A Study on Improving Continuing Education in Scientific Organizations through Information Technology

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Abstract

Nowadays, Learning Management Systems (LMS) are widely used in education and industry. However, it is relatively rare to use LMS in scientific research institutions. The fourth scientific paradigm has prompted research institutions to strengthen continuing education. The essence duty to find new knowledge makes it more challenging for science research institutions to implement LMS. This study proposes a qualitative and quantitative analysis of the application of LMS in research institutions. This includes three major systems of scientific and technological capabilities, ten types of training methods, and an LMS model for research institutions. On this basis, the training management information system (CASMOOC) of the Chinese Academy of Sciences has been developed and implemented to improve the efficiency of training management through informatization, improve the training effect through multi-terminal learning, and accumulate training files to lay the foundation for personalized learning. Digital learning resources play a crucial role within the Learning Management System (LMS). Both professionally recorded lectures in a studio setting and live reports from academic conferences have proven to be effective in addressing researchers' ongoing learning requirements. Diverse methods are employed to create digital learning materials tailored to specific training subjects. The courseware database encompasses over 3000 scientific videos and undergoes annual updates for continuous enrichment.

1. Introduction

With the development of computer and information technologies, the way of knowledge transfer has been significantly changed. In a modern education environment, Learning Management Systems (LMS) provide the interaction between traditional learning & teaching methods and digital materials, thereby offering a student customized learning experience [1].

Since the outbreak of COVID-19 in 2020, the field of e-learning has experienced significant development. E-learning has become increasingly necessary for educational institutions worldwide, relying on remote teaching methods due to the constraints on in-person interactions [2][3].

There are many LMS tools and massive open online courses. E-learning brings many benefits and the most important one is time and cost efficiency [4]. The flexibility offered by e-learning is also widely recognized as one of its major advantages, as it enables learners to engage with specific subjects or topics at their convenience, regardless of location or time [5]. In e-learning, the online course materials can be reused without restrictions. This greatly improves the efficiency of resource utilization. At the same time, resources can also be quickly updated according to the requirement of learning and teaching.

LMS has been widely used in schools, the medical industry, hotels, retail, manufacturing, etc. Some LMSs declare that they could be used in many different institutions. However, there are significant differences in the learning content and methods used among different age groups of users and organizations.

The current research focus of LMS mainly lies in its applications in schools while the software is developed to deepen online learning. In fact, adult learning follows the 70-20-10 principle though the convenience of online learning may increase this proportion. However online learning could not be the only way for adults to update their knowledge. This phenomenon is particularly prominent in the field of scientific research. Through qualitative and quantitative research, this paper discusses the onion learning model of researchers, the main effective training methods, and the LMS design and practice in research institutions.

2. Literature review

2.1. Scientific Research Institutions

There is a long development history of scientific research institutions. In 1660, the first scientific group in Britain, the Royal Society, was officially established. In 17th-century France, the establishment of the Academy of Sciences resulted in a structural segregation between teaching and research, leading to their allocation into separate sectors [6]. The Berlin Academy of Sciences was established in 1700, and the St. Petersburg Academy of Sciences was established in 1724.

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In the 19th century, science entered a stage of comprehensive institutionalization. In the 1950s, Thomas Samuel Kuhn (1922-1996) proposed the concept of scientific community and paradigm theory. Scientific communities are groups of specialists concerned with specific problems or subject areas. The members of these communities communicate, agree on essential judgments and views, and educate their members. The similarities between the members of a scientific community are described by paradigms. A paradigm is understood as a disciplinary system with the following elements: generally accepted theoretical assumptions, basic laws, analogies, models and metaphors on the subject of research, standards, and values.

Universities and research institutions are the primary entities engaged in research within a country. The main responsibility of a research institution is to address world-class theoretical and applied problems. Universities and research institutions are the two primary sectors contributing to global research output. Research institutions are envisioned as entities specifically established to fulfil the primary purpose of conducting research [7].

2.2. The Fourth Paradigm

With the development of information technology, research paradigms are also constantly changing. The first three research paradigms are the empirical paradigm, the theoretical paradigm, and the simulation paradigm. The fourth research paradigm was introduced by Jim Gray in 2009, which is data-intensive scientific research. Within the fourth paradigm, three core activities emerge, including capture, curation, and analysis. Data encompasses a wide range of scales and formats, incorporating substantial international experiments, observations conducted across multiple laboratories as well as individual ones, and even potentially encompassing aspects of individuals' lives. In the new paradigm, data is captured through instruments or simulation and then undergoes software processing before being stored in computers as information or knowledge. Scientists have limited access to their data until a later stage in this pipeline. The distinctive techniques utilized in data-intensive science differ significantly enough to warrant the differentiation of data-intensive science as a distinct, fourth paradigm for scientific exploration, separate from computational sciences [8].

The fourth research paradigm requires researchers to continuously strengthen collaboration and improve their information and data literacy.

