Practical Research on the Lifelong Learning Model of the Largest Scientific Research Institution in China

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Abstract

In the era of knowledge economy, the time cycle of knowledge updating is shortened to 2~3 years. The development of the fourth research paradigm puts forward new requirements for big data and computing ability of researchers. As the highest academic institution of Natural Science in China, the Chinese Academy of Sciences (CAS) has more than 70,000 scientists who distributed in 23 provinces and cities. How to meet the lifelong learning needs of the distributed researchers has become the focus area of CAS in recent years. CAS has practiced for 3years in keeping up with the needs of scientists since 2014. Finally CAS proposed a lifelong learning model and built lifelong learning on-line environment. All kinds of learning data indicate that this learning model is effective and sustainable.

Key words

Chinese Academy of Sciences; lifelong learning; MOOC; continuing education; intelligent recommendation

1 Background

1.1 The development of knowledge updating

According to the study launched by the United Nations Educational, Scientific and Cultural Organization (UNESCO), information technology has brought the high speed development to human knowledge. In 18th Century, the time cycle of knowledge updating is about 80 to 90 years, from nineteenth Century to early 20th Century, it’s been reduced to 30 years, the last century 60~70's, the general time cycle of knowledge updating is about 5 to 10 years, and in the 80~90's of last century, the time has been shortened to 5 years, entered the new century, the time cycle of most disciplines has been shortened to 2~3 years.[1]

With the development of Internet, 90% of the data of human beings are generated in the first two years. The IDC report shows that by 2020, the total number of global data will exceed 40ZB (equivalent to 4 trillion GB).[2]

While the speed of knowledge updating is faster the scientific research paradigm also changes.

1.2 The learning needs the fourth scientific paradigm proposes [3]

Jim Gray who received the ACM A.M. Turing Award in 1998 put forward that scientific paradigms could be categorized in four models. Thousand years ago science was empirical that scientists researched by describing natural phenomena. Last few hundred years theoretical branch occurred that scientists did their work through using models and generalizations. When it came to last few decades scientists carried research by simulating complex phenomena that was called a computational branch. Today we meet the fourth science paradigm that was named data-intensive scientific discovery. It was developed in the big data era. New scientific paradigm poses challenges on today's scientists. Today’s scientists

must catch up with the development of new technology and grasp a few kinds of skills such as the ability of analysis of big data and cloud computing. Most scientists should know how to integrate heterogeneous data and how to deal with mass data and many kinds of domain algorithm and how to visualize the research conclusion. At the same time big data improve the development of interdisciplinary. It means that scientists should know more subjects beyond their only major. Only by doing so can scientists discovery new knowledge.

1.3 The training needs of the development of the Chinese Academy of Sciences [4]

The Chinese Academy of Sciences (CAS) was established on November 1, 1949, in Beijing, where it is headquartered. CAS is the primary academic institution in China in the natural sciences. It is also China's largest comprehensive R&D organization in the natural sciences and high technology. CAS is the linchpin of China's drive to explore and harness high technology and the natural sciences for the benefit of China and the world. CAS brings together scientists and engineers from China and around the world to address both theoretical and applied problems using world-class scientific and management approaches. CAS comprises more than 100 research institutes which are located in 23 provinces and autonomous regions across China. These institutions are home to more than 100 national key labs and engineering centres as well as nearly 200 CAS key labs and engineering centers. Altogether, CAS comprises 1,000 sites and stations across the country. CAS Headquarters in Beijing manages the entire organization under the leadership of the CAS president. CAS has a staff of 70,023, including about 58,697 professional researchers. Of these, approximately 26,521 are research professors or associate professors. CAS is mainly engaged in mathematics, physics, chemistry, astronomy, and earth and life research. With the rapid development of information technology CAS is facing the challenge about how to satisfy the lifelong learning needs of 70,000 researchers who are distributed across China.

