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ICT Use and Increasing Openness in Higher Education — Advanced e-learning and Open Educational Resources —

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1 Introduction

The environment surrounding higher education has been dramatically changing due to social changes such as globalization and aging, as well as to rapid technological advancement. In particular, progress in Information and Communications Technology (ICT) has released space and temporal constraints from the traditional higher education system, providing the foundation for bringing a new kind of higher education.

The Open University, United Kingdom, the Open University of Japan, and other distance learning have long been using radio and television programs as shown in Figure 1, mainly to provide lifelong educational opportunities to working people. In recent years, the widespread use of inexpensive personal computers has created a favorable environment for e-learning. Moreover, the boundary between e-learning and distance learning has blurred, and these have become integrated with the use of electronic content distribution and interactive communication systems on the Internet. It is highly probable that open movement in education such as OpenCourseWare which publishes lecture material and videos on the web will change not only the frameworks of distance learning and e-learning, but also the existing framework of higher education in general.

This article introduces novel higher education using ICT mainly in the United States, and describes increasing openness in higher education and the resulting global ripple effects.

2 Effects of ICT Use in Higher Education in the United States

2-1 Cost assessment

In the United States, the National Center for Academic Transformation (NCAT)[1] was established in April 1999. NCAT is an NPO aiming to improve learning effectiveness and reduce costs in higher education. With support from the Pew Charitable Trusts (an NGO) and the Department of Education

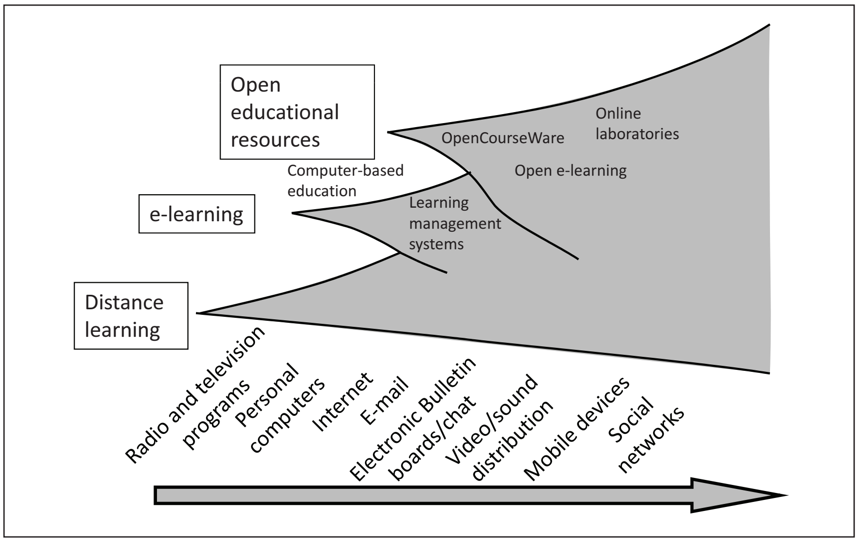


Figure 1: Changes of higher education using ICT
Prepared by the STFC

in the United States, NCAT conducted a project to introduce new educational courses using ICT and to assess the effect of the courses. Figure 2 illustrates the cost-reduction effect of the new educational courses using ICT, as indicated by NCAT. The chemistry course at Arizona State University reduced the cost per student from $439 to $351. The total number of students who took the course was 4,640, and the total cost reduction amounted to $408,320. The math course at Virginia Tech reduced the cost per student from $91 to $21, achieving a 77% cost reduction. The Spanish course at the University of Tennessee also cut the cost per student from $109 to $28. The courses that have shown significant cost reduction include math, chemistry, languages, and English composition. The common characteristic of these courses is that they are basic-level courses where students' achievements can be clearly determined.

The cost calculation and allocation methods considering common facilities need to be further examined. This project is very important, because it aims to objectively verify a portion of higher education courses from the perspective of cost effectiveness and, at the same time, to promote the use of ICT. The following sections introduce some specific cases.

2-1-1 e-learning centers with teaching assistants

Virginia Tech opened a learning center called the Math Emporium, which has 537 computers for math e-learning.[3] The center is open all day, and students can independently learn according to their own schedules. In addition, students have opportunities (80 hours per week) to get personal assistance from professors, lecturers, and teaching assistants. On weekdays, teaching assistants work until late at night, so that even after faculty office hours, students can get learning assistance. After the onset of this system, the GPA (Grade Point Average) increased from 2.39 to 2.42 on a four-point scale, and the percent of students who acquired credits raised from 80.50% to 87.25%.

Cost per student also decreased through independent e-learning and support from teaching assistants. One of the reasons was that the novel courses received more earnings from tuition due to the increased number of students compared to traditional courses. Another reason was that the active use of teaching assistants, who cost less than professors and lecturers, led to personnel cost cutting.

The University of Idaho and the University of Alabama also established similar e-learning centers (the Polya Mathematics Center and the Mathematics Technology Learning Center, respectively). After the introduction of e-learning at both universities, equal or better learning effects were observed, and the percentage of students who failed to acquire credits decreased.

