

# Building Moodle-based Learning Management Systems for Universities: A Development Report of the Gikadai LMS

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## Abstract

The Gikadai LMS is a Moodle-based learning management system developed over the course of two years by the Center for IT-based Education at Toyohashi University of Technology. From its inception to its full maturity, the platform underwent iterative design, development, and revision processes. Now, the platform is fully operational and awaiting user visits and usages. This paper presents the Gikadai LMS as a case study to share a comprehensive understanding of LMS development and to demonstrate the final product. To actualize the university's digital education vision, the project was driven by four objectives that cover system interoperability, open curriculum, e-portfolio management, and online teaching and learning assistance. Four levels of development were implemented as responses: strategy, server, application backend, and application frontend. The final product is a unique Moodle instance that is networked with e-portfolio management system Mahara, integrates Google Classroom functions, allows unlimited video conference meetings simultaneously via the BigBlueButton tool, highly tailored user management and course management in accordance with the university's academic structure, open online classrooms for teachers and students, and friendly online support provided by both asynchronous human agents and a synchronous chatbot.

## 1 Introduction

Toyohashi University of Technology (TUT or Gikadai) is one of only two Universities of Technology in Japan, with over 80% of its students directly transferred from 5-year technical colleges called Kōsens (高専). TUT had approximately 200 faculty members and 2,027 students as of May 2021 (1,176 undergraduate students, 748 master's students, 103 doctoral students, and 277 international students). Moodle has been an optional learning management system (LMS) for teachers and students since April 2011, when TUT switched from WebCT to self-hosting Moodle (IMC LMS, <https://lms.imc.tut.ac.jp>) on a university-based virtual machine. IMC LMS was developed and maintained by the Information and Media Center (IMC, <https://imc.tut.ac.jp>), which manages and operates the network system and computing environment at TUT.

In April 2020, TUT established the Center for IT-based Education (CITE, <https://cite.tut.ac.jp>) to dedicate more resources to e-learning research and practices in response to the increasing demand for online teaching and learning support due to the COVID-19 pandemic. In December 2020, the TUTTI (in Italian it means all, everyone) initiative was launched, to which two additional virtual machines

were allotted for designing and developing a new LMS using Moodle (Gikadai LMS project, <https://lms.cite.tut.ac.jp>), as well as an educational e-portfolio creation and management system using Mahara (Gikadai Mahara project, <https://mahara.cite.tut.ac.jp>).

This paper will focus primarily on introducing the Gikadai LMS project in terms of its objectives and vision, four levels of development activities, and final output that highlights significant designs on four aspects: inter-system communication, user management, course management, and user support.

## 2 Gikadai LMS: Objective and Vision

Although TUT already had the IMC LMS, the Gikadai LMS project (December 2020 to September 2022) was initiated with the goal of transforming the e-learning landscape at TUT through a systematically planned and better designed LMS. The project has the following objectives and vision.

### 2.1 System interoperability

The first objective is to improve the system interoperability between the LMS and various information management systems inside and outside TUT, such as the Academic Affairs Information System (AAIS or 教務情報システム), in which students select courses, the Google Classroom

management system, in which the majority of TUT courses are currently held, and other third-party plugins that can enhance Moodle's functionality. The accomplishment of this objective will contribute to the realization of TUT's vision of improved course management flow and experience.

## 2.2 Open curriculum

The second objective is to develop a cutting-edge learning management system that supports TUT's vision of open curriculum. The open curriculum education can promote open education at TUT and foster a culture of free learning among members. By removing the barriers between classrooms in the online environment, it will also enable all TUT members to share knowledge, learn from peers, and enhance the quality of education.

Gikadai LMS will provide robust support for the delivery of the TUT curriculum, while promoting open curriculum education and allowing all TUT members to audit courses as online students. Students will not be limited by their specializations and will have golden opportunities to access a vast array of educational materials for which they are not required to enroll. Teachers will also be able to audit other teachers' online courses and study their teaching methods.

## 2.3 E-portfolio management

Using e-portfolios in classrooms encourages students to become behaviorally, cognitively, and affectively aware of the learning process [1]. A number of studies have confirmed the positive impact of this type of portfolio on learning engagement [2]–[4].

By pairing the LMS and Mahara, we aim to realize the vision of integrating formal and informal learning in the online environment. Using Mahara assignment on the LMS, portfolios created on Mahara can be submitted as assignments for grading on the LMS. With the aid of digital technologies, students will experience a more vibrant and interactive learning environment and develop the habit of monitoring their own learning progress and outcomes.

