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Governing the Fab Lab Commons: An Ostrom-Inspired Framework for Sustainable University Shared Spaces

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Abstract

The Fourth Industrial Revolution has reshaped shared spaces in higher education, with manufacturing labs (Fab Labs) emerging as vital hubs for collaboration. However, a systematic framework for ensuring their long-term sustainability as shared resources is lacking. This study addresses this gap by conceptualizing the university Fab Lab as a 'commons' and applying Elinor Ostrom's Institutional Analysis and Development (IAD) framework. We propose a new analytical framework for sustainable space sharing, reconstructed from Ostrom's principles into three university policy domains: Resource Policy (Rp), Actor/User Policy (Ap), and Community/Governance Policy (C/Gp). To validate this framework, we conduct a case study of the 'Idea Factory' at Seoul National University, analyzing its operational policies in conjunction with global standards like the Fab Charter. The proposed framework provides practical guidance for establishing spatial policies and architectural plans that emphasize autonomy, adaptability, and polycentric governance. It offers a new paradigm for sustainability in university commons by integrating bottom-up community approaches with robust institutional design, providing a theoretical foundation for implementing effective sharing schemes in rapidly evolving educational environments.

Keywords: shared space; sustainable sharing; fab lab commons; polycentric communities; self-governing; institutional analysis and development (IAD) framework

1. Introduction

This study conceptualizes the FabLab as a representative case of the university commons and connects it with international FabLab network standards (Fab Charter and Fab Foundation guidelines) to propose a new framework for shared spaces in higher education. FabLab commons are not merely local practices but globally embedded models within an international network, and this study explores how such frameworks can guide sustainable sharing strategies for university spaces.

In alignment with the Fourth Industrial Revolution, the patterns and periods of occupancy of shared spaces in the higher education sector have radically changed [1]. Universities' existing common spaces and institutions need to be reorganized owing to the increase in non-face-to-face work and online education [2,3]. Moreover, universities need to implement changes because of the decreasing school-age population, the changing educational methods that have led to changes in the need for space, and the unavailability of space due to each college's long-term occupancy of the available space [4]. Therefore, higher educational institutions need an analysis framework for shared spaces in order to respond to the rapidly changing educational environment.

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The university fabrication laboratory (Fab Lab), which has emerged in the Fourth Industrial Revolution, is a representative shared space that facilitates collaboration [5,6]. Moreover, the innovative policies associated with the Fab Lab's space and facilities creatively increase work efficiency through well-organized sharing. Thus, these policies differ from the conventional top-down governance in the institutional system of universities. For example, the policies, autonomous restrictions, and monitoring rules within the Fab Lab community have enabled continuous growth and change. The power of this Fab Lab space as 'the sustainable commons' derives from the institutional arrangements of communities. The term commons refer to the cultural resources that all members of a society can access, and their common resources, which are not owned privately [7]. The Fab Lab commons is defined as the social practice of governing a resource (space) by a community of users that self-governs the resource through the institutions that it creates [7]. In addition, this commons-based governance is not only a local phenomenon but also part of a globally standardized framework defined by the Fab Charter and Fab Foundation guidelines, which emphasize open access, standard equipment, and global networking. Therefore, university Fab Labs must be understood as simultaneously local commons and nodes in an internationalized network of shared governance.

Moreover, the power of Fab Lab as a sustainable common is related to the network of polycentric user communities. The recently emerged Fab Lab operating institutional systems have a positive impact on educational value and on sharing facilities and spaces. These systems can adapt to changes based on innovative space policies and have a sharing method that can be segmented in terms of time and space occupancy. The Fab Lab is recognized as a pioneer in high-tech production through collaboration practices (peer-to-peer collaboration) and shared systems with local communities and industry [8]. Many universities have strategically expanded their academic communities to the local and global scales, as observed in examples such as MIT [9], where Fab Labs began as a collaboration between the Grassroots Invention Group, and Cornell Tech University on New York's Roosevelt Island [10]. The Fab Lab's innovative spaces and learning methods based on collaboration are strongly related to the community's sharing scheme [6,11]. Fab Labs' educational methods have academic characteristics based on communities (university and region) and information and communication technology [6,12]. These polycentric communities play a significant role in presenting learning models that access information, create content, and share and interact in higher education frameworks to fulfill new requirements in universities [13,14]. These characteristics of Fab Labs as the commons create an innovative educational ecosystem, unlike the existing centralized, hierarchical university system [15,16].