2.3. The Fourth Paradigm

In 2011, the United Nations Educational, Scientific and Cultural Organization (UNESCO) revised the international standard classification of education. It also defines the terms of adult education, formal education, non-formal education, and informal education. Adult education focuses on the individuals who are recognized as adults within their society. The aim of adult education is to enhance the technical or professional qualifications of an adult. The objective is to foster the further development of their abilities, expand their knowledge, and potentially fulfil a formal education level. It also encompasses endeavors to obtain, renew, or enhance their knowledge, skills, and competencies within a specific professional domain. This encompasses the notion of 'continuing education', 'recurrent education', and 'second chance education' [9].

The international standard classification of education includes three levels. The first level has 9 categories and the second level has 25 categories as shown in Table 1.

Table 1. The international standard classification of education

Category	**Subcategory**
General programs	Basic programs
	Literacy and numeracy
	Personal development
Education	Teacher training and education science
Humanities and arts	Arts
	Humanities
Social sciences, business and law	Social and behavioral science
	Journalism and information
	Business and administration
	law
Science	Life science
	Physical sciences
	Mathematics and statistics
	Computing
Engineering, manufacturing and construction	Engineering and engineering trades
	Manufacturing and processing
	Architecture and building
Agriculture	Agriculture, forestry and fishery
	Veterinary
Health and welfare	Health
	Social services
Services	Personal services
	Transport services
	Environmental protection
	Security services

2.4. Andragogy

The exploration of adult learning theory commenced in the mid-20th century. In 1968, Malcolm Knowles, an American adult educator, introduced the concept of Andragogy. This

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framework aimed to differentiate the social and psychological characteristics of adults from those of children in learning activities.

The foundation of Knowles' theory of adult learning revolves around self-directed learning. Adult self-concept is an independent learner. Knowles defines self-directed learning as: "individuals have the ability to actively assess their own learning needs, set learning objectives, identify the necessary human and material resources for learning, choose and employ suitable learning strategies, and evaluate the outcomes of their learning efforts, regardless of whether they receive assistance from others." Adult learning theory focuses on goal and problem orientation. Adult learners have strong learning autonomy. When designing LMS, it is crucial to fully acknowledge and address this aspect [10].

2.5. The 70-20-10 Framework

The foundation of the 70-20-10 framework can be traced back to comprehensive empirical research conducted by McCall Jr. et al. (1988). This research encompassed four distinct studies involving a sample of over 200 accomplished executives from six prominent corporations. The analysis of their data revealed that 70% of an executive's learning was derived from engaging in challenging work experiences, while 20% of their development was attributed to cultivating relationships with others, including colleagues and supervisors. The remaining 10% of their development was attributed to formal training activities [11].

2.6. LMS

Learning Management Systems (LMS) refer to the technologies that facilitate the delivery of courses over long distances. These systems are web-based software platforms that provide an interactive e-learning environment. They automate various aspects of education, including content management, coordination, delivery, and assessment of learning materials and student progress [12].

Many companies also use corporate LMS software to develop and manage their employee training programs, while schools (K-12 or higher education) can use academic LMS software to create and manage their online learning curriculums [13]. The training system is one kind of LMSs and it is also named corporate LMS. In this study, we can use LMS as a training system as most LMS tools declare that they can be used for training. Modern LMS tools play a vital role in ensuring that employees remain up to date with the requirements of their current or prospective roles. A variety of LMS options are available, and Table 2 presents the most popular LMS software of 2023 along with their distinctive features [14].

Table 2. Top 10 LMS Tools in 2023

LMS	Unique features
TalentLMS	Blended learning Homepage builder Comprehensive but intuitive feature set ecommerce Enterprise-grade
SkyPrep	Notify or message learners Access report data in real-time Own the app Stay compliant
Coassemble	Customizable templates Powerful reporting Rich media support Mobile and integration optimized Time-efficient Fast and responsive LMS
Absorb LMS	Pre-configured courses Learner-centric platform More collaborative learning Smart Administration module Course monetization
Graphy	Create courses fast Market like a pro Built for cloud and Android Top-notch security
iSpring Learn LMS	Offline mobile access Rich authoring tool Unlimited storage space Live webinars
BrainCert	End-to-end course management Better transparency and progress monitoring Easier facilitation of different learning methods Simplified monetization of courses Social and collaborative learning environment
360Learning	Comprehensive Authoring Tool Intuitive Course Assessment Collaborative Learning
eFront	Branding and control Flexible learning and training A new-age LMS: gamification Content interoperability
TalentCards	Rich features Fun learning Easy for fresh learners Train multiple staff at once

2.7. Digital learning materials

Digital learning materials, serving as pivotal elements of Learning Management Systems (LMS), have a rich historical standing that predates the emergence of eLearning platforms.