2-1-2 Independent learning assistance through e-learning

The beginning Spanish courses at the University of Tennessee and Portland State University and the statistics courses at Pennsylvania State University

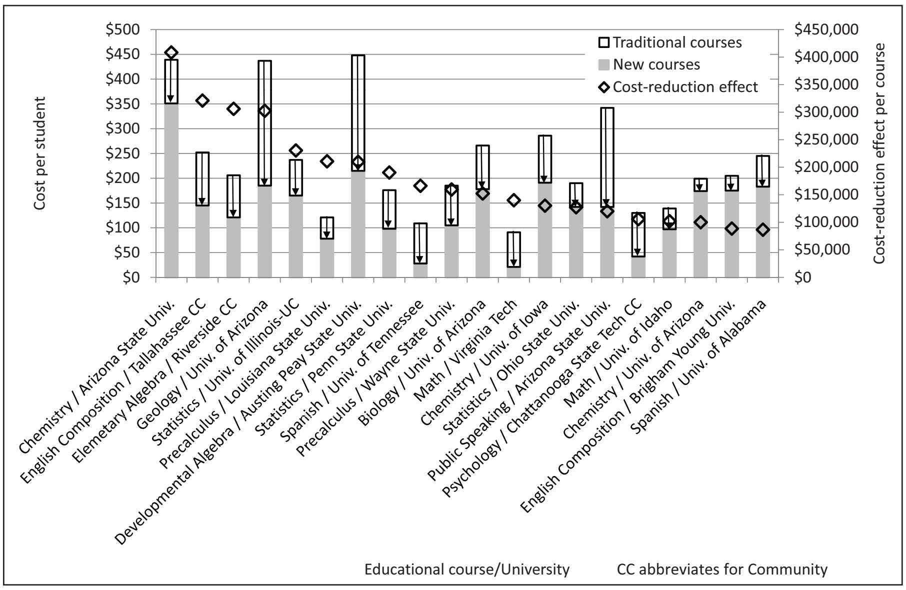


Figure 2: Cost reduction effects in novel courses using ICT

Prepared by the STFC based on Reference[2]

and the University of Illinois at Urbana-Champaign have introduced independent learning for their students using e-learning materials. The teaching staff receives feedback as the learning portfolio collecting learning records and including students' test results using the e-learning systems. The staff could adjust teaching speed in their classes according to students' understanding. This also contributes to improve the progress of the classes. A part of teaching contents explained in the usual classes was substituted by e-learning. Such independent learning assistance reduced the number of classes. As a result, it increased the number of students per teaching staff, and decreased the cost per student.

2-1-3 Online distance learning classes

Online classes can reduce physical constraints in higher education, such as the lack of classrooms. Art courses at Florida Gulf Coast University use an Internet phone and meeting system to conduct online distance classes, without using actual classrooms. This reduces the costs for keeping classrooms and other facilities, leading to cost reduction per student.

In Japan, a partnership between Bond University in Australia and Business Breakthrough, Inc. provides online distance classes in a MBA program.[4] Without studying abroad for a long period of time, it is possible for students to participate in a program offered by an overseas institution of higher education. In addition, RareJob, Inc., a language education company, uses free Internet phone services to have students and graduates from the University of the Philippines (living in the Philippines) teach English conversation classes.[5] This kind of transnational online distance education has led to the creation of new businesses that utilize highly skilled workers in developing countries.

2-2 Imroving efficiency through learning management systems based on ICT

Learning Management Systems (LMSs) and Course Management Systems (CMSs) enable information sharing between teaching staff and students, the centralized management of handouts and assignments, the management of students' progress, and achievement assessments. Digitized teaching materials used in e-learnig are also included in LMSs. By introducing LMSs into higher education, a smaller number of teaching staff are able to effectively teach classes for a larger number of students.

Blackboard[6] (commercial system), Moodle[7] (open source system), and Sakai[8] (open source system) are known as LMSs. The number of registered Moodle users has been increasing, and at the end of 2010, more than one million people were using Moodle around the world (Figure 3).

Figure 4 shows a screenshot of Sakai LMS and available functions. Sakai offers collaboration, teaching/learning, and portfolio tools. The collaboration tools provide functions for sharing information between teaching staff and students and for promoting communication among participants. The latest version of Sakai includes collaborative functions with cloud applications like Google Docs, Gmail, and SNS like facebook. The teaching/learning tools provide syllabuses, assignments, and tests. The portfolio tools offer feedback to students about their assignments as well as the management of their learning progress.

In addition, mobile learning (m-learnig) using smart phones and other portable devices based on the LMS have been tried.

Since various LMSs have been developed, the compatibility between different systems has also been examined. For example, the Advanced Distributed Learning (ADL) Initiative in the United States[NOTE 1] developed SCORM,[9] which integrates a set of standards, specifications, and guidelines. In addition, ISO/IEC JTC 1/SC 36[11] discusses technology standardization concerning LMSs.

2-3 Management systems for higher education

Kuali Foundation has developed and released (as an open source) a comprehensive management system that includes not only learning management tools, but also administrative and research management tools for universities.[12] Kuali's administrative management modules have been introduced at the University of Southern California, Cornell University, Indiana University, and Colorado State University. Colorado State University had estimated $5 to $7 million for the introduction of an administrative management system

[NOTE 1]
The Office of the Under Secretary of Defense for Personnel and Readiness (OUSD P&R) created the ADL Initiative in 1998 during the Clinton administration.[10]

on the market, but ended up paying only $2 million by adopting Kuali's administrative management modules.[12]

2-4 Cloud educational applications

Google offers Google Apps for Education free of charge for educational institutions. This is a cloud application that includes e-mail, group calendars, and Google Docs.[13] If an institution changes its email system to Gmail, it can continue to use same e-mail addresses with previous system, and so the transition is easy. By using such cloud services, educational institutions can provide ICT-based services to their teaching staff and students without having to set up and manage their own servers.

