A Recommendation for the Digitalization of University Education (2)

~Series: Practical Implementation at Small-Scale Universities — From Knowledge Sharing and Visualization of Outcomes to the Use of AI ~

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1. Introduction

In the previous installment, we discussed the importance of bottom-up initiatives that advance the digitalization of education by starting from areas that are readily accepted by both faculty and students. As an example, we introduced a project that began with pre-enrollment programs and extended into first-year education through the implementation of online learning. In this installment, we will present how this initiative served as a foundation for university-wide deployment.

2. Structuring the Knowledge Framework and Its Integration into the Curriculum

At our university, the use of e-learning for reinforcing foundational science and engineering knowledge in first-year education — along with blended e-learning practices in information-related courses — served as a springboard for exploring university-wide applications of ICT. The initiative was jointly led by the University Information Center, which promoted the operation of e-learning, and the University Education Center, responsible for curriculum management. At the time, it was decided that, given the fundamental role of face-to-face instruction, discussions would not pursue the direction of integrating e-learning into every single course. However, since all courses inherently contain instructional content, the visualization of related knowledge and its shared use across the university was regarded as beneficial from a quality assurance standpoint. As a result, the university adopted a basic policy of compiling a science and engineering knowledge repository (or knowledge map) aligned with the overall university curriculum structure. This initiative was selected for funding under the Ministry of Education, Culture, Sports, Science and Technology's Support Program for Contemporary Educational Needs (2007), which provided financial resources for its implementation. Specifically, faculty members from a range of foundational and specialized domains — including chemistry, physics, electronics, optics, control, telecommunications, and information — collaborated to classify the scientific and technical knowledge covered in their courses by hierarchical levels. Through this process, approximately 4,200 terms were defined and organized into a searchable database.

The knowledge map was categorized by academic domain. In the field of information science, for example, it was structured in a four-level hierarchical (tree-like) format: at the first level were programming languages, followed by Java at the second level, object-oriented programming at the third level, and finally classes at the fourth level [1].

These activities were carried out as part of the university-wide Faculty Development (FD) initiative for improving teaching practices. Deliberations were held during monthly faculty meetings (Academic Affairs Coordination Meetings), which were attended by nearly all teaching staff. University faculty members tend to be deeply invested in their own courses but are often said to show little interest in what is being taught in adjacent classrooms. This was also true at our university. Initially, the president began by patiently and repeatedly explaining the significance of the initiative. As discussions progressed, it became clear that each instructor had differing perspectives on the granularity of knowledge and definitions of competency, which made aligning the overall framework a time-consuming process. Nevertheless, the process eventually fostered meaningful cross-disciplinary dialogue. For example, mathematics instructors in first-year education and faculty members teaching applied mathematics in specialized engineering fields engaged in discussions within the same group. These exchanges provided valuable opportunities to reflect on each other's teaching. The knowledge repository developed through these efforts was consolidated into the CIST Portal, the university's internal portal system. There, faculty members could reference and register the specific knowledge elements (i.e., terms or concepts) taught and utilized in each of their courses. Since this task was conducted collectively by all faculty members, the data could be reflected across the entire curriculum. This made it possible, for instance, to visualize the connections between first-year foundational courses and upper-level specialized courses through shared knowledge terms — a feature that students now use to help guide their curriculum planning. For instructors as well, this system allowed them to identify cases where specific knowledge covered in specialized courses had not been introduced in any foundational courses, prompting significant improvements to curriculum design. Furthermore, the knowledge repository was also linked to the university's e-learning system (CIST Solomon), enabling instructors to refer to the same e-learning materials across different courses, as long as they shared the same knowledge elements (see Figure 1). This system has been effectively applied in a MEXT-certified program on Mathematical Data Science and AI Education. In this program, e-learning materials aligned with the required knowledge levels were pre-developed and shared across multiple course groups within the university, with each course referencing the relevant knowledge elements to utilize the same materials.