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Remarkably, the initiation of distance education can be traced back to the establishment of the Open University, United Kingdom, in 1969, thereby etching its legacy as the premiere institution venturing into this avenue. In its nascent stage, it adopted television broadcasting and radio transmissions as instrumental medium to propagate education across geographical confines. This inventive academic environment was supplemented by a wealth of teaching resources, including meticulously curated books, and bespoke videotapes, catering to the needs of their dispersed learning community. Over the course of time, the morphology of digital learning materials has undergone considerable transformations, aligned with technological advancements and innovative teaching methodologies. In 2023, the Open University championed the integration of podcasts within classroom parameters, a breakthrough strategy that underscored its continued commitment to pedagogical innovation. The term 'podcast' is an amalgamation of the words 'iPod' and 'broadcast', beginning as form of digital media designed for easy consumption on personal devices. Educational podcasts essentially serve a dual purpose within this framework. Existing podcasts can be readily incorporated into learning practices, serving as knowledgeable supplements to the standard curriculum. Simultaneously, it empowers students to harness their creativity and knowledge by generating original podcast resources, thereby fostering a culture of collaborative learning and reciprocal knowledge exchange. Thus, the evolution of digital learning mediums is a testament to the dynamic nature of the pedagogic landscape, continually adapting to leverage contemporary technologies to enhance teaching and learning experiences.

The year 1989 marked a significant milestone in the evolution of digital education when the University of Phoenix embarked on an online educational program. This pivotal move set the stage for the development and integration of open educational resources (OER) into mainstream education. First coined during UNESCO's 2002 Forum, the term 'OER' has since been defined by the Organization for Economic Co-operation and Development (OECD) as "digitized materials provided freely and in an unrestrictive manner, benefiting educators, students, and self-learners. They can utilize and repurpose these resources for teaching, learning, and research".

However, it became evident that there was no universal schema for open file formats in the realm of OER, creating a hiatus in the standardization of these resources. Despite this, the OER encompasses publicly accessible materials and resources for usage, reiteration, enhancement, and redistribution under stipulated licenses catering to a wide range of learners and educators.

Stepping into the 21st century, the Massachusetts Institute of Technology (MIT) pioneered the OpenCourseWare project on April 4, 2001[15]. This landmark initiative placed all undergraduate and graduate course materials from MIT online, offering unrestricted, free accessibility to any interested individual irrespective of their geographical location. The resultant large-scale, web-based library of MIT course materials— the MIT OpenCourseWare— marked a paradigm shift in the way educational resources were made available.

In 2006, the non-profit educational organization, Khan Academy, was founded by Salman Khan, an educator with a vision for creating a suite of online learning tools to facilitate student education. The academy is notable for its production of concise video lectures, offering a visually stimulating understanding of diverse academic topics— much akin to traditional classroom teaching. These lectures, made available on YouTube, exhibit recordings of drawings on an electronic blackboard. Furthermore, the organization's website is a comprehensive repository of supplementary practice exercises and educational materials for teachers and students alike.

Adding another innovative approach to online education, David M. Penrose, better known as the One Minute Professor, an independent eLearning consultant, and instructional designer, has shed light on the methodology for creating microlectures. Microlectures refer to concise instructional content, optimized for online and mobile learning scenarios through a constructivist approach. This content caters not only to the limited attention span of digital learners but also allows for self-paced, location-independent learning.

As the New York Times identified, 2012 as "the year of the MOOC," several well-funded providers, in collaboration with top-ranking universities, saw the light of day, including Coursera, Udacity, and edX. MOOCs— Massive Open Online Courses— signify an online course designed to accommodate unlimited participation and ensure open access via the web. Alongside conventional study materials like lectures, readings, and problem sets, MOOCs frequently offer interactive user forums, encouraging global and community interactions among students, professors, and teaching assistants [16]. This new age learning ecosystem not only enriches the global academic community but also propagates information accessibility.

3. Theoretical Framework

3.1. The Onion model

In the panorama of psychological research, the 1970s saw McClelland, a renowned American psychologist, question the widely accepted premise that academic achievement stood as a reliable bellwether for professional success. This thought-provoking challenge paved the way for the emergence

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of the concept of "competency" that offered an innovative paradigm to predict individual performance and potential.

Crystallizing within the landscape of competency frameworks is the notable onion model, introduced by scholar Richard Boyatzis in 1982. Delineated extensively in his work, the onion model offers a unique multi-layered framework that mirrors the complexity and depth inherent in the construct of competency [17].

A visual representation of this model, encapsulating its distinct layers and the interrelations among them, is provided in Figure 1. Through a clear diagrammatic depiction, the onion model's structure and core underlying principles come to light, giving the reader an intuitive understanding of this innovative approach to conceptualizing competency.

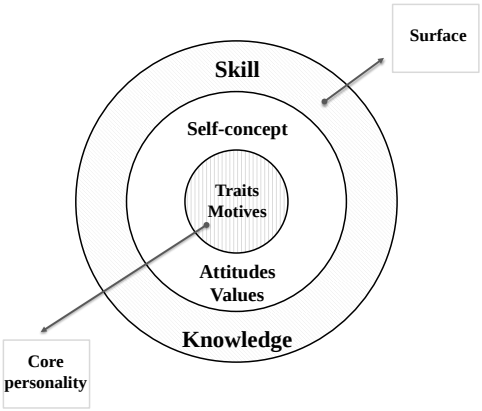

Figure 1. The Onion model [17]

3.2. Grounded theory

The genesis of grounded theory traces back to 1967 when it was pioneered by Glaser and Strauss, a seminal development that has since strongly impacted the landscape of sociological research. Over time, the application of grounded theory has transcended sociology and has found resonance in diverse disciplines including, but not limited to, Anthropology and Nursing [18].