3 Globally influential open educational resources

Educational contents represented by OpenCourseWare, educational tools including learning management systems developed as an open source, and related intellectual properties, are called open educational resources (OERs). The following section introduces some of these globally influential open educational resources.

3-1 OpenCourseWare

OpenCourseWare (OCW) is "an open and a free publication of formal course materials of universities on the Internet."[14] OCW provides syllabuses, lecture notes, assignments, and exams and their answers. OCW also sometimes provides lecture videos and

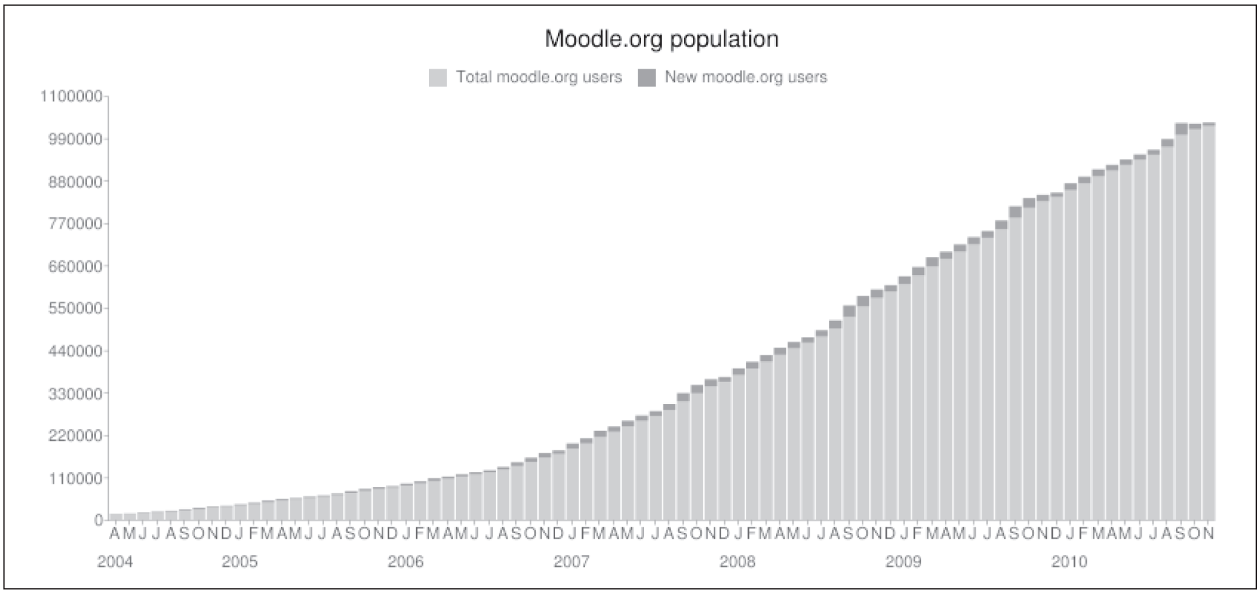
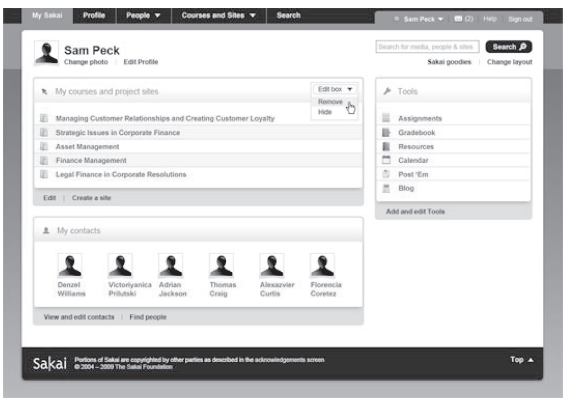


Figure 3: Changes in the number of Moodle's (open source provider's) registered users

Source: Reference[7]

(a) Screen shot



(b) Functions

Collaboration tools
- Announcements
- Site-related information
- List of participants
- E-mail archive
- Wiki
- Blog
- Calendar
- Chat
- Discussion forums
- Glossary
- External link
- News

Teaching/learning tools
- Syllabus
- Timetable
- Assignments
- Tests & Quizzes
- Grade book
- File sharing

Portfolio tools
- Progress management
- Feedback
- Report management
- Templates

Figure 4: Sakai (open source provider's) LMS system

Prepared by the STFC based on Reference[8]

e-learning materials. Universities do not offer degrees or credits to OCW users who are not their students. Additionally, universities do not allow such outside OCW users to contact their teaching staff. Not all content in a class is included in OCW materials due to copyright issues that does not allow to open to the public.

As Figure 5 illustrates, Massachusetts Institute of Technology (MIT) has offered OCW courses since 2002, and published more than 2,000 courses in 2010.[15] 8.01 Physics: Classical Mechanics is a representative MIT OCW, for which all the class content is published, including lecture videos, notes, exams, and answers.