3. Course Design with a Focus on Generic Competencies

While the effort to systematize knowledge reflects the nature of a science and engineering faculty, from the perspective of societal demands, the development of generic competencies — such as communication skills and problem-solving abilities — has also become increasingly important. At the time, such abilities were frequently discussed using terms like "fundamental competencies for working persons" (coined by the Ministry of Economy, Trade and Industry) and "bachelor's level competencies" (used by the Ministry of Education, Culture, Sports, Science and Technology). These competencies are not meant to be developed through any single subject but rather across the entire undergraduate curriculum. To achieve this, it is crucial that each course, including those in specialized fields, be designed with the intentional development of diverse competencies in mind. At our university, blended learning — in which knowledge acquisition is partially replaced by e-learning — had already been implemented at an early stage. Building on this foundation, we launched a university-wide flipped classroom project as part of our efforts to reform instruction in support of generic skill development. In this approach, knowledge reinforcement — traditionally done in the early part of class — was shifted to pre-class learning, allowing students to acquire foundational content in advance. Specifically, in classes involving practical exercises and active learning, knowledge acquisition was moved outside of class, while in-class time was used for problem-solving activities such as group work. This initiative was promoted university-wide with funding from the Accelerated Program for University Education Rebuilding (2013). As of 2025, flipped classroom models have been introduced across multiple areas of the curriculum. These include compulsory courses on programming offered in the first and second years, second-year data science courses, and practice-based specialized courses within the Department of Information Systems Engineering. Although the workload for students is significant, the university's annual Institutional Research (IR) surveys consistently rank these courses among the top for perceived educational value — frequently cited by students as "the most beneficial."

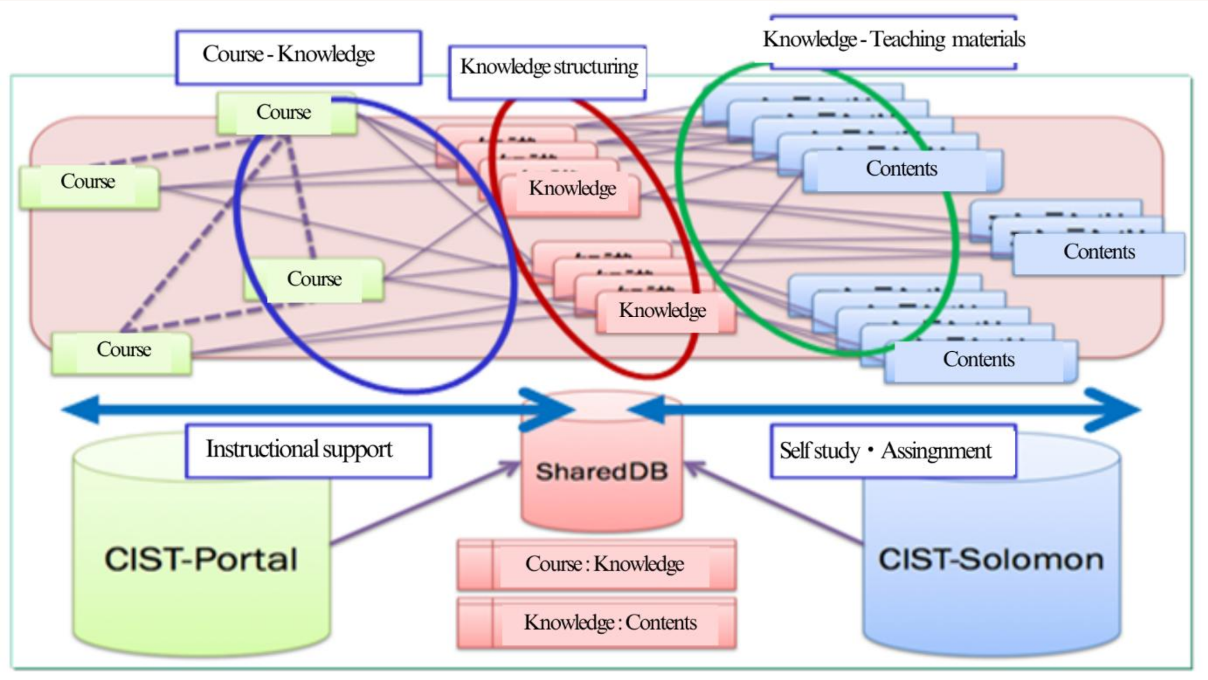

Figure 1: Structuring Knowledge and Linking It to Courses and e-Learning Materials [2]