## 2.4 Online teaching and learning support

The fourth objective is to provide efficient and effective support for the adoption and use of the LMS by teachers and students, so that educational activities at TUT can gradually transition from using proprietary technical solutions to open-source technical solutions.

# 3 Four levels of development

The Gikadai LMS involved four levels of development: strategy level, server level, application backend level, and application frontend level (Figure

1).

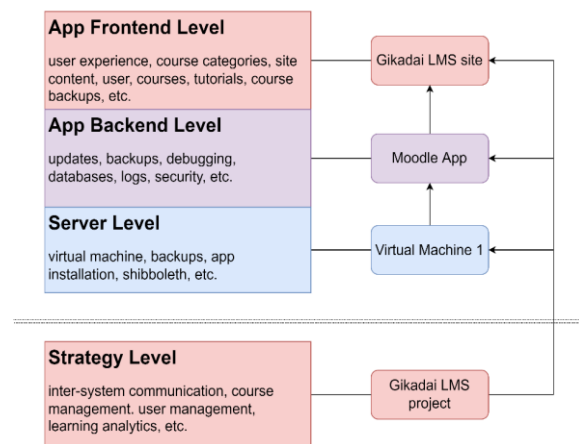


Figure 1. Four-level development of the Gikadai LMS

## 3.1 Strategy level

E-learning strategy is a blueprint consisting of a vision and a framework for detailed e-learning actions designed to achieve e-learning objectives. When properly conceived and planned, it can significantly increase the likelihood of success for the organization implementing it.

Guided by the work of Morrison [5, pp. 112–134], the activities at the strategy level included team discussions on the following aspects of content: vision, content, senior executive support, business case, success criteria, stakeholders, learning value chain, technology, culture, transition, risk register, roll out and communications, human resources, schedules, and milestones.

## 3.2 Server level

The server level primarily encompassed tasks like virtual machine/server installation and maintenance, Shibboleth installation, virtual machine security, virtual machine/hosting backups, etc. This level required close cooperation with IMC.

## 3.3 Application backend level

This level included tasks such as installing the Moodle application on the server, updating the application, backing up the application's database and directories, debugging errors, securing the site, customizing the site, etc.

## 3.4 Application frontend level

The tasks at this level involved both structure and content aspects of the Moodle website concerning its appearance and user experience, including but not limited to user management, course management, site content development, site tutorial development, data structure design, etc.

## 4 The final output

This section will discuss the final outlook of several significant designs and developments within the Gikadai LMS (Figure 2).

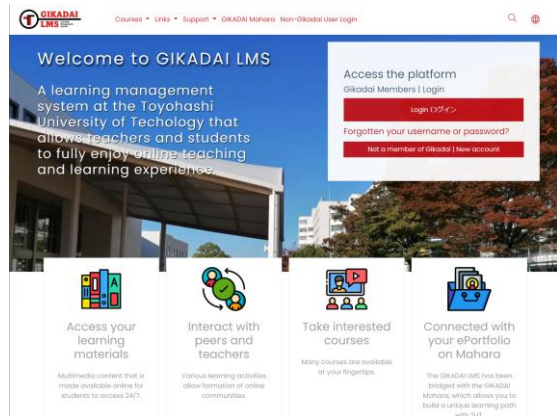


Figure 2. Front page of the Gikadai LMS

### 4.1 Inter-system communication

**Login.** The Gikadai LMS supports Shibboleth authentication method, powered by GaKuNin. Everyone with a TUT email account can sign in to the LMS without a problem.

**Course enrollment.** The action plan to synchronize academic data from AAIS to Gikadai LMS has been established (Figure 3). The only communication between AAIS and IMC LMS consisted of the LMS administrator downloading the course keys from IMC LMS to a PDF file, which was then manually distributed to students within AAIS. After selecting courses in AAIS, students were required to search for course enrolment keys and log into the IMC LMS to self-enroll in the chosen courses. However, the Gikadai LMS will automate the entire course enrollment process by mapping AAIS and LMS systems at the database level. As a result, students select courses on AAIS, and enrollment data is synchronized automatically to the Gikadai LMS system. When students log in to the Gikadai LMS, their chosen courses will be displayed on their Dashboard. The mapping was accomplished by configuring the Gikadai LMS with the “External database enrolment plugin”, which is already a part of the core Moodle installation.