It is estimated that more than 100 million people have accessed MIT's OCW website, and about 60% of the visitors are from Asia and Europe. MIT has delivered audio and video using YouTube, iTunes U, Podcast, and flickr providing photo sharing services in addition to OCW since 2008. There are mirror sites of MIT OCW that provide translated and localized versions around the world. These contribute to the extension of opportunities for higher education in developing countries.

In addition to MIT, Tufts University and many other universities in the United States offer OCW courses. The Open University[16] in the United Kingdom and the Open University of Japan (which have been conducting distance education) have also provided OCW courses. According to the OpenCourseWare Consortium, 107 organizations in 208 countries conduct OCW activities.[17] In Japan, Japan OpenCourseWare Consortium (JOCW) established in 2005 is active to popularize OCW as well as offering OCW. As shown in Figure 6, the number of OCW courses offered in Japanese and English have been increasing. In French-speaking countries, UniversitySurf,[18] an OCW portal site, offers more than 1,500 courses. A similar portal site called Universia[19] exists in Spanish-speaking countries. In China, China Open Resources for Education (CORE) is conducting OCW-related activities.[20]

It is not easy to assess the overall trends in OCW offered by various web services around the world. Apple's iTunes U offers more than 350,000 lecture videos and materials from over 600 universities.[21] In the case of iTunes U, a university can limit access to its own students, so content is not necessarily open to the public. It is substantially estimated that an even greater number of higher educational resources have been used around the world.

3-2 Open Learning Initiatives

The Open Learning Initiative (OLI) at Carnegie Mellon University (CMU)[22] aims to make advanced e-learning content as an open educational resource. The OLI offers free e-learning content in physics, chemistry, biology, biochemistry, statistics, French, etc..

Figure 7 illustrates online materials and a virtual lab offered by the OLI at CMU. In the online materials in Figure 7(a), a computer-based tutor on the computer

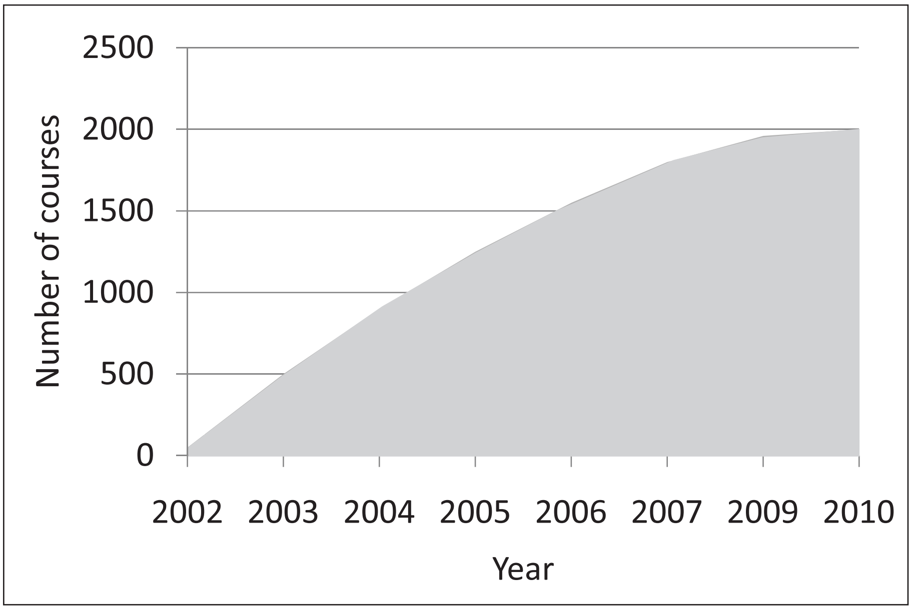


Figure 5: Changes in the number of OCW courses at MIT

Prepared by the STFC based on Reference[15]

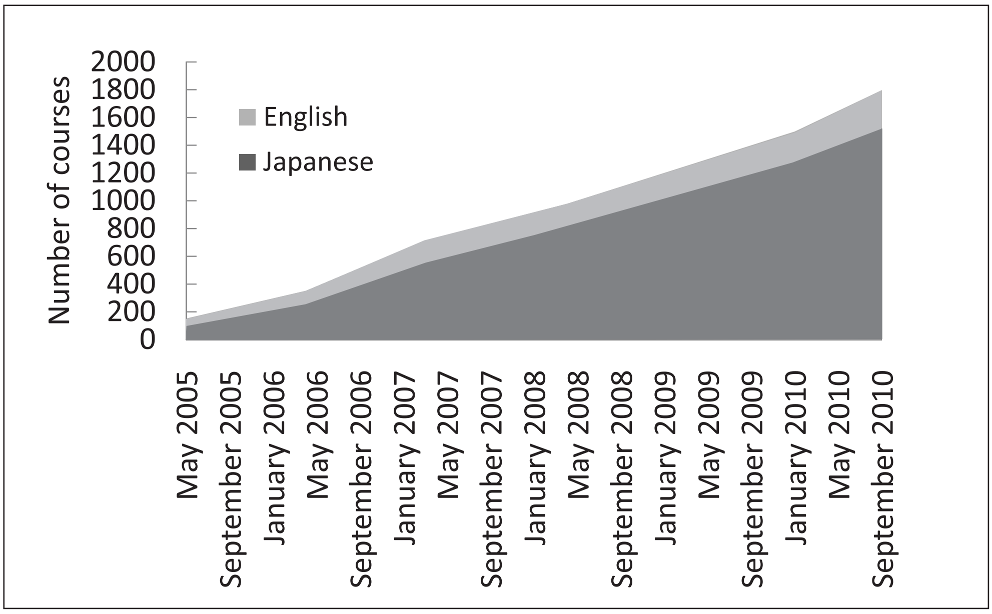


Figure 6: Changes in the number of OCW courses published in Japan

Source: Reference[14]