Numerous studies have considered the technical aspects in education, and the industrial aspects of Fab Labs [5,6,10,11,14,17]. However, knowledge about how educational institutions operate in the process of transitioning sustainability to practice in this social context of Fab Lab is lacking [8]. Moreover, little is known about Fab Lab institutional space policies in the higher education sector. Therefore, this study creates an analytical framework, aiming to propose a new sharing method through university Fab Labs. It can reveal venues for new higher educational space coinciding with the Fourth Industrial Revolution. To this end, this study: Reviews the critical theoretical background related to the theory and implementation of the commons;

- Introduces the institutional analysis for sustainable commons of Elinor Ostrom, who was awarded the 2009 Nobel Memorial Prize in Economic Sciences for her analysis of institutional governance, especially the commons;
- Reviews significant studies on the commons in the university Fab Labs;
- Reconstructs Ostrom's framework to accommodate higher education institutions;

- Analyzes the Fab Lab space and its policies using the proposed analysis framework (reconstructed framework);
- Reveals a sustainable paradigm for commons in the university space for responding to the rapidly changing educational environment.

Thus, this study explores the ways in which sustainable space commons in the university has been responding to the rapidly changing educational environment. It builds an analytical framework to develop a sustainable sharing scheme and to determine its space policies and architectural plans, which can be used by universities. This study is significant because its analytical framework provides an alternate understanding of the shared paradigm of other higher education spaces, and not just the makerspace, in the post-pandemic era. Further, it discusses future research directions to validate the proposed framework for other spaces, particularly as regards the institutional connections and the use of Fab Labs in cyberspace.

2. Theoretical Framework and Methodology

The commons consist of three components—resources, institutions, and communities—forming the analytical basis for applying commons theory to FabLabs. Ostrom's framework highlights how successful commons depend on clear boundaries, self-governing rules, and active community participation. This tripartite structure provides the foundation for analyzing FabLabs as sustainable models of university shared spaces.

The sequence of reviews is as follows. First, the study reviews critical concepts relating to the theory and implementation of commons, and it introduces Ostrom's institutional analysis on sustainable commons. Next, it introduces the university Fab Lab, focusing on the commons issue. Lastly, it constructs an analytical framework of the university sharing scheme with a focus on common issues, while cross-referencing with the Fab Charter and Fab Foundation guidelines as international benchmarks. This ensures that the framework is not restricted to a single institutional or national case but can be generalized and tested against global standards of FabLab operation.

2.1. Review of Literature on the Commons

The terms "commons" and "the dilemma of the commons" came into widespread use after Hardin's seminal study on this topic [12,18]. This dilemma is based on Hardin's theory, known as the "tragedy of the commons [18] (p. 1243).," which explains the degradation of shared resources (i.e., pastures) due to excessive exploitation. The dilemma of commons implies through the assumption that humans are inherently selfish by nature that, "the degradation of the environment to be expected whenever many individuals use a scarce resource in common [7] (p. 2)." Thus, the dilemma of commons creates social conflict. Therefore, two traditional solutions to the dilemma have emerged. One is the privatization of commons, and the other is direct intervention by the central government. This dichotomous argument has been well received in line with the capitalist economy [7,12,19,20].

However, Ostrom proved [7] that a principle concerning community can overcome the dilemma of commons without privatizing the commons or creating a Leviathan authority to govern its use. She emphasized that a successful common provides sustainability beyond simply sharing. Ostrom defined the commons as the social practice of a community of users that self-governs the resource through institutions the commons create [7]. Further, she asserted that successfully governed commons have some common institutional principles (i.e., eight institutional principles for successful or sustainable commons management) and certain regularities.