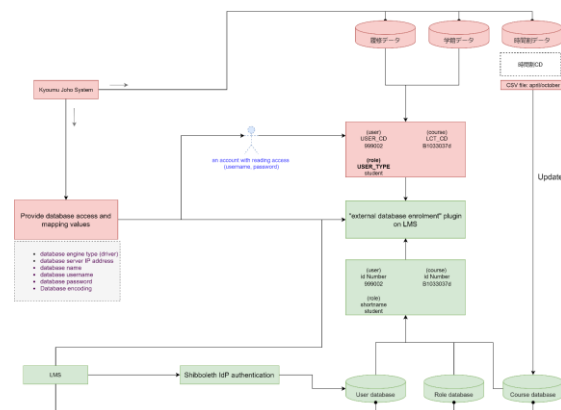


Figure 3. Mapping AAIS and Gikadai LMS

**Mahoodle.** The Gikadai LMS is for formal learning in degree programs and classrooms, whereas the Gikadai Mahara is for informal learning in student projects, student clubs, study groups, interest groups, laboratories, etc. Connecting Gikadai LMS to Gikadai Mahara (also known as "Mahoodle" by the community) enables communication between these two systems. Through XML-RPC/MNet authentication, Gikadai LMS (Moodle 3.11.8+) was bridged with Mahara (21.10.1), allowing LMS users to directly sign into Mahara. On the LMS, the Maharaws plugin (<https://bit.ly/3BXJf1U>) was installed to enable the Mahara assignment function. Figure 4 depicts the technical configuration and data transfer between bridged Moodle and Mahara. In Mahara, students create pages and collections of pages. In Moodle, instructors create Mahara assignments. On the Mahara assignment submission page, students can view their existing collections/pages and choose one to submit as an assignment. Meanwhile, when the Mahara portfolio is enabled on Moodle, forum posts, assignments, chats, database entries, and glossary entries can be exported to Mahara. They can then be added as e-portfolio content to Mahara pages.

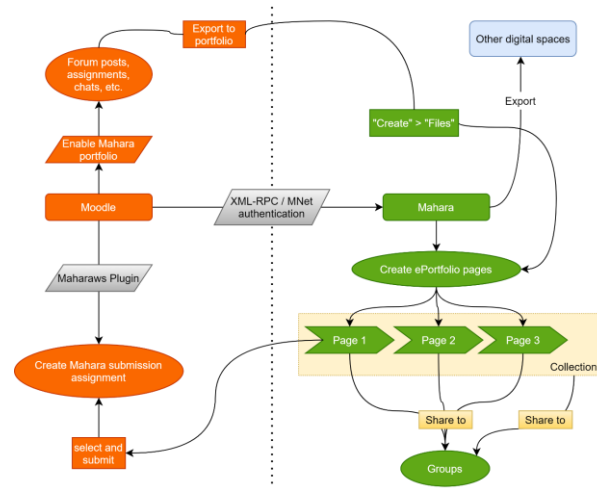


Figure 4. Mapping Mahara and Gikadai LMS

*Google Classroom functions.* Due to the large number of teachers and students at TUT who are accustomed to using Google Classroom for course delivery, it was deemed necessary to provide Google Classroom’s capabilities in the Gikadai LMS at least for the duration of the transition. **First**, we needed to add the Google service as one service on the OAuth service page inside Gikadai LMS. Personal Google account is also acceptable for this step. **Second**, the assignment function of Google Classroom (Figure 5) can now be used independently within Gikadai LMS. However, it is not linked to any Google Classroom courses a teacher may have. It is in fact a separate activity that has been created and placed within the LMS. The configuration and installation procedure can be found at <http://bit.ly/3UEloLZ>. **Thirdly**, users are able to link their Google Drive account to Gikadai LMS. Once connected, users can select files directly from the folders of their Google Drive (Figure 6). To achieve this function, we had to enable the Google Drive repository on Moodle, make Google Drive repository visible, choose the OAuth 2 service for Google Drive to be “Google”, and configure the Google Drive plugin. **Finally**, with the installation of the Google Meet plugin on the Gikadai LMS, teachers can now directly create a new Google Meet session (Figure 7). They can set up a notification to remind students before the meeting begins, configure the meeting’s repeating rule, and sync previously saved meeting recordings from Google Drive to the Gikadai LMS.