Often pigeonholed as essentially qualitative in nature, grounded theory transcends this classification, by seeking an intuitive balance that integrates the robust strengths inherent in quantitative methodologies with the depth and flexibility offered by qualitative approaches.

This intriguing blend of methodological possibilities finds its roots in the disparate educational backgrounds of its founding fathers. Strauss, an academic associated with the University of Chicago, and Glaser, affiliated to Columbia University, brought to bear their unique research philosophies on the development of grounded theory. As a result, the grounded theory paradigm successfully amalgamates the nuanced, textured qualities of qualitative interpretive traditions with the unerring logic, meticulous rigor, and systematic analytical facets characteristic of conventional quantitative survey research [19].

Their collective academic evolution and contribution offer an expansive perspective, honing grounded theory into a synergistic tool that mirrors both the versatility of qualitative inquiry and the pointed precision of quantitative research.

4. LMS in Research Institutions

Our empirical research study was designed meticulously with its central focus on comprehending the domain of training content and methods adopted by scientific researchers. We accomplished this through an exploratory approach consisting of multiple phases of questionnaires and interviews performed in unison with the Chinese Academy of Sciences.

The methodological process unfolded chronologically as follows:

1) The inception of our study in 2014 marked our first data collection phase. We administered a questionnaire survey encompassing 639 scientific researchers hailing from 114 different institutes under the umbrella of the Chinese Academy of Sciences. This respondent group was itself a heterogeneous mix, encompassing 142 early-career researchers, 218 mid-career researchers, and 279 scientists entrenched in their senior research careers. Furthermore, the age-based distribution of the participants was duly considered, resulting in a categorization of 453 respondents between the ages of 25-35, 150 constituents aged 36-45, and a scaled-down group of 36 individuals between the ages of 46-55.

2) Advancing towards 2018, we orchestrated a symposium bringing together 54 emerging talents in the domains of science and technology. Within this space, dynamic dialogues and interactions were cultivated to harness their collective insights regarding their training necessities.

3) Fast-forwarding to 2020, we undertook a comprehensive interview-based exploratory study with a dual-pronged approach: first, engaging with 13 research institutions, and second, connecting with 11 field-specific researchers. These purposeful discussions yielded invaluable perspectives catering specifically to the training content and methods meriting the attention of scientific researchers.

Utilizing the grounded theory approach as our analytical basis, we endeavored to dissect and decipher the amassed data. Through this immersive process, our goal was to garner a holistic and nuanced understanding of the training requirements intrinsic to the scientific researchers' community. Thereby, our research contributes significantly to the ongoing discourse around effective training strategies in the field of scientific research.

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4.1. The Onion Model for Scientific Competency

This research endeavor synthesizes three foundational concepts - the academic community concept, the existing Onion model, and the International Education Classification Standard affirmed by UNESCO - towards building a robust theoretical framework addressing scientific competency. By employing the grounded theory approach, we have attempted to remodel the traditional Onion model to effectively capture the multifaceted nature of scientific competency.

Consequently, we present our unique "Onion Model for Scientific Competency". This rejigged Onion model serves as a conceptual compass, guiding our understanding and interpretation of scientific competency in a layered fashion - akin to the layers of an onion.

To this end, Figure 2 visually encapsulates our developed Ogre model, elucidating the interconnections between its different layers and how they correlate to not only the academic community but also sync with the internationally standardized educational classification as per UNESCO.

In essence, our developed Onion model offers a comprehensive and nuanced perspective for examining scientific competency, paving the way for more insightful deductions in the realm of scientific academia.

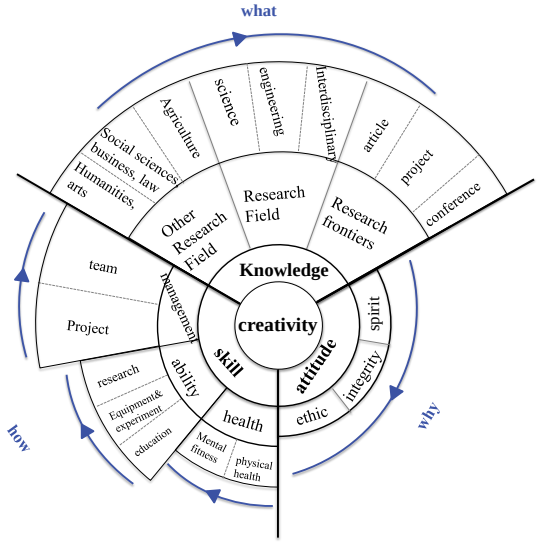

Figure 2. The onion model for scientific competency

Research institutions embody the epicenter of innovation, entrusted with the primary responsibility of pioneering advancements across diverse fields. The utopia of innovation is an intricate blend of three fundamental components - knowledge, skills, and attitudes which work in a nuanced synergy to engender progressive outcomes.