The commons are not merely shared resources but comprise three components: resources, institutions, and communities [20–24]. This tripartite structure provides the analytical foundation for applying commons theory to Fab Labs. The argument that the commons are not the physical properties of resources, but spaces defined by social relationships between people using resources [25,26], also suggests that institutional and community connections are indispensable in defining the commons. Ostrom's interpretation of the commons system also encompassed these three components: the resource itself, the operating rules for its use, and the community that uses it and governs its use.

Ostrom proposed a variety of frameworks to improve the generalization level of commons analyses. Moreover, she tried to theorize and discover the numerous situations underlying the variables and the "elements that make up the situation of commons." She sought to identify a particular framework to solve the variables of a specific situation and problems in the situation as a group, rather than an abstract dimension of research [27]. In this attempt, she developed the institutional analysis and development (IAD) framework (see Figure 1) and the social–ecological system (SES) framework.

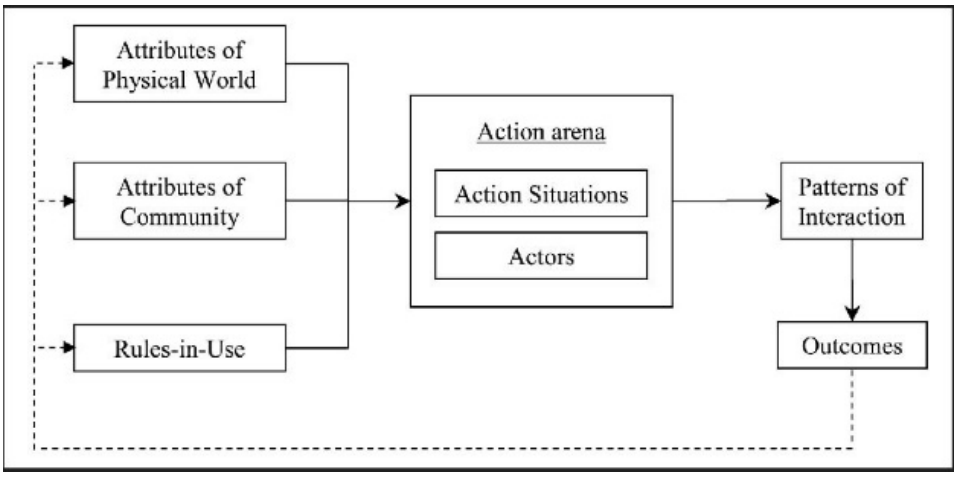


Figure 1. Institutional Analysis and Development framework; Solid arrows: direct influence; Dotted arrows: information feedback and institutional learning [21].

The IAD framework is a conceptual analysis framework that Ostrom developed on the basis of numerous case presentations and demonstrations related to the system of shared resources. It has been widely adopted to evaluate the effectiveness of schemes and to examine the processes through which the organization emerges and changes [20]. Further, Ostrom used it as the analytical framework for a research program on the collective management of natural resources, which significantly contributed to her selection as the co-winner of the 2009 Nobel Memorial Prize. According to Ostrom, her IAD framework encompasses the physical constraints as well as the constraints imposed by the rules that affect user outcomes in certain behavioral situations, and the consequences of repetitive situations and community norms [7,20]. This is an analytical framework for analyzing voluntary, self-governing, and disciplined shared resource management systems. In addition, it analyzes the effects of the physical characteristics and the user rules of organizations on members' motivation or behavior, and the consequent improvement in their practices [20]. When divided into a policy hierarchy, the commons are stratified into rules, institutions, and laws, which Ostrom embodied to create an IAD system analysis framework.

The IAD framework is similar to a map for analyzing how an organization's rules, physical conditions, and characteristics affect its members' behavior or motivation, and how these three factors improve physical or economic conditions. This multi-sectoral taxonomy enables detailed analysis. The SES framework reveals the situation of the

commons through classifying the variables in 'the sub-system' [20,28]. The four main subsystems of the commons are governance, the resource system, the resource unit, and the user. Various types of these subsystems are used in analyzing the commons. To this end, in the present study, it is analyzed by dividing it into the physical conditions, the community attributes, and the operating rule schemes at the beginning of the analysis of the framework [19]. SES improves the threshold of IAD by expanding the number of related context variable categories. All common resources are complex, and SES is a diagram of this complex system (the resource-ecological system). This system is primarily divided into subsystems and internal variables.