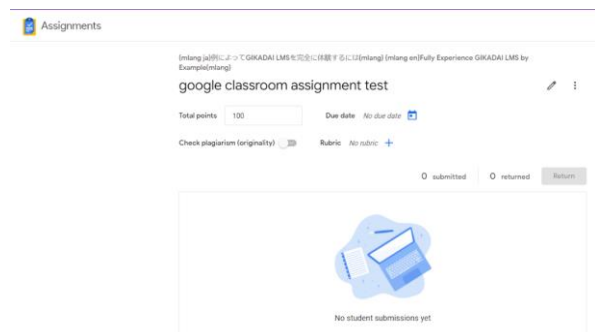


Figure 5. Enabling Google Assignments in Gikadai LMS

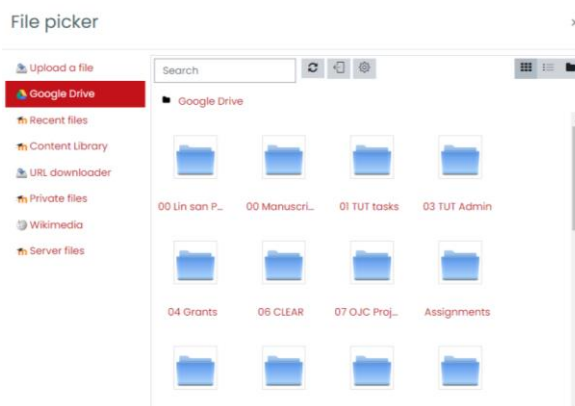


Figure 6. Enabling Google Drive in Gikadai LMS

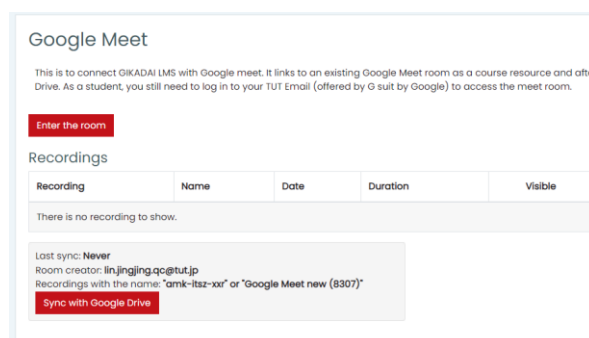


Figure 7. Enabling Google Meet in Gikadai LMS

*BigBlueButton.* In collaboration with the Bluesky project [6], the Gikadai LMS also enabled the BigBlueButton (BBB) video conferencing function as an alternative to Google Meet. Project Bluesky began as an effort to create a collection of BBB servers that could be utilized by numerous Japanese universities. Each BBB session produces two distinct types of recordings (Figure 8). The presentation-style recording can be viewed chapter-by-chapter or page-by-page based on the associated materials (e.g., used PPT when the recording happened), and only browser-based view is supported. The mp4 video recording cannot be viewed chapter-by-chapter or page-by-page but can be downloaded. It is recommended that TUT instructors download their own recorded meetings to local disks. The virtual private server (VPS) is unable to differentiate between recorded files. The VPS is shared by multiple partner universities; consequently, files are typically mixed based on which universities used that VPS over time and who is using which VPS is assigned in real time by the system.

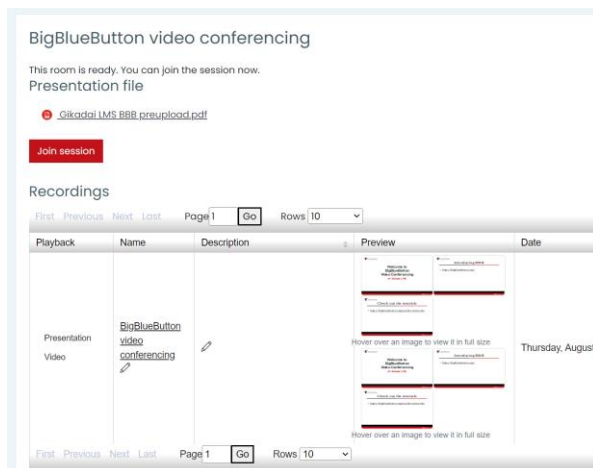


Figure 8. Enabling BBB in Gikadai LMS

#### 4.2 User management

*User roles.* The Gikadai LMS defines nine user roles (Figure 9).