1.4 The rapid development of information technology changes learning model

With the development of information technology and multimedia technology our learning model changes accordingly. More and more learning resource gives more opportunity to us. In 1989 University of Phoenix launched its online program [5]. The term of open educational resources (OER) was firstly coined at UNESCO's 2002Forum on Open Courseware [6]. OER are freely accessible, openly licensed text, media and other digital assets that are useful for teaching, learning and assessing as well as for research purposes. The organization for Economic Co-operation and Development (OECD) defines OER as:" digitized materials offered freely and openly for educators, students, and self-learners to use and reuse for teaching, learning and research". There is no universal usage of open file formats in OER. The term OER describes publicly accessible materials and resources for any user to use, re-mix, improve and redistribute under some licenses. Massachusetts Institute of technology (MIT) announced OpenCourseWare on April 4, 2001[7]. Under this project MIT put all of the educational materials from its undergraduate- and graduate-level courses online, freely and openly available to anyone, anywhere. MIT OpenCourseWare is a large-scale, web-based publication of MIT course materials. Khan Academy is non-profit educational organization created in 2006 by educator Salman Khan with a goal of creating a set of online tools that help educate students [8]. The organization produces short lectures in the form of YouTube videos. The videos show a recording of drawings on an electronic blackboard, which are similar to the style of a teacher giving a lecture. Its website also includes supplementary practice exercises and materials for

educators. All resources are available to users of the website. In July of 2017, Khan Academy became the official practice partner for the College Board's Advanced Placement. David M. Penrose (aka the One Minute Professor), an independent instructional designer and eLearning consultant, has articulated the process for creating microlectures[9]. The term microlecture is used to refer to actual instructional content that is formatted for online and mobile learning content using a constructivist approach. More specifically, as described in the Chronicle of Higher Education, these are approximately 60 second presentations with a specific structure. According to The New York Times, 2012 became "the year of the MOOC" as several well-financed providers, associated with top universities, emerged, including Coursera, Udacity, and edX. A massive open online course (MOOC) is an online course aimed at unlimited participation and open access via the web. In addition to traditional course materials such as filmed lectures, readings, and problem sets, many MOOCs provide interactive user forums to support community interactions among students, professors, and teaching assistants [10]. Moocs as shown in Figure 1.

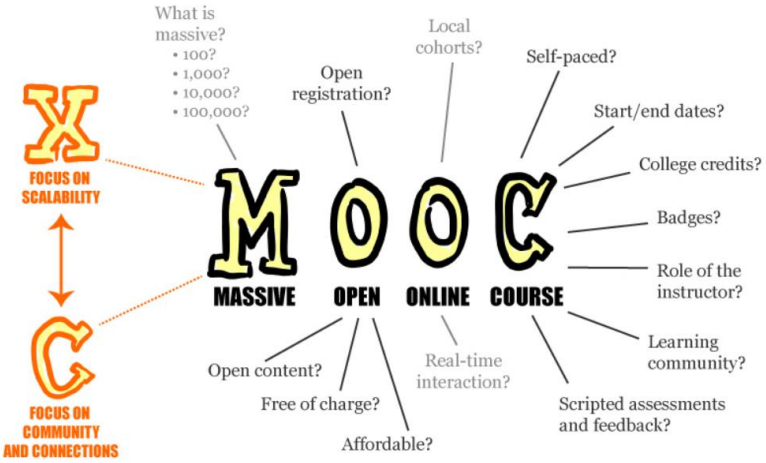

Figure1

2 The scientists' lifelong learning needs

The Semantic Web technologies have great potential to support lifelong learning endeavors, allowing for informal, just-in-time, day-to-day learning. The fourth scientific paradigm proposes new challenges on the researchers. How to realize the organizational mission of the Chinese Academy of Sciences? In consideration of the training needs of CAS we also must understand the researchers' personal lifelong learning needs.

We gathered the researchers' learning needs mainly through questionnaire and interview. CAS comprises more than 100 research institutes which are located in 23 provinces and autonomous regions across China while its headquarters is in Beijing. We mainly do two kinds of questionnaire. Firstly CAS launches a training need survey every 5 years. This kind of survey covers all the workers of CAS. The investigation issues focus on content needs and learning methods. Secondly every research institute carries out investigation among its own staff every year. The second type of survey focuses on subject learning needs and expected teacher. The results of the two types of survey could give us enough data to analyze the researchers' needs thoroughly.