Attitudes at research institutions are anchored in the pillars of research ethics, integrity in scientific endeavors, and an overarching scientific mentality. These elements forge a robust ethical framework that fosters an environment conducive to scientific inquiry, while ensuring that ethical protocols and scientific integrity are non-negotiable values. This ethical substrate influences researchers' motivation, thereby impacting their efficiency and productivity, and ultimately the quality of research outcomes.

Skills form the second pillar of this triad. A hale constitution, both physically and mentally, is indispensable, given the demanding nature of scientific work. Foundational research skills, spanning the spectrum from experimental design to data interpretation, and managerial skills in leading scientific programs and managing research grants, are also critical. Together, these skills arm researchers with the necessary competencies to navigate the challenges of the research landscape.

The final element, knowledge, accentuates the holistic literacy that researchers are expected to exhibit. This extends beyond domain-specific expertise, demanding a well-informed understanding of cutting-edge developments not only within one's own field but across interconnected disciplines as well. This broad-based expertise is reflective of the inherently interdisciplinary character of research and underscores the significance of scholarly dialogue in fostering a dynamic and progressive academic environment.

In encapsulating these realms of influence - attitudes, skills, and knowledge - research institutions serve as torchbearers in the pursuit of scientific exploration, innovating novel solutions to complex problems, and expanding the frontiers of our understanding.

4.2. The Training Mode in Scientific Research Institutions

In our research study, we implemented a rigorous analytical process on a corpus composed of 639 questionnaire responses and 78 interview transcripts. Using grounded theory as our theoretical lens, we carefully dissected and examined this multifaceted data to uncover insightful patterns and trends.

Through this meticulous analysis, we were able to delineate ten distinct modes of training. These varied methods range from individual, self-directed learning to collective participation in formal training classes and salient academic seminars.

Of particular interest is the realm of academic seminars which, upon further examination, demonstrated a complex internal structure. Based on various parameters such as the scale of the seminar, its duration, and participants involved, we were able to sub-categorize academic seminars into seven distinctive types. This taxonomy of seminars underlines the diversity inherent within this singular mode of training.

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A comprehensive elaboration of these training modes, including intricate details regarding their scale, frequency, and the participants involved, is encapsulated in Table 3. This table serves as a concise guide, presenting an overview of the distinct modes of training that have been identified through the course of our analysis.

Hence, our research endeavors to navigate through the dimensions of training, offering a nuanced understanding of its multifarious forms. It emphasizes the importance of diverse modes of knowledge acquisition within the academic milieu and their collective contribution to the broader goal of educational advancement.

Table 3. The 10 training modes

Method	**Scale**	**Duration**	**Participants**
Academic visit	Individual	3~24 months	Foreign institution
International conference	More than 100	~3 days	International academic peers
Academic annual conference	More than 100	3~5 days	International academic peers
Academic lecture	About dozens	Half a day	Famous expert
Academic salon	About 20	Half a day	Academic peers
Project meeting	According to project	Half a day	Project members
Lab meeting	According to lab	Half a day	Laboratory members
Train class	About 20~50	3~5 days	Similar staff
Self-study	Individual	According to self	Self
Online learning	Individual	According to self	Self

4.3. LMS for Scientific Research Institutions

Informed by our classification of training modalities, we have conceptualized a bespoke design for a Learning Management System (LMS) specifically aligned to the unique needs of research institutions. This design proposition represents a user-centric approach, emphasizing the varied learning behaviors and preferences exhibited by the users. These learning behaviors encapsulate a spectrum, including online engagement and knowledge exchange, intra-organizational learning and communication, autonomous self-directed learning, as well as an external learning interface and communication channels.

Our innovative LMS design is holistic, addressing every critical facet of training, namely the trainee, the audience demographic, the content and methods of instruction, the trajectory of career development, and the tangible effects of training. In order to provide a complete learning support system for these pivotal elements, our LMS design incorporates diverse features that empower learning. These include multi-platform learning, multimedia instructional materials, socially-mediated learning experiences, incisive data analysis, and streamlined course organization management.

An illustrative representation of these components and their interplay within our LMS design is detailed in Figure 3. It visually maps out the core aspects of our proposed LMS and their synergistic engagement, thereby providing a clear overview of this novel, comprehensive learning management system tailored for research institutions.