2.2. Review of Literature on the Fab Lab Commons

Numerous studies have suggested that it is incorrect to consider community concepts a part of organizational theory [29,30]. The literature reviews of organizations such as Fab Labs demonstrate that their communities make them sustainable. O'Mahony discussed the community's influence on organizational development and revealed that communities help organizations emerge, lead to organizational capabilities and growth, and last longer than organizations [30]. In particular, the characteristics of a Fab Lab community are strongly related to the basic Fab Lab values and the organization's sustainability.

The organizational features of a Fab Lab are that it is public, participatory, polycentric, and network-oriented. Crucially, these features are codified in the Fab Charter, which, along with Fab Foundation's operational criteria, provides a globally recognized standard for FabLab operation [9]. This means that the sustainability of Fab Labs is not solely dependent on local institutional arrangements but also on their adherence to international norms that allow comparability and interoperability across more than 1500 Fab Labs worldwide. The Fab Charter demonstrates universal values beyond the individual conditions of every country, region, and facility. These values apply to each Fab Lab's policy, which indicates that the value of sharing is implicit within this charter. Currently, more than 90 countries have a total of approximately 1500 Fab Labs [6,31], of which 16 are in Korea. To share the ideology and spirit of Fab Lab growth, the World Fab Labs Conference recommends "as the four elements needed for Fab Labs, (1) be open to the public; (2) operate according to the ideology of the Fab Labs charter; (3) be equipped with general recommended equipment; and (4) participate in global networks" [6,9,31]. The Fab Lab movement is active in France and the United States and in emerging and developing countries. Among Asian countries, India, Japan, and Republic of Korea are leading the rapid development of Fab Labs. Fab Labs have a worldwide network because local public spaces and many universities around the world have Fab Lab facilities.

To produce an appropriate common space, the management and operation of space networks must be improved by simultaneously identifying challenges and opportunities for current network management [32]. The value of Fab Labs is related to their fostering free innovation; establishing communities of practice of knowledge, learning, control, and intelligence; and democratizing tools and information [22,33]. The spread of Fab Labs facilitates collaboration between universities and industries through students from the universities for applied sciences, freelance experts, businesses, and other business providers [34]. Similarly, many types of Fab Labs reflect the different relationships found in their maker communities [35]. The nature of these Fab Labs creates polycentric communities based on networking, rather than on hierarchy. The collaborative creation and knowledge dissemination will require rules that are carefully negotiated by various stakeholders [36]. Jane Fulton argued that sustainable development goals should be achieved through multi-stakeholder partnerships for roles for universities [37]. However, unlike Fab Labs, many universities have difficulty forming social connections due to hierarchical governance [16].

The organizational feature of Fab Lab communities is that these are public and participatory. In this regard, Smith argued, "Based on the core value of participatory design, we can be essential to developing a holistic approach to participatory design as a sustainable practice of social change" [38]. A holistic approach is required because Fab Labs are global workshop initiatives that provide open access to projects and encourage the sharing of available knowledge between experts and the public [39]. Thus, members are taught through knowledge exchange at Fab Labs, which also serve as platforms for providing various educational, social, and economic benefits [13,14,40]. From an interdisciplinary perspective, attention should be paid to the core role of social science in boosting collaborations with other professionals, engaging stakeholders, and fostering a broader practical and conceptual interdisciplinary platform to envision, build, and share academic content [41,42]. Further, the system of Fab Labs that work closely with each other and other entities in urban and regional ecosystems is much more successful in achieving sustainability compared with industries [43]. Its communities can develop sustainable, innovative solutions to solve social and regional problems [13]. Fab Labs should work with sustainability-focused makers and stakeholders as shared workshops to develop sustainable practices of social change [42].