In this research we mainly analyze the data form the survey that carried out among all the researchers in 2014. This survey was named "A questionnaire on the needs of continuing

education and training in CAS". A sampling survey among 872 researchers was carried out in 2014. According to the proportion of different title levels the training superintendent of HR Department decided the list who took part in the survey. The survey was executed from March to June in 2014.

2.1More working time less learning time

The 872 researchers that took part in this survey are from 117 scientific institutes. Among them, there are 233 science and technology managers and 639 scientific researchers. As shown in Table 1 below.

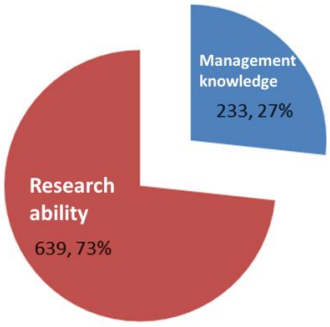

Table 1

For the purpose of understanding the learning needs of various post we sampled 255 junior researchers and 338 middle level researchers and 279 senior researches. As shown in Table 2 below.

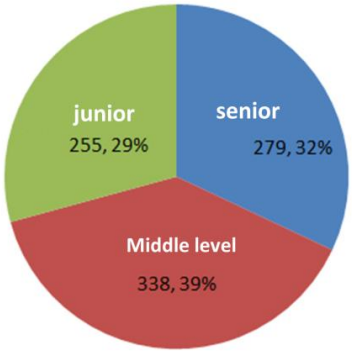

Table 2

We try to know the researchers' learning time by the question "how long time do you engage in researching work every day". 72% of the Interviewee work more than 9 hours a day. 95% of the Interviewee work more than 8 hours a day. Even 32% of the Interviewee work more than 10 hours a day. These results show that work takes the researchers too much time every day that they could not have enough time to learn. We need to think about how to balance work and study time. As shown in Table 3.

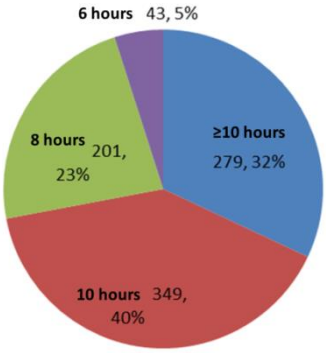

Table 3

2.2 The effective training way

As the learning time was so limited we want to know the most effective way of training. 324 researchers thought it is more effective to study while working. 190 interviewees believed that the best way is to get away from the job and concentrate on learning for a while. 358 researchers regarded all kinds of lectures, visits and exchanges as the best way to meet their learning needs. It means that 41% of the interviewees prefer to visit and interact with each other. As shown in Table 4.

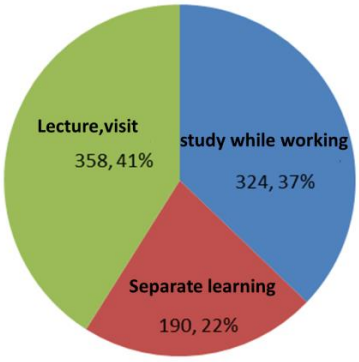

Table 4

2.3 The learning content needs

Furthermore we want to know what kinds of learning content the scientists needed to improve their work. The options for this problem included management ability, frontier knowledge, interdisciplinary knowledge, scientific research ability, and scientific literacy. While CAS is engaged in almost fields in natural science the researchers' needs were distributed in many fields. 37% of the researchers wanted to learn more knowledge about scientific management. 31% of the interviewees needed to know more about frontier knowledge and interdisciplinary content. We can infer that these researchers were interested in cross field. 22% researchers thought they need to improve their research ability. Finally there were 91 researchers want to improve their scientific literacy. This means that 10% of the interviewees wanted to understand general knowledge beyond their own research fields. As shown in Table 5 below.