comments on a student's answers. When a student makes a mistake, the student can quickly check why he/she has made the mistake. It makes efficient independent learning possible. Figure 7(b) shows a virtual laboratory where a neutralization reaction is simulated and the result is visualized. This application allows a student to understand the changes in molar concentration, temperature, pH, etc. when the reaction has started by mixing the solutions. It is useful to better understand chemical phenomena.

The OLI at CMU consists of academic courses without limitation and open & free courses that limit available functions as shown in Table 1. Anybody can take the open & free courses, but the users are not allowed to contact teaching staff at CMU or to receive credits. Not only CMU students, but also students and teaching staff at other educational institutions can take the academic courses if they register. However, credit accredit to a student depends on the educational institution that the student belongs.

3-3 Khan Academy

Khan Academy,[23] a non-profit educational institution, uses YouTube to provide more than 1,800 lecture videos in math, physics, chemistry, and other subjects covering elementary, secondary, and tertiary education levels. Each lecture video in each topic is ten to twenty-minutes long. Instructor uses a computer pen tablet that replaces an ordinary lecture board, so that the lecture videos can be created inexpensively without using special equipments including movie camera and so on. Khan academy also offers some captioned lecture videos and web applications for exams. The content is regarded as high quality and suitable for independent learning, and is supported by Google Inc. and the Bill and Melinda Gates Foundation.

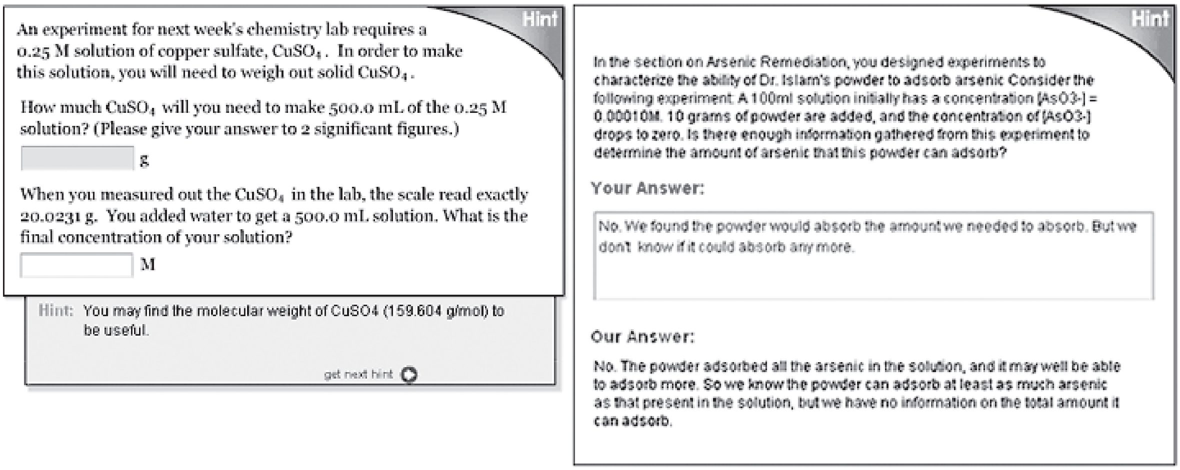
3-4 Online laboratories

Research equipments and computers connected to the Internet have been shared to a greater extent than previously in various research areas. This is an aspect of the changes in research called e-Science.[24] There is also a movement toward educational equipment and facilities being used more openly. For example, the iLab project offers online laboratories that can be operated using a web browser.[25] The iLab project provides opportunities of online experiments in physics, chemistry, electronic engineering, and other subjects. Not all experiments can be conducted online. However, interactive experiments can be done through the remote operation of measurement control tools connected to computers in many cases. The National Science Foundation (NSF) in the United States supports the iLab Network project that universities in the United States and Australia participate.[26]

One example of an online experiment in the iLab Network project is the use of inductively coupled plasma atomic emission spectrometry at Northwestern University in the United States (Figure 8). The device applies thermal excitation to a sample at 4,000K and then observes an emission spectrum when the sample

(This virtual laboratory simulates a neutralization reaction and shows the changes in molar concentration, temperature, pH, etc. when the reaction has started by mixing the solutions.)