4. Fully Online Flipped-Classroom Design and the Digitalization of Learning Activities

In response to the COVID-19 pandemic, the flipped classroom approach described earlier was redesigned for fully online implementation, with group work components conducted via video conferencing tools such as Zoom. From a course design perspective, students were expected to acquire the necessary knowledge beforehand through Web-Based Training (WBT) and to watch video explanations of the lecture content in advance. Additionally, with laptops becoming mandatory for all students, programming-related assignments could now be completed independently at home [3]. As a result, the in-class portion was reduced to approximately 30 minutes of online group discussion per team, focused on sharing and evaluating solutions to given problems. The shift to online learning also eliminated physical classroom capacity constraints, enabling significant changes in instructional logistics. For instance, a practical class that previously required four separate face-to-face sessions could now be consolidated into a single online session (see Figure 2). Under this new model, each student was only required to participate in a 30-minute group session. Therefore, a single 180-minute class could be divided into six cycles (180 ÷ 30). With 240 students enrolled, 40 students per cycle (240 ÷

6) would access Zoom in turn, and each would move to their assigned breakout room. Assuming each group consists of four students, ten breakout rooms would be required. By assigning one teaching assistant (TA) per room, and scheduling them across all six cycles, the entire group of 240 students could be accommodated within a single class session (two class periods).

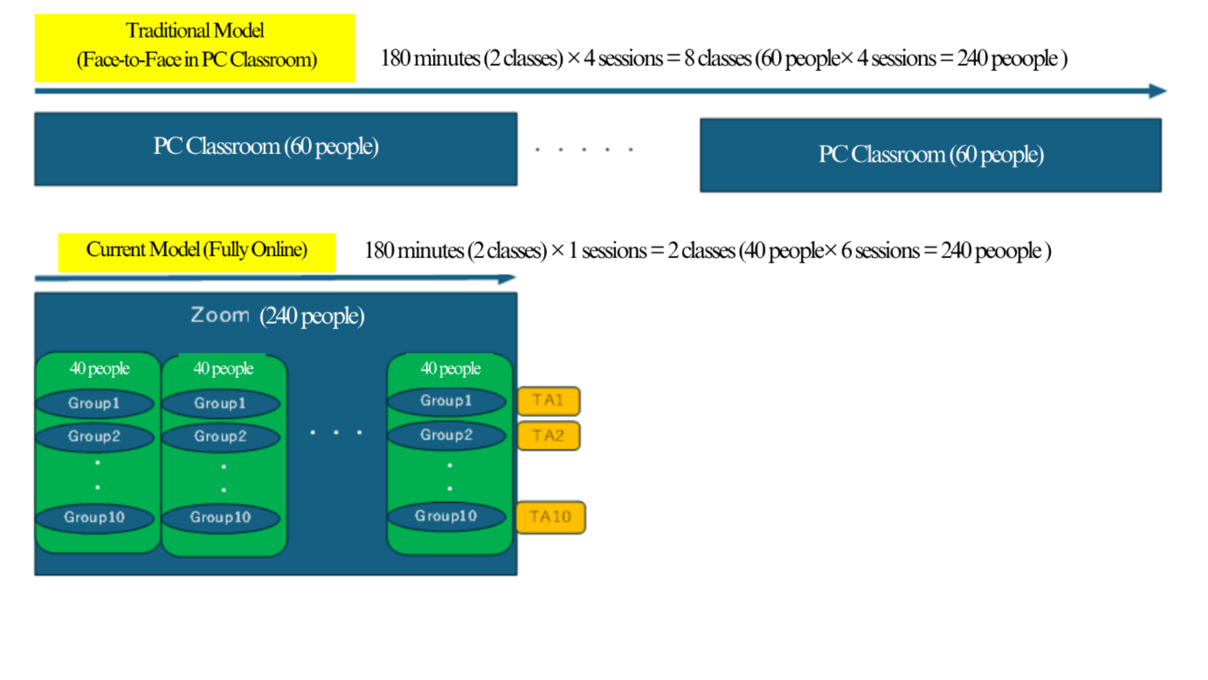

Figure 2: Comparison Between Fully Online and Traditional Classes

This series of online classes is characterized not only by efficient course management, but more importantly by its effectiveness in promoting autonomous and self-directed learning among students. In this context, the critical issue becomes how to support each student's individual learning process. Because the course design is fundamentally consolidated in an online environment, much of the learning process — including pre-class preparation activities and submitted assignments — is digitally recorded. This allows teachers and TAs to provide personalized advising based on each student's progress and outcomes. Within this natural and timely context, there is growing interest in the potential use of generative AI to support such personalized learning support [4]. This topic will be explored in the next installment.

References

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