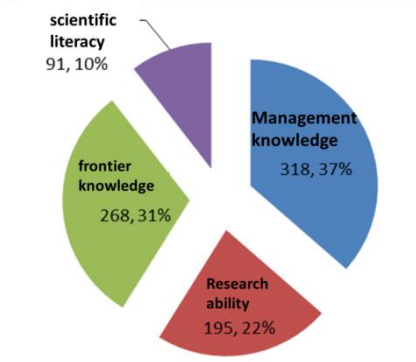

Table 5

2.4 Other personal learning needs

For getting more details of personal learning needs we design some subjective questions in this survey. One of the question is “what service do you want the institute to provide you in continuing education and training according to your research career planning and development.” Mostly every researcher wrote down their own needs. We summarized these answers and sorted into three major aspects.

2.4.1 Strengthening continuing education support through policy

Many researchers advised CAS put forward independent policy about continuing education. There are four points in details. Firstly CAS should design all the continuing education work from Top-level to improve training work Standardized and systematized. Secondly CAS was supposed to ensure learning time for every researcher by policy to resolve the conflict between learning time and work time. Thirdly CAS should provide more continuing education opportunity such as studying abroad or exchanging abroad. Finally CAS was supposed to ask every institute to set up special funds to support continuing education and training and encourage every researcher to learn.

2.4.2 Building learning platform to promote the sharing of resources

CAS comprises more than 100 research institutes which are located in 23 provinces and autonomous regions across China. So there is a need to share resources for these distributed scientists. Some researchers suggested building learning platform to promote the sharing of resources. This can solve many problems by a learning platform. First of all every researcher can learn any time anywhere by learning the resources on the platform. It overcame the barrier of time and space for learning. Many scientists who major in the same field often are distributed across China. How could they exchange each other’s ideas effectively and share knowledge quickly? Through a learning platform many researchers can interactive effectively and even develop deep cooperation. There are many continuing educational resources in more than 100 research institutes. Every scientist could get all of the resources through a learning system.

2.4.3 Individualized and problem-based learning

As mentioned above, the interviewees wanted six kinds of learning content. It included research ability, interdisciplinary, information literacy, scientific literacy, management ability and industrialization. Which way do the researchers prefer to get these knowledge and ability? Scientists put forward three learning modes. The first was to provide training service for various kinds of post, and provide corresponding training content according to the levels of posts. Second was to provide individual learning service for every scientist. The third was to

concentrate on the research focus to improve the occurrence of effective learning especially through the problem oriented learning model.

3 Practical researches on the lifelong learning model of scientists

The formats of continuing educational resources CAS provided before 2014 were consisted of training classes. This kind of training mode can fix the learning needs about frontier knowledge and management ability effectively. In a training class the training participants can exchange face to face and interact with each other. It was proved that training class is an effective way of training.

Under the fourth scientific paradigm scientists should update their knowledge especially the knowledge about big data and cloud computing. And scientists may develop more and more cooperation between similar or different subject. How to update scientists' knowledge effectively? Training class is an expensive model. The learning materials cannot be stored and shared widely while a training class can only accept no more than one hundred training participants one time. And we cannot gather all the learning data. While the period training class ends the learning ends.

3.1 drafting policy to ensure the learning time for every scientist

In order to guarantee the time for every researcher to study, CAS drafts a policy named "Measures for the registration and management of continuing education and training time". It claims that the scientists have the right and obligation to receive continuing education and training, and the institutes have the duty to carry out continuing education and training. In this policy a scientist's learning time should be up to 100 hours, and the leaders of the bureaus are not less than 110 hours every year. Scientist's study time is related to job promotion and annual assessment. This regulation is made to protect scientist's learning rights and interests. As shown in Figure 2.