The focus of this literature review was to identify key concepts associated with the commons and the features of Fab Lab communities: these engage in networking and are polycentric, public, and participatory. The literature reviews showed that these properties of Fab Labs are related to the commons as key factors in making Fab Labs sustainable. In the next section, factors that influence sharing schemes are extracted based on a comprehensive understanding of this conceptual framework of the commons (resources, rule in use, and communities).

2.3. Restructuring Ostrom's Framework for the University Context

Applying Ostrom's SES (Social-Ecological Systems) framework directly to a university setting presents a challenge: unlike natural commons (e.g., fisheries, forests), university spaces operate within a rigid administrative hierarchy. Therefore, this study reconstructs Ostrom's triad into policy-oriented domains—Resource Policy (Rp), Actor Policy (Ap), and Community/Governance Policy (C/Gp).

This is not a mere relabeling but a necessary operationalization to bridge the gap between abstract commons theory and university administration.

- Resource Policy (Rp): Aligns with the university's "Facility Management" codes, addressing the physical boundaries of shared spaces.
- Actor Policy (Ap): Corresponds to Student Affairs regulations, transforming static user lists into dynamic 'rules-in-use' (e.g., monitoring and sanctions).
- Community/Governance Policy (C/Gp): Maps to the decision-making hierarchy, shifting from top-down control to polycentric self-governance.

The theoretical structure of this paper follows a hierarchical logic: Ostrom's IAD framework serves as the overarching meta-theoretical map; the 8 Design Principles function as the specific evaluation criteria for sustainability; the Fab Charter provides the global normative standard; and our proposed Rp/Ap/C/Gp framework acts as the localized analytical tool to apply these concepts to the specific administrative reality of higher education.

3. Research Methodology and Research Studies

3.1. Research Design

This study adopts a qualitative single-case study approach focusing on the 'Idea Factory' at Seoul National University (SNU). This case was selected because it represents

a paradigmatic shift from the university's traditional "siloed" space management to a "commons-based" governance model.

3.1.1. Data Collection and Limitations

Data for this study were collected using a triangulation method to ensure validity, primarily drawing from official administrative records and digital logs. Crucially, the spatial usage data and quantitative statistics regarding the Idea Factory and campus-wide facilities were obtained through a formal consulting project commissioned by Seoul National University Headquarters, titled 'Research on Efficient Space Management and Utilization'.

Through this project, the authors were granted authorized access to the following three key data sources, which were directly applied to the assessment indicators defined in Appendix A:

1. Archival Analysis (Applied to Rp & C/Gp Indicators): We systematically reviewed internal institutional documents, specifically the SNU Facility Management Status Report [44]. These documents provided baseline data on the university's historical space allocation. This analysis was crucial for evaluating 'Resource Unit Mobility' (Table A4) by highlighting the structural inability to share resources across departmental silos before the introduction of the new framework.
2. Digital Infrastructure Analysis (Applied to Rp Indicators)—CAFM (Computer Aided Facility Management) logs: We analyzed the operational protocols of SNU's official Integrated Space Management System (https://ist.snu.ac.kr/en/space-management/, accessed on 20 November 2025 [45]). This system manages information on university buildings, floors, and room details, while allowing users to reserve individual rooms through the Information Technology Services Department. We juxtaposed this centralized platform—which typically requires rigid login credentials and pre-authorization—with the Idea Factory's autonomous booking platform. This comparison serves as empirical evidence for the university's Resource Policy (Rp), validating how the institution technically overcame historical barriers to enable campus-wide space sharing.
3. Fab Lab's Digital Logging and Monitoring (Applied to Ap Indicators): Instead of relying on manual observation, we utilized the Idea Factory's dedicated digital infrastructure, specifically its exclusive web-based Real-time Space Occupancy Dashboard and Equipment Reservation System logs. We analyzed six months of log data from this facility-specific platform to track actual usage patterns, peak-time congestion, and no-show rates. This quantitative data was directly used to assess the 'Monitoring' level (Table A3), verifying whether the surveillance mechanism operates via autonomous transparency (Level 1) or hierarchical control (Level 3).