- **Authenticated user.** All logged-in users via Shibboleth authentication method have this role. Every logged-in user can request new courses. However, only teachers are advised to do so. Students ought not to.
- **Manager:** Like administrator role but with slightly less technical capabilities on the system.
- **Course creator:** These are some users who are manually assigned the ability to create new courses. Typically, this role is assigned to the headmaster, department head, or program coordinator.
- **Teacher:** TUT teachers are assigned this role either by being manually assigned to a course, or approved course request, or synched role data from AAIS.
- **Course inspector:** All teachers at TUT are manually assigned to this role to allow them the free access to other teacher’s courses without participating. It is also possible to exclude courses from course inspectors’ access.
- **Non-editing teacher:** The role is assigned by course teachers to co-teachers or teaching assistants. It allows the user to view and grade students’ work.
- **Student:** Logged in users can self-enroll or get enrolled to courses in the role of student depending on the enrolment methods of courses.
- **Auditing student:** Any student can request to audit a course on Gikadai LMS by sending a request to the administrator.
- **Guest:** Can view some limited content without logging into the system.

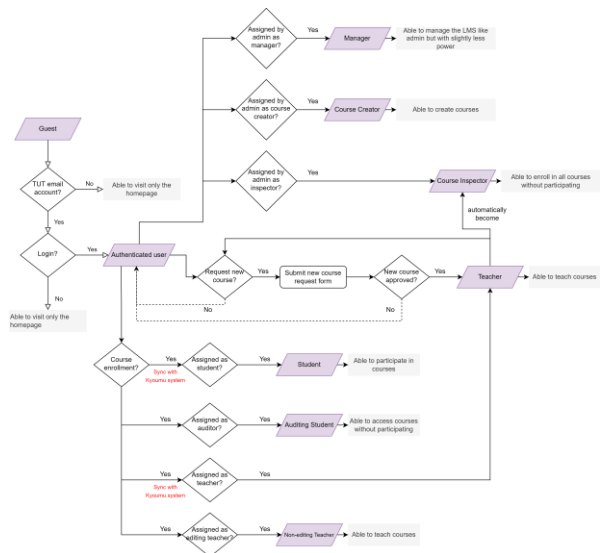


Figure 9. User roles in Gikadai LMS

*User cohorts.* All users of the Gikadai LMS are manually organized into three cohorts: faculty, students, and staff (Figure 10). Cohorts are site-wide or course category-wide groups that make it easy for all cohort members to enroll in a course. For example, if a course is required for all students, the teacher can add cohort synch as an enrollment method and select “student cohort” to automatically enroll all TUT students in the course.

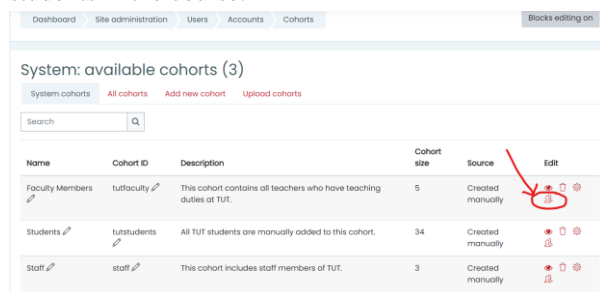


Figure 10. User cohorts in Gikadai LMS

#### 4.3 Course management

*Alignment with the university curriculum structure.* The course categories of the Gikadai LMS are structured in accordance with the TUT curriculum structure outlined in its Course Requirement Guide Book 2021 (<http://bit.ly/3DGDJbb>). The Gikadai LMS uses the degree programs’ education levels (undergraduate courses, master’s courses, and doctoral courses) as its first-level course categories, as opposed to the IMC LMS’s use of TUT’s five faculties. On the second or third level of the hierarchical structure, the faculties become subcategories. Figure 11 demonstrates specifics.



Figure 11. Course categories in Gikadai LMS

*A complete database of all TUT courses.* The LMS administrator will receive csv files from AAIS staff regarding the available courses in their system and upload the csv file using the “upload courses” function on Moodle in April and October of each year. Using this method for the first time on April 15, 2022, the Gikadai LMS now contains a comprehensive list of 1,320 degree-program related courses. The Gikadai LMS is also equipped with the csv flat file enrolment method, which permits the uploading of a csv file to a specific path on the LMS server, where it can be read and modified by the web server process. The file is deleted automatically after processing. However, once AAIS and Gikadai LMS are connected, the aforementioned two methods will no longer be necessary, as new courses added to AAIS that are not present on Gikadai LMS will be automatically added to Gikadai LMS.