中国科学院继续教育与培训学时登记管理办法

第一条 为进一步加强和规范继续教育与培训工作，贯彻落实人才高地建设的相关要求，深入实施"全员能力提升计划"，强化全员培训理念，完善继续教育与培训学时登记管理制度，根据《干部教育培训工作条例》、《专业技术人员继续教育规定》等有关规定，制定本办法。

第二条 全院正式在册职工（以下简称职工）的继续教育与培训学时认定和登记管理工作，适用本办法。

第三条 职工有接受继续教育与培训的权利和义务，单位有履行继续教育与培训的职责。

第四条 院人事局是我院继续教育与培训的主管部门，负责全院继续教育与培训学时登记的检查监督。各单位要建立完善职工继续教育与培训档案，如实记载职工参加继续教育与培训情况和考核结果。

第五条 继续教育与培训的主要形式包括：

（一）专项培训班；

（二）学术进修，技术研修，职业资格认证培训；

（三）国内外学术会议、讲座；

（四）出国（境）培训，公派留学；

（五）网络在线学习；

（六）各类专题讲座；

（七）自主选学、在职自学等。

凡参加上述形式的各类继续教育与培训均可累计计算继续教育与培训学时。

第六条 继续教育与培训学时登记应包括培训名称、培训内容、培训地点、培训时间、考核结果等内容。

第七条 职工的继续教育与培训学时登记采用网络登记的方法，通过中国科学院继续教育网（www.casmooc.cn）进行审核和记录。

第八条 职工每年参加继续教育与培训的时间累计不少于100学时，其中所（局）级领导人员不少于110学时。

第九条 职工学时登记方式：

职工参加院内各单位举办的继续教育与培训项目，由培训主办单位提交继续教育与培训项目执行情况，并根据培训考核情况进行登记；

Figure 2

3.2 Establishing training implementation system and standardized the training process

CAS has established a training implementation system for every kind of post. CAS is responsible for the training of the strategic management. Various bureaus are responsible for various special management training. The Institute is mainly responsible for scientific and technical professional training for scientific researchers. The Continuing education bases under CAS are responsible for the integration of training in the field of discipline. The Continuing education bases under the Ministry of Human Resources and Social Security of the People's Republic of China are responsible for professional and technical training for all of the Chinese scientists. Based on our practices we carried out theoretical research to standardize the training process for all of the institutes mentioned above. The standardized training process includes six phases. It is a whole process from survey to plan to implement to resource to assessment until statistical analysis.

3.3 Developing many kinds of training resources to meet individualized needs

The training implementation system has clearly defined the training responsibilities of all institutes. Under this training implementation frame we have carried out further work to specialize training content and methods. The main formats of the training resources include training class and online courseware and teacher.

3.3.1 Building competitive training classes

The training class is implemented offline usually. It focuses on the training of frontier knowledge and management ability. We further subdivide training classes into short term special technical classes, professional technical high research classes, post training, academic conferences and academic lectures to meet every post's learning needs. CAS has implemented more than 5000 training classes one year as every training class has its own special training objectives and trainee.

In addition, in order to meet the researchers' study aboard needs we have increased support for studying abroad, and supported researchers to carry out short-term academic exchanges abroad. As shown in Figure 3.

培训班统计表

从 2017-01 到 2017-12 培训名称： 查询

培训名称	实施状态	是否精品	起始时间	地点	参训人数	工作人数	经费开支	联系人	联系电话	操作
栅格空分（三）	已实施	否	2017-12-25 00:00	江苏省苏州市高新区道元路18号403	30	1	0.0	杨欣虹	0512-68075672	查看
中亚原子吸收光谱分析技术与应用培训班	已实施	否	2017-12-25 00:00	塔吉克斯坦杜尚别	25	0	5.4	赵莉	0991-7823116	查看
2017年度实验室学术委员会会议	已实施	否	2017-12-24 08:30	嘉定蓝宫	45	2	4.0	杨彦丽	021-69918443	查看
财务管理及报表分析培训	已实施	否	2017-12-22 09:00	本地	50	0	1.7	杨玉麟	010-62582315	查看
先进界面技术团队项目进展年终总结	已实施	否	2017-12-22 08:30	能源楼217	13	0	0.0	孙德业	13370885896	查看

