups in multiple colleges of science, engineering, and medicine across the

university can independently operate and use instruments on the computer.

3.2 Appointment Management

It is necessary to establish a real-time and convenient intelligent reservation system in order to enable the large-scale instruments in the platform to be fully and orderly applied by students^[10]. The most commonly used reservation system on the platform in the past was designed based on a computer platform website. This system can display information about large instruments and available appointment times. Users who need to use instruments, send samples for testing, and other needs, both inside and outside the school, can register and make appointments. However, the ease and speed of operation of the computer platform need to be improved. Therefore, the Qingdao University Analysis and Testing Center platform is currently developing an appointment system app and WeChat mini program to further enhance the convenience of the appointment system, allowing users to make and cancel appointments anytime and anywhere, achieving 24-hour appointment services. In addition, in appointment management, the platform has established a certain appointment system to prevent resource waste. For example, only authorized users who have received training can open appointment permissions; If you are unable to use the corresponding equipment on time after making an appointment, you should cancel the appointment 2 hours in advance in the system. If you are unable to cancel the appointment due to unforeseen circumstances, you should post a message in the platform communication group for students in need to use it; Students who fail to use the platform on time after making an appointment should have their corresponding platform points deducted. If the points are below the warning line, the user's appointment permission will be suspended for one week.

3.3 Usage Management

Developing a management system for instrument usage is key to maintaining the smooth operation of the platform^[11]. Firstly, the platform combines the instrument software with the card swiping electronic control machine, and

utilizes the campus information network and the built-in identity authentication management system of the campus one card to ensure that the user's identity is consistent with that of the reservation holder and the time is the same. Meanwhile, intelligent management systems can also provide users with convenient services such as information and data management, allowing them to remotely process data and improve convenience. Since its trial operation, it has served 12 colleges within the campus, as well as external units such as Huanghai Institute, Ocean University of China, Qingdao Energy and Engineering Research Institute, and its utilization rate has been increasing year by year, providing technical support for the scientific research of high-level teams. According to statistics, the usage time of over one million large instruments on the platform has been increasing year by year since its trial operation in 2020. Taking the usage record of field emission scanning electron microscopy as an example, the total usage time of scanning electron microscopy reached 5095.22 hours, with 1244.28 hours in 2021-2022 and 3850.94 hours in 2022-2023, an increase of over 300%. The usage information of all instruments on the platform, including cumulative charges, service duration, service frequency, number of users, number of test samples, failure rate, etc., is automatically registered and analyzed by an intelligent system.

3.4 Safety Management

In the management of large-scale instrument platforms, safety management is often related to the personal safety of technical personnel and users, as well as the property safety of large precision scientific research instruments, but it is often overlooked. On the one hand, security management refers to the management of users. Due to the diverse identities and high turnover of users, personnel management is complex and cumbersome, and it is necessary to plan and establish an efficient personnel management system in advance; On the other hand, it refers to the management of experimental supplies. Due to the different research contents of different users, the types of samples and reagents in the platform are

complex and diverse, and the storage and waste disposal of hazardous chemicals often pose safety hazards. Therefore, hazardous chemicals in the platform should be classified, registered, and supervised, and waste should be collected at designated locations and treated in a unified and standardized manner^[13-14]. In order to enhance the safety awareness of platform users and strengthen safety management, the platform has formulated comprehensive and targeted safety regulations and management methods, including personnel authorization management, operation safety management, hazardous chemical safety management, waste management, platform safety inspection system, etc. The platform provides security training and exams for first-time users, and only those who pass the exam can be granted access control permissions. At the same time, platform technicians take turns on duty as security inspectors, conducting security checks and supervision work at any time, reporting problems in a timely manner, and revoking user access control permissions once violations and safety hazards are discovered. In addition, the laboratory intelligent system is equipped with a 24-hour all-round video monitoring system, which records and monitors the safety and usage of the laboratory in real time.

3.5 Fee Management

Large instruments are often expensive, have high maintenance costs, and consume high energy, so funding is one of the necessary conditions to ensure the normal operation of shared platforms. Due to the different demands and purchase types of instruments and equipment among major universities, as well as different target user groups, the government is unable to provide unified guidance on the settlement of shared fees. Therefore, the establishment and management of large-scale instrument sharing platforms are currently determined by major universities themselves in terms of policies and fee standards. However, the formulation of charging standards is still in the exploratory stage. If the fees are too high, it will lead to the loss of user groups, and if the fees are too low, it will result in the platform being unable to afford

maintenance costs and labor expenses for technical management personnel. The Qingdao University Analysis and Testing Center platform currently adopts a label based billing model for on campus and off campus users, where different instruments and labels are charged differently. At the same time, the platform adopts an account prepayment method, which means depositing a certain amount of money in the user's account, using a large-scale instrument management system to complete billing and accounting, and collecting monthly testing fees for the use of large-scale instruments. The majority of the fees collected are used for the maintenance and repair of instruments, gradually achieving the goal of "using machines to maintain machines" and a virtuous cycle of open sharing of large instruments. A small portion is used to organize training lectures and academic exchanges, enhance the skills of platform users, strengthen visibility, promote the output of innovative major achievements, and promote the construction of the school's Double First Class.

4 Conclusion

Since its trial operation, the Qingdao University Analysis and Testing Center platform has continuously summarized practical work experience, explored and adjusted platform construction and management, steadily improved the utilization and sharing rate of large instruments year by year, increased service personnel and service duration, extended instrument usage cycle, and put the platform on track and developed in an orderly manner, achieving intelligent management. At the same time, it has also promoted the output of major research results and gained wide recognition from users. However, the development of large-scale instrument sharing platforms is a complex and long-term task. Due to the short establishment time of the platform, it has not yet faced the situation of instrument maintenance and upgrading. Therefore, we will also lay out in advance and continue to make progress. The construction of the Qingdao University Analysis and Testing Center will always adhere to the core idea of "people-oriented", with the goal of

building a testing platform that is "internationally first-class, domestically leading, and characteristic of Qingdao University" and "sharing, serving, cooperating, and innovating", promoting the output of high-level original achievements, enhancing the ability to undertake national level major and key research projects, forming technological achievements with significant transformation prospects, and providing efficient and high-quality research and development services and high-end testing for innovative and technology-based enterprises and research institutes. At the same time, by sharing equipment resources, promoting the integration and innovation of industry, academia, and research, and facilitating cooperation between university teachers and enterprises, we will closely focus on the industrial development of key areas related to national economy and people's livelihood, such as medicine, environment, and energy, from a technical perspective; By sharing high-precision and universal equipment resources, covering multiple industries such as marine, chemical, biological, textile, materials, and energy, we serve the interdisciplinary development of university research teachers; Release the scientific and technological resources of universities and research institutes to the whole society, and achieve the sharing of scientific innovation and technology.

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