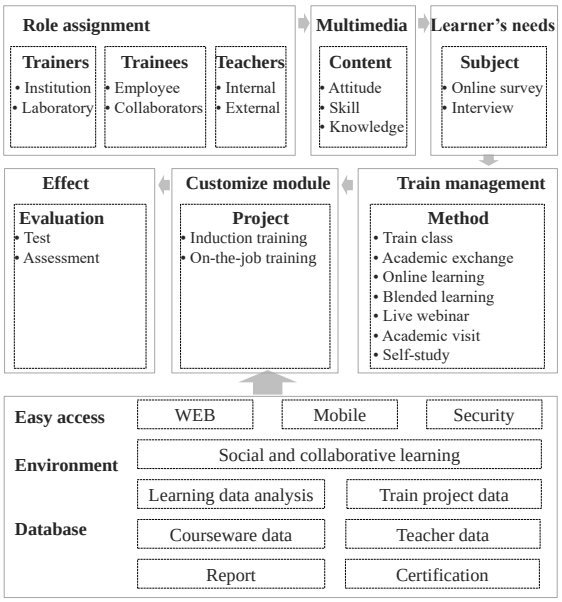

Figure 3. The proposed LMS design

Within the framework of research institutions, offline learning emerges as a significant modality of training and instruction. As such, the design of our novel Learning Management System (LMS) specifically highlights the element of digitizing offline learning management to dovetail with the emerging trends within education technology.

Systems such as these amplify the organization's offline learning endeavors by making them more efficient and manageable. Beyond systematizing the offline learning progression, our LMS is structured to meticulously capture and chronicle pertinent learning-related data.

Accruing this data underpins the enrichment of personalized training schemes. The usefulness of

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individualized data points becomes imperative when seeking to tailor the learning path and methodologies to each learner's unique needs and strengths. Thus, the learners' archived data serves as a bedrock upon which adaptable, custom-fit learning experiences can be conceived and implemented.

The interplay between the LMS, offline learning, and data-enhanced personalization strategies is schematically depicted in Figure 4. This visual representation delineates the manner in which various components of the learning ecosystem collaboratively inform and enhance the learning experience within research institutions.

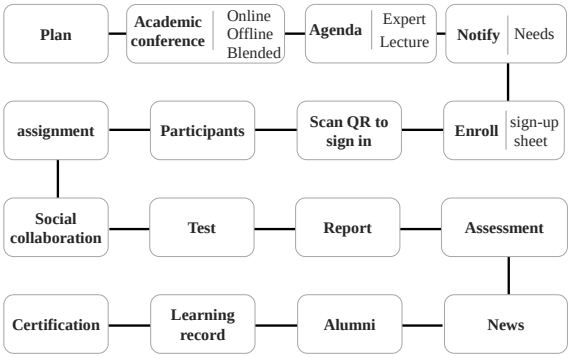

Figure 4. Digitalization of offline learning

5. LMS function

Since 2014, we have been on an unwavering mission to develop and continually refine our eLearning platform shaped by Learning Management System (LMS) design principles. This platform is designed to function as the hub for digital learning, offering a seamless integration of two primary functionalities - management and learning.

Through the web-based interface, users are granted complete access to all available features and functions. Additionally, we have extended the provision of learning support to mobile applications, democratizing the process of learning and making it accessible irrespective of geographical and technical constraints.

In order to facilitate effective operation, our platform delineates two primary user roles - administrators and learners. The administrator role maintains an overarching control on the managerial aspects of the platform, while the learner role primarily interacts with the learning resources available. This clear demarcation of roles ensures a streamlined management of the digital learning environment, enhancing its efficaciousness and user-friendliness.

5.1. Web-based learning platform

Our comprehensive learning platform, accessible via a web-based interface, extends an array of functionalities, with prime emphasis on the management subset. These management functions span across an array of tasks such as training schematics, project coordination, integrative databases for educational resources and pedagogical staff, statistical evaluation, surveys, advanced analytics, examinations, and more, allowing administrators to mold their digital learning environment to align with their unique requisites.

A distinctive feature of our platform's manifold components is the provision of training project management, a tool that noticeably enhances the efficacy of organizing offline training endeavors. Subsequent to producing a robust training scheme, administrators can generate an online pre-training survey to gauge specific learning needs. Simplified data assembly, coupled with provision for insightful analysis, bolsters the designing of a course curriculum grounded in real-time learning needs.

The platform also introduces a user-friendly course registration process, utilizing a QR-code-based system to provide straightforward entry to offline courses. This mechanism not only streamlines the learner experience but also aids administrators in effortlessly compiling comprehensive participant lists.

Boasting an intrinsic statistics module, our learning platform avails over 10 variants of statistical reports to administrators. These analyses serve as a powerful resource, furnishing administrators with fact-based insights that fuel informed decision-making, thereby driving the future growth and refinement of the platform. Through its feature-rich architecture, our eLearning platform thus fosters an enriching interplay between administrative control and learning efficacy, continually amplifying its potential as an educational tool.

5.2. Mobil learning

Understanding the constraints of limited screen real estate that mobile devices offer, our focus has been on optimizing the learning functionality for such platforms. A significant milestone in this regard was the development of a dedicated learning application initiated in 2018. Recognizing evolving user behavior and technological trends, the application was innovatively re-envisioned and upgraded to a lightweight learning mini-program in 2021.