*Course templates.* On the launching page of a new course, a list of course templates are displayed, allowing teachers to choose how to begin designing their courses based on the available templates (Figure 12). This support is enabled by the Kickstart Moodle plugin.

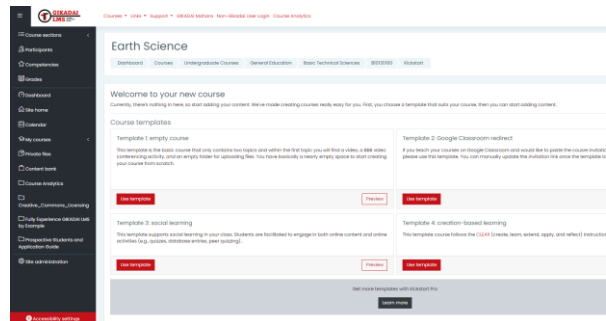


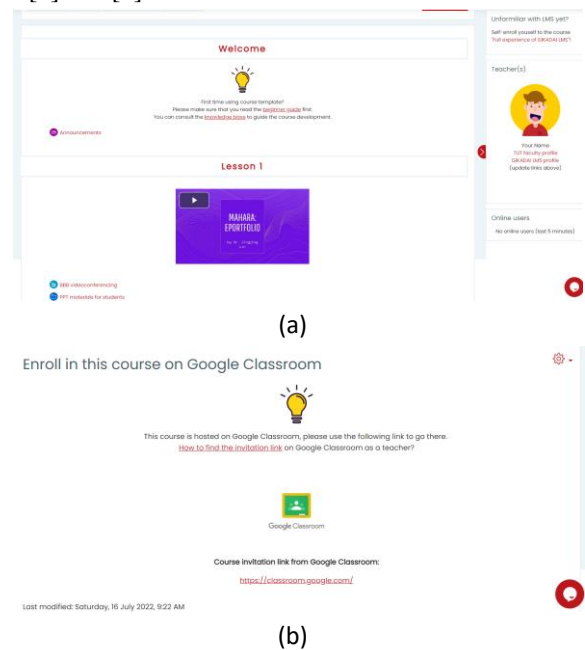
Figure 12. Course templates in Gikadai LMS

Four course templates are available now.

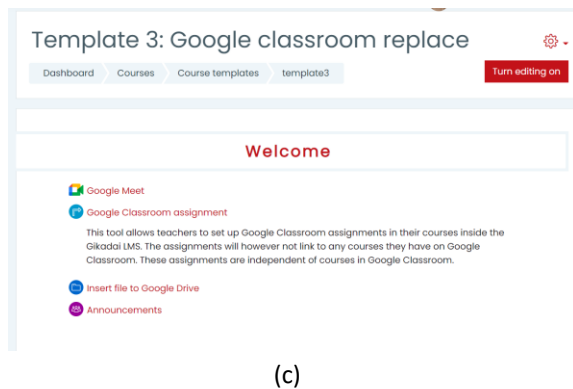
- Template 1: default course (Figure 13.a). This

course template allows instructors to create an entirely new course using the topic format. This template includes the following components by default: A label indicating the availability of tutorials on using the course templates; an embedded YouTube video; a BBB activity; a block indicating who the teacher is.

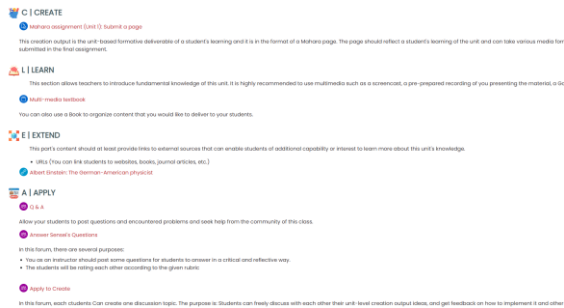
- Template 2: Google Classroom redirect course (Figure 13.b). This template serves as a placeholder for Google Classroom courses. It is a simple page listing the invitation link to the Google Classroom course. This template includes a label reminding student that this is a course redirect page and instructing instructors on how to locate the invitation link for their course on Google Classroom, and a link to the Google Classroom course which must be manually updated by the instructor.
- Template 3: Google Classroom replacement course (Figure 13.c). This template course is ideal for teachers who wish to continue teaching within Gikadai LMS while retaining Google Classroom’s functionality. Google Meet, Google Classroom assignments, and the direct insertion of Google Drive files are among the features.
- Template 4: creation-based learning (Figure 13.d). This course template follows the CLEAR (create, learn, extend, apply, and reflect) model of instructional design and experiments with Mahara assignments as assessment activities. See details in [7] and [8].