导出 总数:5764|每页记录数 5 [首页] [上一页] [下一页] [尾页] 转至 3

Figure 3

3.3.2 Online courseware

We fully analyze the advantages and disadvantages of each kind of online courseware such as open courseware and microlecture and MOOC. CAS builds science micro courses and three-part-separated Screen Web Course to update the knowledge of scientists. In order to help the scientists solve the typical research difficulty we explore the science micro courses. The length of each science micro course is not more than 20 minutes, which is taught by our researcher. A science micro course can be a series of short videos or only one short video. As we produce more and more science micro courses we divide the series into two category, scientific professional research micro courses and science popularization micro courses. The scientific professional micro courses are produced for scientist to improve their major research ability while the science popularization micro courses are produced to improve most scientists' scientific literacy and promote interdisciplinary. In addition, we have invited the academicians to tell the scientific story to develop micro course to meet the training needs of the scientific spirit. Based on the high quality training subjects offline we build three-part-separated Screen Web Course. This kind of web course lasts for 1 to 3 hours usually and it can explain professional knowledge systematically and thoroughly. Now we try to combine all of these courseware resources into Point - line – surface series in order to meet the different depth learning needs. Science micro course as shown in Figure 4. Three-part-separated Screen Web Course as shown in Figure 5.

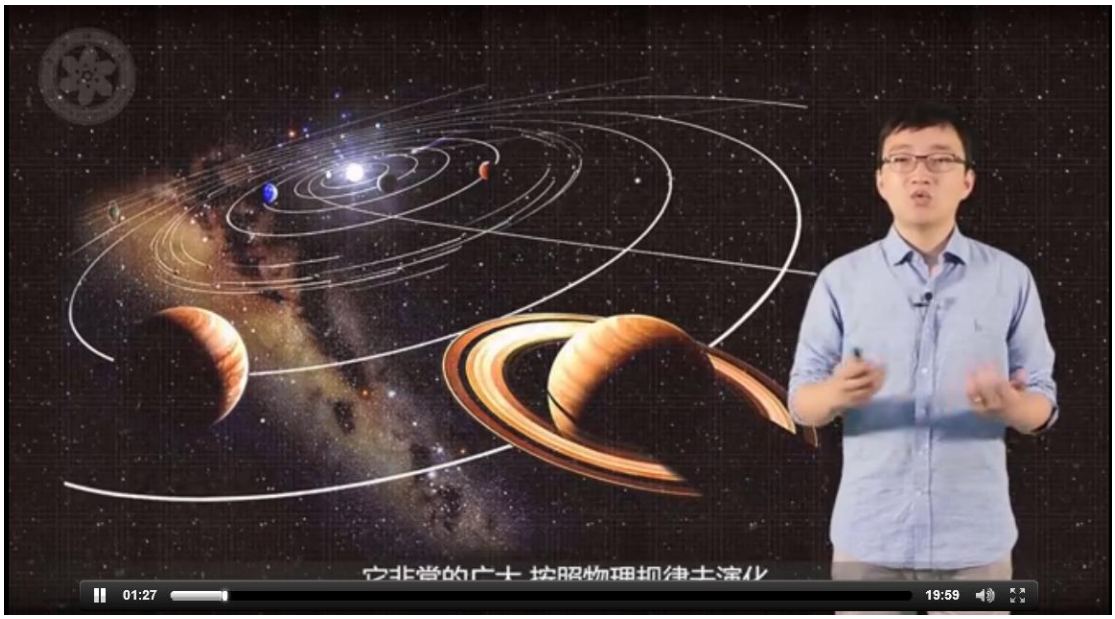

Figure 4

Figure 5

3.3.3 Teacher database

While there is no best teacher only the most appropriate teacher CAS chooses the excellent scientists who are good at lecturing among 70000 scientists. Through building teacher database we guarantee the quality of courseware and continuing education. We set up a variety of evaluation indicators to select better teachers and provide learning opportunity to improve teacher's teaching skills. As shown in Figure 7.

Figure 7

3.4 Organizing training assessment to improve the training work

In order to ensure the effect of the continuing education, CAS has developed a series of assessment indicators. This assessment indicator system mainly includes organization guarantee, policy, curriculum system, training need analysis, plan making, training implementation, and project evaluation, training funds, training materials, training teachers and resources sharing. CAS evaluates every institution's outputs of training work each year through data extraction and face to face assessment.