Note on Data Availability: It should be noted that due to the university's strict security protocols and privacy policies regarding internal administrative data, the raw datasets cannot be made publicly available. However, the patterns derived from this data were cross-verified with facility managers during the consulting process (see Appendix B for Manager Interview) to ensure accuracy.

3.1.2. Operational Context: From Exclusivity to Open Commons

Unlike traditional laboratory facilities that are strictly restricted to specific departments, the Idea Factory operates on a philosophy of "Open Access." Although physically located within the College of Engineering and administratively under its jurisdiction, the facility serves the entire university community.

As illustrated in Figure 2, the operational model is distinguished by three key features:

1. Universal Access via Education: Any university member, regardless of major, is granted access rights upon completing a mandatory environmental safety training session.
2. Digital Self-Regulation: Due to the high volume of diverse users, manual management was deemed inefficient. Consequently, an internet-based reservation system (Figure 2) was implemented. This system allows for real-time traffic management and ensures fair distribution of resources without constant staff intervention.
3. 24-Hour Autonomous Maintenance: The digital logging system enables the facility to operate on a 24 h basis through user autonomy, contrasting sharply with the rigid "9-to-6" operating hours of typical administrative offices.

Online reservation system demonstrates how high-traffic equipment (e.g., 3D printers, Laser cutters) is managed. The system visualizes occupancy in real-time, enforcing the rules-in-use (Ap) and enabling 24 h autonomous maintenance by the user community.

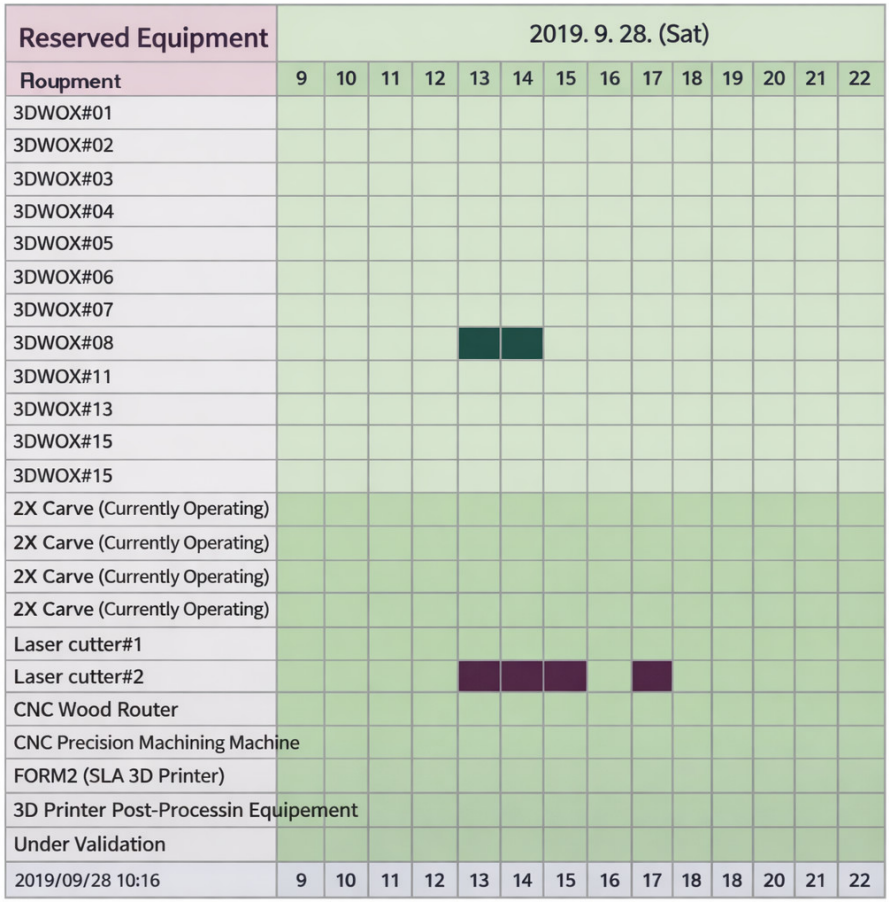


Figure 2. Digital Self-Governance Mechanism Reservation Platform.