This overhaul allows users to directly access the learning resources hosted on our mini-program via the internet, eliminating the necessity of cumbersome app downloads and installations, thus making the program more readily available and user-friendly.

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The primary features encompassed within the learning function of our mini-program predominantly consist of access to online educational materials, registration for offline courses, and the ability to view personalized learning records. Post completion of any course, users have the ability to evaluate the learning experience and articulate feedback in the form of comments. Furthermore, to acknowledge completion and achievement, electronic certificates are automatically generated and provided to the users, thus providing tangible recognition of their accomplishments.

In summary, the transition to a mini-program format enhances user flexibility and accessibility, ensuring an enriching learning experience seamlessly integrated within the familiar browsing environment. This seamless experience includes the comfortable one-click registration of courses and real-time progress tracking, rounded off with the capability of rating and commenting on course content, and capped with a token of acknowledgment in the form of an electronic certificate upon completion.

6. Casmooc Resources

Our commitment to the advancement of online education has led us to undertake a series of rigorous investigations, with the prime objective of developing high-quality digital learning materials. The framework of these comprehensive studies is meticulously designed to scrutinize the intricate science and art behind the development of effective courseware.

Realizing that crafting distinguished courseware is a complex process, we acknowledge that there exist multiple pathways to reach our end goal. Rather than constraining ourselves to a single method, we take a multi-faceted approach, garnering insights from various educational theories, technological advancements, and pedagogical strategies.

One foundational methodology we frequently employ is incorporating fundamental learning principles such as Behaviorism, Constructivism, and Cognitivism into our course design process. These robust theoretical frameworks guide us in curating and organizing enriching content that promotes deep, enduring understanding among learners. Each step of our courseware development process, from initial design to final implementation, is guided by a constant feedback loop. Utilizing various evaluation methods, including formative and summative assessments as well as user feedback, we continuously refine our course materials, making room for enhancements and improvements.

6.1. Courseware category

Informed by the Onion Model of Scientific Competency, we have conducted an in-depth categorization of the online course content. We approached this stratification process in a tiered manner: the primary level includes knowledge, skills, and attitudes.

Diving into the first category, 'Knowledge' is sub-classified into two types: 'Research Frontiers' and 'Basic Knowledge.' 'Research Frontiers' comprises video interpretations of journal articles, scientific project presentations, and academic conference proceedings. This compelling multimedia content provides insights into the leading edge of various research fields.

On the other hand, 'Basic Knowledge' forms the bedrock of any educational pursuit and this category includes a variety of disciplines. It spans the natural sciences, engineering, interdisciplinary studies, agriculture, social sciences, business, law, humanities, and arts, providing a comprehensive foundational understanding of these areas.

The second emphasis in our course is 'Skills,' which we split further into 'Research Capabilities,' 'Management Abilities,' and 'Health.' 'Research Capabilities' encapsulate scientific writing and reading skills, information literacy, mastery of lab equipment and experimental procedures, as well as pedagogical competencies.

'Management Abilities' introduce students to the vital skills of team and project management, prepping them for collaborative research environments. 'Health,' on the other hand, consists of mental wellness and physical health modules, acknowledging the significant role played by wellbeing in academic and professional success.

Finally, 'Attitude' is the last but equally significant component of our course. It is further divided into 'Ethics,' 'Integrity,' and 'Spirit.' These elements aim at nurturing an academic culture defined by respect for ethical norms, unwavering integrity, and a relentless pursuit of knowledge.

In essence, the online course content represents a calculated blend of well-rounded knowledge, practical skills, and positive attitudes that holistically addresses scientific competency, staying true to the Onion Model’s framework.

6.2. Diverse approaches

To effectively encompass a diverse range of pedagogical contexts and requirements, our research proposes a conceptual framework for categorizing recording methods along two dimensions.

The first dimension pertains to the recording location, viz., studio and live scene settings. This aspect guides the visual and acoustic elements of the course content which significantly influence learner engagement and comprehension.

The second dimension concerns the instructional source - the course instructor. This emphasizes the role of the instructor in administering the course

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content which crucially shapes the learner's experience and understanding.

Exemplifying application of these dimensions, we have produced studio-recorded material for the Management Ability and Spirit courses. These have been meticulously crafted as training courses, delivered in a controlled setting to ensure consistency and focused learning instruction.

On the other hand, Skills courses have been created in authentic laboratory environments, offering the learners an immersive, real-world training experience. These live-scene lessons exemplify interactive learning experiences, enriching the educational content with practical demonstrations and direct instructor interactions.

The Academic Exchange sessions, however, have been studio-recorded but designed as user-generated content, leveraging the controlled environment while maintaining a participatory dialogue.

Lastly, we have crafted Cutting-Edge Science courses by recording academic conferences. Again, these are designed as user-generated content, yet they provide access to cutting-edge scientific dialogue, presenting the learners with first-hand exposure to advanced research narratives.

In essence, our pedagogical model encourages dynamic learning experiences, blending precisely curated content within controlled settings with the authenticity and vibrance of user-generated content in live scenes. We believe this diverse and considered approach nurtures robust, comprehensive educational offerings.