3.5 Building CASmooc eLearning system and recording big learning data

Now we have many kinds of continuing education resources such as training classes and

online courseware and teacher information distributed in every research institute of CAS. And we have set up a standard training process. We urgently need an electronic learning platform to gather and integrate learning resources to provide them for scientists. We also need a system to supervise all the institutes execute the training class according to the standardization. Based on all the work mentioned above in this paper we build CASmooc that is our MOOC platform for every scientist in CAS. In 2016, CASmooc was officially launched online to provide learning service for every scientist anytime anywhere and record every researcher's learning data. The CASmooc platform's function mainly consists of three parts: the platform of management, the platform of learning and the platform of resource sharing. Its management function means it can support every institute implement the total continuing educational process and the total training class process. Its learning function means it serves every scientist in selecting online courseware and registering training class and taking part in surveys. In the process of learning online course and training class every learner can interact with others. Of course the learners have the right to comment on and score the courseware. In order to ensure the authenticity of the learning data, every scientist must use his real name on this CASmooc platform. Its sharing function means that all of the Courseware resources, training project resources and teacher resources are integrated and retrieved. CASmooc supports every institute determine whether open their resources or not autonomously. The open scope includes non-public, department sharing, unit sharing, CAS sharing, and total public sharing. Mobile learning is more convenient for us with the development of mobile terminals. We developed CASmooc applications on android and IOS system. In consideration of the utilization of fragmentation time of scientist such as the time on the way to work our APP supports off-line learning. Scientists can download courseware on their mobile terminals under Wi-Fi environment and learn the courseware offline. The interesting thing is that when you link to the network again, the learning record is also stored in the database. And while scientist takes part in a training class he can record his learning data by scanning QR code. Scientist also can record his learning data anytime anywhere through using his mobile terminal. CASmooc system supports institute live training course and this method reduces the cost of participating in a training class on a business trip. CASmooc as shown in Figure 7.

Figure 7

4 Results and conclusions

4.1 **The Lifelong Learning Model of CAS**

Since 2014, CAS has been initially drafted “Measures for the registration and management of continuing education and training time”, established the continuing education implemented system, developed a variety of training resources, and organized training assessment work several times. Finally CAS has built an electronic learning system named CASmooc which supports all of the work offline mentioned above and records big learning data. CAS has formed its effective life-long learning mode for researchers. As shown in Figure 8.