3.2. Fab Lab Space as the Strategy of Universities

Makerspaces have emerged as essential strategies of universities as a "collaboration space," which can be viewed as convergence research, and as an experimental space, or "creative space," which is a new concept. Thus, an integrated educational strategy covering sustainable academic communities is needed [43]. Universities in Korea have been actively supporting laboratory-based Fab Labs as part of university strategy. These innovative collaboration spaces were created by shifting to a new paradigm, such as the Fourth Revolution that has led to space creation. The universities' education strategies can be observed through classification methods in conjunction with the keywords for their

talent competency strategy presented by the Korea Educational Development Institute [46]. According to the Institute's study, the most crucial competency keywords for fostering creative talent are "cooperation," "communication," "creative thinking," and "collective creativity." When these capabilities are supported in the knowledge base of a professional field, talent is born through inclusion and acceptance at the sociocultural level.

In addition, a Fab Lab is a representative innovative space in terms of expanding networks [5]. Conceptually, a Fab Lab is an in-between space between real space and virtual space, combining network structures. It is a space where accessible networks between creatives can become more active by properly integrating virtual places and real spaces [4]. Charles Schweik argued that collaborative principles (collective action) for open-source software development projects can potentially be applied to new knowledge development [37]. Unlike in the past, it can connect to the network at the individual level to plan, design, and produce goods. Many universities worldwide actively seek to keep up with, and introduce, this rapid movement of the Fourth Industrial Revolution with Fab Labs [47]. Therefore, such expansion of Fab Lab networks is the reason to view university facilities as commons and to evaluate these in the framework for the commons.

Universities spaces are common resources. However, unlike Fab Labs, many universities in Korea experience difficulty in having the characteristics of commons in terms of institutional governance [17,48,49]. First, they face a problem because the institutional method of the university space is stuck in top-to-bottom governance and central control. Second, conversely, many Korean university campuses have been fighting the privatization of space by colleges [25,48,49]. Both problems arose because as Korean and Asian universities incorporated the rapid changes in the modern educational system, they only aimed to achieve visible efficiency [25,48,49]. This scenario is related to the problem of contradictory spatial problems as a dilemma of the commons and as unsustainable commons [7,19,20]. Therefore, universities need to explore the sustainable sharing scheme of Fab Labs through implementing innovative institutional policies and space plans [34]. To develop a sustainable space-sharing plan for the universities in Asia, including Korea, this study investigates the case of Idea Factory [50] (the Fab Lab at Seoul National University; (see Figure 3)).

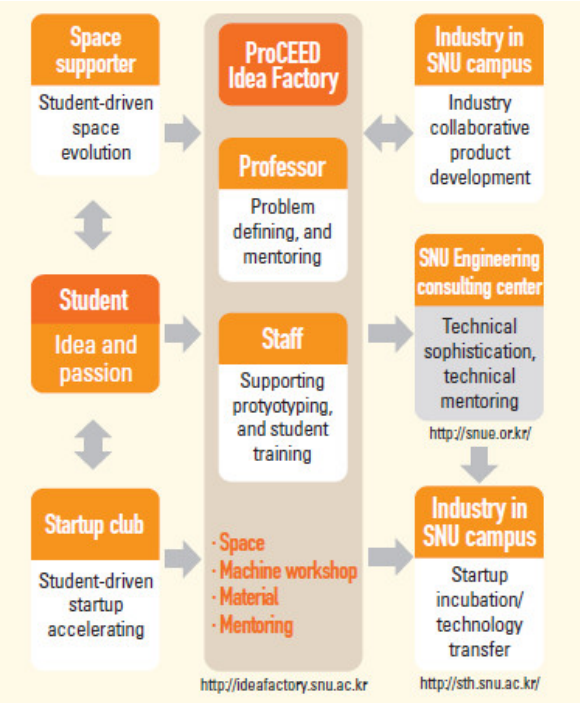


Figure 3. Polycentric organizational governance of Idea factory and "start-up" ©Idea Factory.