(a) Online materials



(b) Virtual lab

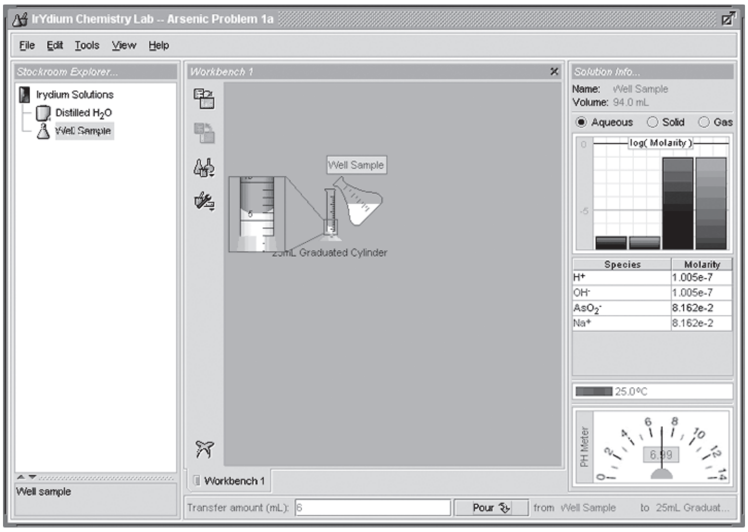


Figure 7: Online chemistry materials and a virtual lab offered by the Open Learning Initiative (OLI) at Carnegie Mellon University (CMU)

Source: Reference[22]

Table 1: Tools offered by the OLI at CMU

	Open & free courses	Academic courses
course materials	○	○
Simulations, Computer Based Tutors, Virtual Laboratories, and Self-Assessments	○	○
Formative Feedback for student	○	○
Access to an Instractor teacher	×	○
Graded Exams	×	○
Tracks Student-Learning as Feedback for Instructors	×	○
Credit / Verification of Course Completion	×	○

Prepared by the STFC based on Reference[22]

returns to the ground state. The device identifies the elements composing the sample and determines their quantities from the spectrum. For example, online environmental science experiments targeting college and high school students allow the study of metals contained in samples such as water, soil, plants, etc.. This online laboratory adopted a learning management system and automatically provides students registration, content and related OCW to be pre-learned.

As such, online laboratories allow teaching staff and students to share expensive equipments from anywhere in the world and conduct experiments without constraints of their own equipment. In particular, online laboratories are effective in the situation where special equipment is only owned by a limited number of organizations. Widely providing advanced science and technology programs will contribute to extend educational opportunities in these fields. Of course, it is also hoped that these online laboratories will be widely used not only in higher education but also in secondary education.

4 Prospects of Changes in Higher Education Using ICT

This chapter discusses changes in higher education using ICT mainly in Japan as well as the impact of increasing openness in higher education around the world from the three perspectives in the following sections.

4-1 Scalable educational infrastructure

In the traditional teaching style in which a teaching staff lectures to students in a classroom, the number of students is limited according to the size of the classroom. However, online lectures and e-learning can easily expand the number of students and the physical distance between a teaching staff and students. When an institution in higher education only has a small number of students, it can work together with several other institutions to gather many students and boost scale merit. If the number of students decrease in the future, the scale can be easily adjustable. In Japan, institutional collaboration based on e-learning have already been conducted in the framework of the Support Project for Strategic University Collaborations by the Ministry of Education, Culture, Sports, Science and Technology.[27,28] There is a possibility that institutional collaboration in higher education taking advantages of ICT will be important in Japan where birthrate continue to decline, compared with other countries.

In Japan, cram schools and companies have more introduced e-learning taking advantages of ICT than universities so far. If more universities adopt ICT, it will be possible for them to invest saved resources in new research or other educational improvements. If universities use the saved resources for reduction in tuition and scholarships, it will lead to expand equal educational opportunities in higher education.

4-2 Expanding use of advanced e-learning

e-learning, and mobile learning based on learning management systems enable students to access educational content from outside the university whenever they want. Moreover, social network systems may allow extended communication between

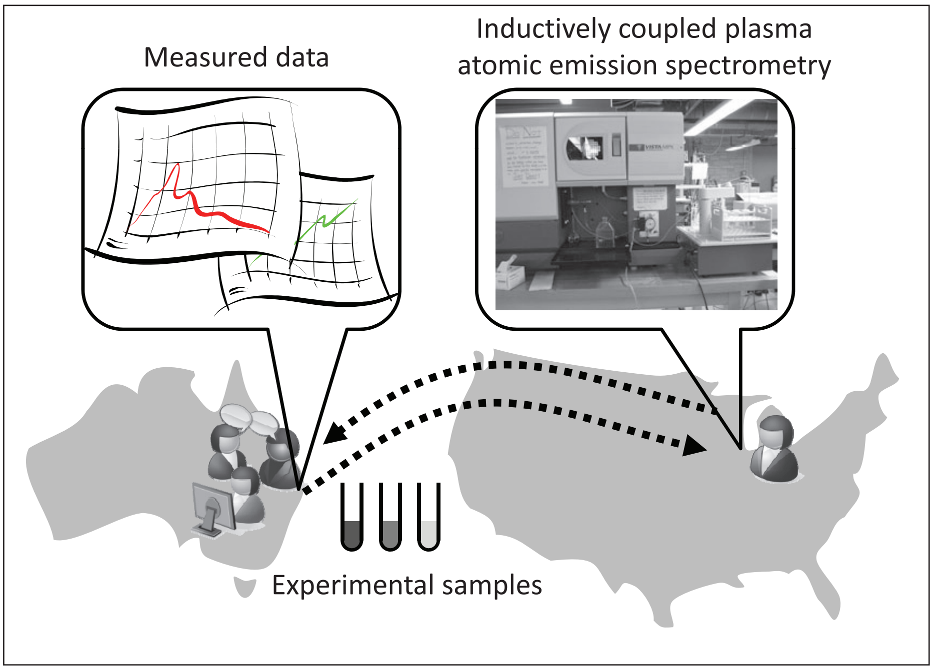


Figure 8: Online experiments of environmental science provided by Northwestern University in the United States through the iLab Network project

Prepared by the STFC based on Reference[26]

teaching staff and students who do not belong to the same institution. If advanced e-learning improves the effectiveness of independent learning, problem solving and experience based learning can be emphasized in actual classrooms. If e-learning is used more widely, the roles of tutors will be more important, and the balance between teaching staff and students in higher education will be changed in the future.