(b)



(c)



(d)

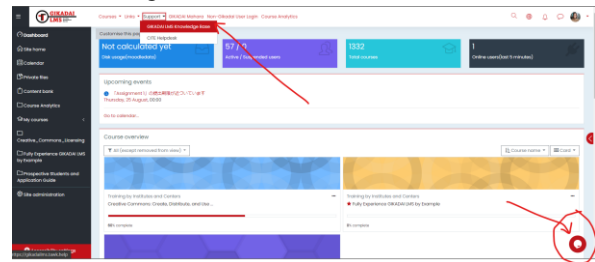
Figure 13. Course templates in Gikadai LMS

**Course backup/archive and reset.** A rollover is the process of preparing Moodle for the upcoming academic term. Carr [9] identifies three approaches to academic year rollover: (1) clone a new Moodle instance annually, (2) backup a course and then reset it to remove all enrollments, grades, etc., and (3) clone a course and retain both the live and archived versions. Considering the situation at TUT, the “backup a course and reset” approach is the default setting with three steps: (1) the administrator will execute a bulk backup of all courses on the platform during a specified time window by executing a script on the terminal; (2) all backups will be downloaded and saved to a local external disk for archival purposes; and (3) teachers will reset their courses. The “clone a course and archive” approach is only accessible upon request from individual instructors. The administrator will copy the entire course and place it in the “Archive” course category upon receiving the request. Before resetting the original course, the instructor is instructed to verify that the archived version is complete.

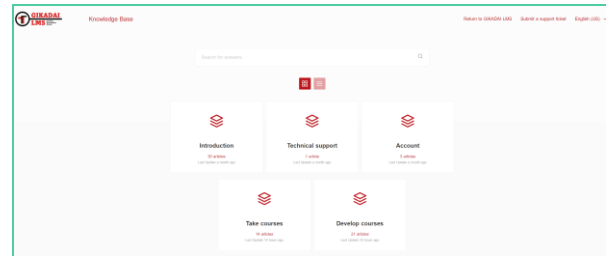
#### 4.4 User support

**Knowledge base and chat bot.** We utilized the free technical solution of tawk.to to create a knowledge base for providing searchable tutorial support, such as how to create a new page or assignment (Figure 14.b). The knowledge base is accessible in both English and Japanese languages. Gikadai LMS also integrated a tawk.to chat bot. The chat window is located at the right bottom of the platform. When users click on the

chat bot, they will be able to not only chat with a CITE support agent, but also search the knowledge base for solutions (Figure 14.c).



(a)



(b)



Support is offline

Support is online

(c)

Figure 14. Knowledge base and chat bot in Gikadai LMS

**Example course to fully experience the LMS functions.** The tutorial course “Fully Experience GIKADAI LMS by Example” provides examples of available resources and activities (Figure 15). All logged-in users are automatically enrolled in this course due to cohort synchronization. Thus, they are able to see what resources/activities are supported by Gikadai LMS and how they will appear once successfully implemented. A copy of the course won the Best Moodle Open Courseware of 2021 (honorable mention) award from the Moodle Association of Japan.



Figure 15. The example course and the award

*CITE help ticketing system.* When online synchronous support is unavailable, users can still submit help tickets using an asynchronous support system on the CITE website (Figure 16, <https://cite.tut.ac.jp/en/helpdesk/add-ticket>).



Figure 16. The CITE helpdesk page

## 5 Conclusion

This paper describes in depth the development of a university-level Moodle-based LMS and demonstrates the final appearance of the platform. It provides a case study for other Japanese universities to use as a guide when creating or renovating LMS. Before launching the LMS to the entire campus, additional work is required to perform quality assurance. Teachers and students must be properly trained on how to use the platform. Research activities should be conducted concurrently with the development of the LMS in order to continuously seek evidence-based teaching approaches and incorporate them into course templates for use by teachers. Teachers can be invited to participate in action research with CITE to redesign their courses and conduct collaborative research for academic publication. To identify and disseminate best practices in the shared community, outreach activities are also encouraged to improve communication between universities' e-learning support labs and centers.

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