6.3. Professional studio

To construct premium digital learning resources, we established a professional recording studio explicitly designed to cater to various recording needs. The studio is partitioned into seven dedicated functional zones, each contributing unique attributes to the production of educational content.

The 'Video Recording Room' is equipped with cutting-edge technology to record visually engaging material. Notably, it features green screen capabilities, which imbues our video content with versatility by enabling manipulation of the video background. This attribute enhances the allure of our content, stimulating learner interest and engagement.

The 'Broadcasting Area' functions as the nerve center of our recording processes. It is designed to oversee, manage, and monitor all recording activities. Additionally, it houses the resources for post-production video editing, ensuring our content is seamless and professionally presented.

Our 'Audio Recording Room' is acoustically tailored to capture clear and vibrant audio content. It caters to the production of complementary audio materials or independent audio-centric educational resources.

We conduct our 'Academic Exchanges' in the purpose-built 'Interview Area.' Here, we foster a conducive environment to facilitate healthy intellectual dialogues; these discussions are recorded and developed into rich, interactive course materials.

The 'Release Area' is particularly designed to record report videos. This space accommodates the production of announcement videos, press releases, or any other material requiring a formal presentation backdrop.

In our 'Interactive Area,' we employ interactive screens to capture real-time explanations and visualizations from instructors. This technology enriches our digital resources by providing detailed, illustrative explanations, amplifying learner comprehension.

Finally, the 'Speech Area' replicates a mini stage, where instructors deliver their presentations in a lecture-style setting. This setting enables the creation of traditional lecture-format content that students find familiar and effective.

In conclusion, our professional studio brings together an array of specialized recording spaces, each contributing uniquely to our goal of generating superior quality digital educational resources.

6.4. Courseware database

Our educational endeavors have culminated in the creation of an extensive library of over 3000 video-based courseware items. These encompass a wide range of disciplines, skill sets, and comprehensive knowledge repositories.

Specifically, we have harnessed live recordings of academic conferences to craft courseware for advanced fields such as Synthetic Biology, Applications of Machine Learning, and Urban Environmental Studies. These courses provide learners with top-tier insights into these rapidly evolving fields, offering real-time expert discussions and research developments.

In addition to these specialized courses, we have also developed a collection of Basic Knowledge courseware. Courses such as those dedicated to Brain Science serve as a part of this repository, providing students with a robust foundation in crucial scientific domains.

Moreover, as part of our commitment to encouraging independent research skills and scholarly excellence, we have also curated an Information Literacy Series. This includes a set of instructional videos that guide learners in the use of databases, and the development of effective writing, reading, and research skills.

By marrying foundational knowledge with cutting-edge research developments, our courseware library ensures a holistic learning experience. It prepares learners not only to absorb and understand comprehensive bodies of knowledge but also equips

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them with the essential tools for effective academic exploration and research.

7. LMS Application

Pedagogical profiles curated for over 70,000 research personnel and other staff members contribute to the extensive archive that we have successfully constructed. This compilation encompasses both the online and offline learning segments, thereby producing a meticulously detailed record of everyone's educational journey.

The magnitude of data harvested from this endeavor is impressive. It comprises virtually 1,100,000 hours of online learning metrics and surpasses 3,400,000 hours when considering offline training. This conglomerate of learning data manifests the scope and depth of our learning programs and the impact it harbors on a wide researcher and staff demographic.

Equally noteworthy is the portfolio of nearly 40,000 offline training initiatives that have been implemented under this system. Each phase of these projects, from conception to completion, has been systematically documented and added to our robust database.

These statistics underscore the widespread utility and popularity of our learning platform. Simultaneously, the profound data footprint generated through these efforts illuminates the vast learning encounters being facilitated, captured in their entirety, which can serve as a critical resource for future educational strategy designing and implementation.

8. Conclusion and Recommendations

In accordance with the above design principles, we upgraded the LMS of the Chinese Academy of Sciences (www.casmooc.cn) in 2021. And a revision survey was conducted, with active participation from 345 users. 75% of users believed that the content design was clearer. The LMS accumulates 9 million hours of learning data every year and establish learning profiles for each user.

This study mainly analyzed the characteristics of training in research institutions, as well as the design and practice of LMS, and has achieved certain results. The practice result demonstrated that the principle is useful. However further work is needed to be carried out on the integration of academic exchange and LMS to achieve efficient continuing education for researchers.

The development trends of LMS in research institutions also include:

1) Analyzing learning data can promote precise learning. For research users, it is also possible to analyze the trend of interdisciplinary research and recommend potential research partners and research topics for users.

2) Integrating academic exchanges with LMS can expand users' academic circles, promote scientific research exchanges, and accumulate cutting-edge scientific and technological data.

3) User-Generated Content (UGC) could play a greater role as the science community focuses on mutual education, such as academic exchange. The generated content by users in a research institution is more important than other institutions, and further research is needed on UGC.

4) AI enhance learning. AI can provide problem-based learning for users.

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