In Japan, e-learning-based outsourcing services have been provided for remedial education to students who lack academic capabilities required at universities. Remedial education using e-learning has been conducted for prospective students who have passed AO (Admission Office) exams or have been admitted based on recommendations.[29] It is expected that efficiency in higher education will be improved through outsourcing services using e-learning, not only in remedial education, but also in general and professional education. For example, such services can be used to teach students who have different professional education backgrounds in interdisciplinary research. In order for students with different academic backgrounds to quickly acquire the basic knowledge required for research, supplementing the curriculum with e-learning and other tools will be effective. In remedial education, teaching staff in universities do not have much psychological resistance to adopt e-learning, since they consider the remedial education outside the scope of education in universities. However, the introduction of e-learning into general and professional education will lead to reconsider the traditional educational system, including personnel organization at higher educational institutions. Professionals involved in higher education must pay more attention to the fact that global changes in technical trends require institutions of higher education to change.

4-3 Increasing open educational resources

OpenCourseWare (OCW) providing educational materials free of charge to prospective students and self-learners can be considered as ways for higher educational institutions to send information to society. For example, OCW provides lifelong study to self-learners who were not able to receive higher education due to their regional or cost issues. OCW plays role to restore accumulated intellectual resources in universities to society. On the other hand, OCW is an effective publicity tool for educational institutions to attract excellent students from around the world. This may increase gaps between educational institutions in the future.

If we consider higher education from the aspect of public goods shared in society, open educational resources can be regarded as common pool goods[NOTE 2] that anyone can learn independently without cost. Open educational resources that offer more open educational opportunities are different from club goods provided by the traditional educational system, where educational institutions exclusively accredit credits and award degrees to students who pay tuition. If some people wish to learn without needing to acquire degrees as signaling for guarantee their capabilities, part of the knowledge acquisition process in higher education can be easily and effectively replaced by open educational resources. Meanwhile, we emphasize the aspect of public goods in terms of open educational resources that is not limited to specified institutions, there will be new issues how we share social expense to develop and maintain such resources as well as the management of intellectual properties and copyrights. These imply important changes when we overlook the future of the higher education system.

It is estimated that MIT spends between $10,000 and $15,000 to make OCW content for each course,[15] which suggests OCW content of 2,000 courses costs $20 to $30 million. Since the content needs to be updated annually, the university must continuously share the cost for the maintenance of OCW. In the United States, the William and Flora Hewlett Foundation, the Andrew W. Mellon Foundation, the Bill & Melinda Gates Foundation, and other

[NOTE 2] : Classifications of goods

	Competitive	Non-competitive
Excludable	Private goods	Club goods
Non-excludable	Common-pool goods	Public goods

*If the consumption is non-competitive and the supply is non-exclusive, the goods or services are called public goods. Non-competitive means that a person can consume goods or services without paying any costs. Non-exclusive means that multiple people can equally consume the goods or services.

private foundations have been providing funds that greatly contribute to the expansion of open educational resources including OCW. The progress of ICT reduces the infrastructure costs for providing open educational resources, but the support for continuous maintenance and improvement of open educational resources still remains an issue. Currently, organizations and teaching staff who recognize the worth of open educational resources provide such resources. Although contribution to open educational resources is regarded as part of their educational activities for individual teaching staff, it will be necessary to provide incentives, e.g. performance evaluations for teaching staff, to keep their efforts to expand open educational resources.

To provide equal educational opportunities, the International Institute of Educational Planning in UNESCO[30] and the Open eLearning Content Observatory Services[31] funded under a project in the European Union have portal sites offering research, reports, and information on open educational resources. It can be considered as an effective way to develop public infrastructure to maintain this kind of portal site and other repositories that do not belong to a certain institution of higher education apart from direct funding support.

Licenses applied to open educational resource basically follow the Creative Commons licenses,[NOTE 3] however similar but original licenses have also been applied. Since Creative Commons licenses are composed of detailed articles, allowance and restriction can be flexibly set up either for commercial or non-commercial use as well as treatment for their derivatives. It is generally allowed to distribute copied materials for educational use in a class without a fee for publications including academic journals published from academic institutions as well as commercial publishers. However, similar allowance cannot be applied to the open content. Contribution from researchers are also required to enrich the open educational resources, for example, they actively open a part of research achievement to the public under the Creative Commons licenses through Wikimedia Commons or similar sites.