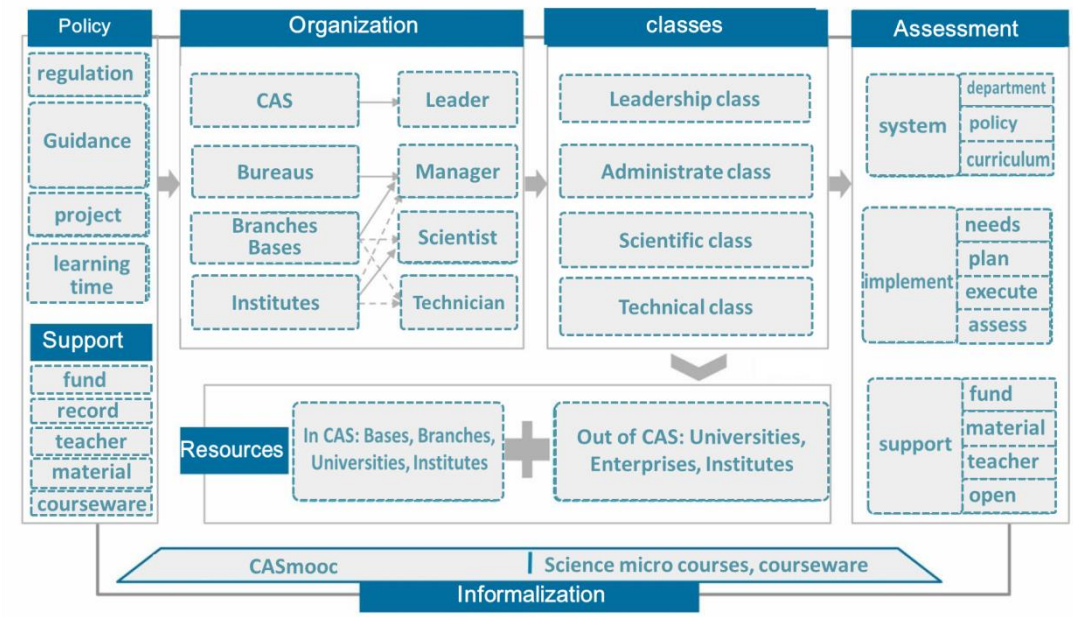

Figure 8

Through the comparison of the learning data in 2014 and 2017, we can see that our lifelong learning model is more effective and has gained some achievements through our practice.

4.2 The learning data comparison

Through analyzing the learning data in 2014 and 2017 we can see there are three changes in 2017. First of all there has been a big increase in the learning data and the learning data is more detailed. Second, the scope of learning data statistics becomes larger. The third is to set up a study file for each scientist.

4.2.1 The number of training classes and trainees increased significantly

In 2014, CAS held 2224 training classes and there are 146 thousand trainees involved.

In 2017, CAS held 5765 training classes and there are 321 thousand trainees attended.

250 thousand scientists are trained outside CAS in 2017 while there is no record about this data in 2014. In 2017 there are 571 thousand trainees involved totally.

4.2.2 The learning data is more detailed

In 2014, the learning data mainly included the training classes held in CAS. In 2017, the learning data included both in CAS and out of CAS, and these data were identified as offline learning data or online learning data.

In 2017, the total number of learning data of CAS was 5415868.9 hours, of which the online learning data were 621966.2 hours and the offline learning data were 4793902.7 hours. The internal learning data of CAS are 2387246.1 hours, and the external learning data out of CAS are 3028622.8 hours.

4.2.3 Building learning file for promoting individualized learning

In 2017, CAS created personal study file for every 70 thousand employees. The personal study file includes training classes, external training classes (outside CAS), self-study, and study aboard, online learning courses. Among them, online learning includes many fields such as names, learning URLs, learning time and time length, and offline learning includes names, organizers, time, length and the place. These personal files will be accumulated into individual learning data to support personalized learning recommendation in the future. CAS big learning

data is based on every scientist's learning data.

4.3 Feedback data

In 2016, after CASmooc running half a year, a questionnaire survey was carried out about CASmooc, and more than 100 researchers participated in the investigation. 95% of the users thought that CASmooc is beautiful and easily used. And later we have an interview with 20 researchers from 8 research institutes in Wuhan branch to get user's suggestions. They suggested making more science micro - courseware to meet fragmented learning needs. They suggested that sum up all kinds of success experience in using CASmooc and carry out various exchanges to share experiences to improve the use of CASmooc. They suggested that policy incentives combine with the construction of high quality resources and change passive learning into active learning.

5 conclusions

After more than 3 years of exploration, CAS has initially established a life-long learning model for researchers. All kinds of feedback data indicate that CAS has achieved some achievements. But with the development of information technology, especially the development of big data technology and the scale of open resources, CAS in the future will still take efforts to promote deep learning and build sharable learning environment.

5.1 Deepening the description and aggregation of resources

We plan to further describe the resources, and use knowledge map and ontology to integrate resources at the semantic level so as to better meet the individualized learning needs of scientists [11].

5.2 Building a socialized and active learning platform

We will deepen the level of service, from the Institute to the laboratory, eventually to person. We will continue to build online learning environment and introduce Integral mechanism, social mechanism, and live broadcast function into our CASmooc. By analyzing the big learning data, we have a plan to build model for every scientist. Using a variety of algorithms to realize the personalized recommendation of learning resources and improve the learning experience of users [12].

5.3 Promoting the sharing of scientific educational resources all over the world

On the basis of the continuing education network of the Chinese Academy of Sciences, we will share our resources with various scientific research institutions all over the world, promote the exchange of disciplines and promote cooperation.

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