5 Conclusions

The introduction of advanced e-learning into higher education is expected to improve learning effectiveness and to reduce costs, which are conflicting problem to be solved in the traditional higher education system. Open educational resources will easily replace part of the knowledge acquisition process in higher education. The worth of institutions of higher education will be evaluated from the originality of their curricula and content appeared in their special programs such as problem solving and experience based education, rather than knowledge acquisition process where ICT can be used.

Open educational resources represented by OpenCourseWare have greatly contributed to social education by closing regional gaps in higher education and expanding lifelong educational opportunities for many people. At the same time, this increasing openness may require redefining the traditional higher educational system based on the degree accredit. The impact of ICT such as advanced e-learning and open educational resources should be regarded as a change of technological trends that presents issues to institutions in higher education. Such technological change may bring great transformation to institutions of higher education, so professionals involved in higher education must share a common awareness of the issues.

We guess the discussion on higher education and ICT in Japan has mostly been confined to specialists in educational engineering. According to the instances shown in the spontaneous activity of institutions of higher education and nonprofit organizations mentioned in this article, the discussion should be put into a broader context that includes the management of universities and globalization, which has the potential to develop further.

If higher education in Japan is required to respond to global changes, it will obviously be essential to steadily introduce technological innovation using ICT into education. It is necessary to consider the impacts of external environmental changes including advanced

[NOTE 3] : Creative Commons licenses[33]
It offers intermediate licenses that are different from protection or renunciation of all copyrights or. A licenses is defined by a combination of 1) attribution (the original work must be credited), 2) non-commercial use (the work must not be used for commercial purposes), 3) no derivative works (the original work must not be altered), and 4) share-alike (derivative works must be released only under a license identical to the license of the original work).

ICT in higher education from a broader perspective as well as labor saving tasks in education and research using ICT from a day-to-day perspective.

For each institution of higher education, it is required to expand current efforts from specialists engaged in teaching to the institutional administration. The first step to for the purpose would be to share understanding and discussion between teaching and administrative staffs beyond specialties and organizational boundaries.

It is also desirable for the government to assess in a certain standard and announce spontaneous activity of each institution from the perspectives of learning effectiveness and costs. To encourage the sustainable efforts in each institution, it would be effective to reflect the assessments to the distribution of funding.

ICT is expected to release physical and temporal constraints in the traditional higher educational system and to enable a scalable educational infrastructure, where a considerable increase of investment in educational resource is not required even if the scale expands. It has become increasingly clear that advanced e-learning and open educational resources have multifaceted impacts, such as expanding learning opportunities due to lower costs, improving the effectiveness of independent learning, and creating borderless learning environments (Figure 9). Of course, these are not effective in all aspects of higher education, though we guess that their impacts on education aimed at knowledge acquisition, in particular, are considerable.

Acknowledgements

We would like to express our appreciation to Professor Yoshimi Fukuhara at Keio University for providing us with reference materials and advice.

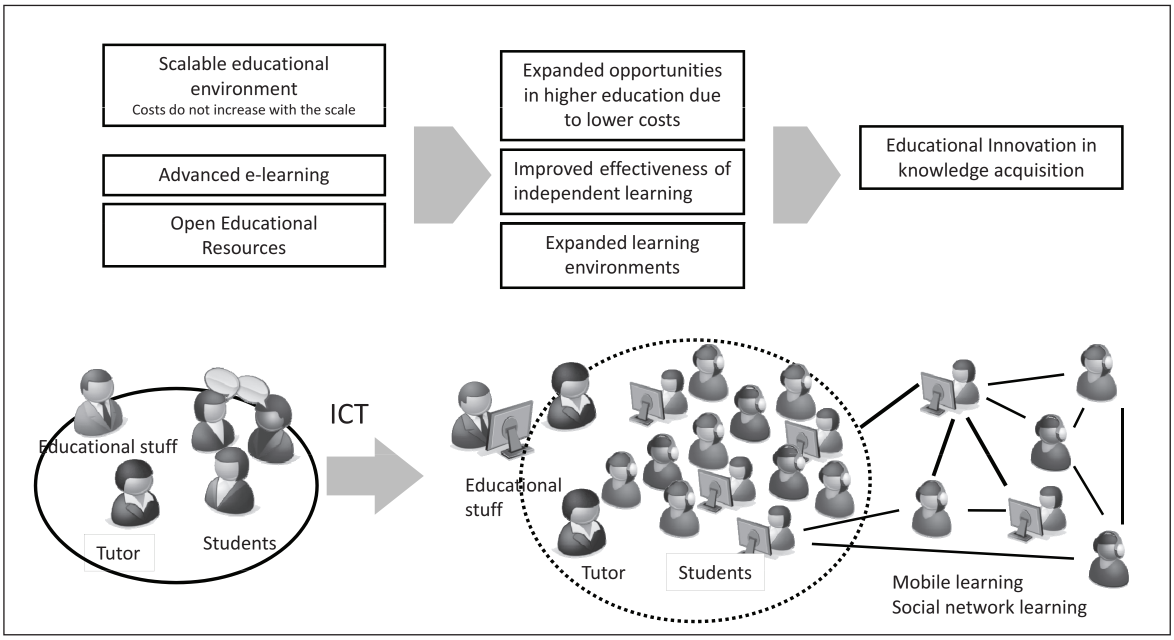


Figure 9: Prospects for changing higher education with the use of ICT

Prepared by STFC

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Profile

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(Original Japanese version: published in February 2011)