3.3. Sharing Strategies Through Fab Labs (Idea Factory)

The background and essential values of Idea Factory align with the essential elements of the Fab Charter. All members who have completed the mandated environmental safety training can use this open space. The availability of 24 h maintenance means that the occupied time slots vary compared with those at other university labs without this facility. In addition, although it is affiliated with an engineering college and operates in a college building, it is open to everyone. This space's characteristic is that it offers the advantages of multidisciplinary systems and thus enables members to conduct creative classes and projects. Since various members participate and operate in this space, its function is user-centered, based on responsibility and mutual trust rather than University-centered. The network itself is based on trust and the belief in sharing [51,52]. The Idea Factory manager mentioned in an interview that the change in the perception of shared spaces was most prominent while running the space (Appendix B). He pointed out that the biggest problem with a shared space lies in the owner's consciousness, not the availability of money, and that there should be a vision for space, which appears in the semi-communal reflective space [6].

There is a networking system for makerspaces in Seoul National University itself. It previously existed within each university's buildings, and currently, the spaces that were not related to each other are linked together as start-up ecological networks. The Idea Factory, a creative factory, a design research park, an entrepreneurship center, a research park start-up investment center, and a research park are planned and will operate on the campus in conjunction with SNU Techno Holdings Inc. For network reinforcement through the partial sharing of space, it is open to outsiders as a creative space. These were unused or occupied spaces in each department. These spaces, which function as start-up hubs, have been transformed into a shared space with space's information system available to all users, so it is accessible to all members or outsiders. These spaces are makerspaces characterized by natural networking and a wide variety of program exchanges. In addition to the "SNU Entrepreneurship Ecosystem" in Korea, numerous networks have been established for multidisciplinary education and for international universities, such as Tsinghua University in China and Hong Kong University of Science and Technology, for global design education.

This institutional innovation of Idea Factory offers the potential of not only opening up the spaces privately occupied by each college in the university, but also positively affecting innovative education and learning. Thus, this case study provides new insights into the shared environments of university spaces.

4. Results

This study reconstructs Ostrom's tripartite model (resources, institutions, communities) into three university policy domains: Resource Policy (Rp), Actor/User Policy (Ap), and Community/Governance Policy (C/Gp). Applying this framework to the Idea Factory at Seoul National University, and cross-referencing it with Fab Charter principles, the study demonstrates both the local validity and the international scalability of the proposed framework.

Based on the critical review of the concepts of commons and Fab Labs and their application to space commons in the university, an analysis framework was developed to improve the understanding of sustainable sharing schemes. The proposed framework represents the effect of the shared space policy applied to the concept of the commons. The framework may be useful to universities in developing a sustainable shared space scheme and determining related policies and architectural plans. It would serve as a guideline on

implementing metrics according to changes in situations such as space, users, communities, and governance for performing a spatial sharing system analysis.

4.1. Restructured Framework for Analyzing Sustainable Sharing Scheme in the Space Policy of Fab Labs

While the formal rule dictates a three-strike ban for no-shows, our analysis reveals a significant institutional tension between administrative efficiency and educational goals.

The Conflict: Engineering students engaged in long-term capstone projects frequently violated reservation time limits, arguing that rigid slots disrupted their workflow.

The Resolution: Rather than strictly enforcing the ban, the governance body (C/Gp) introduced a probationary period and allowed overnight storage" for verified project teams.

Interpretation: This demonstrates that sustainability in a university commons is not achieved by rigid rule adherence, but by the flexibility of Actor Policy (Ap) to adapt to the academic cycle.

The spatial governance of Fab Labs (see Figure 3) differs from that of the existing university space (facility) and depends on the provision of new facilities to support "cooperation," "communication," "creative thinking," and "collective creativity" in universities. Further, an earlier sentence is "According to the Institute's study, the most crucial competency keywords for fostering creative talent are "cooperation," "communication," "creative thinking," and "collective creativity"." This new type of facility is difficult to distinguish according to the traditional classification of space and inevitably leads to confusion about the existing space (facility) classification method [4].

The standards of the information systems in Korea's higher education facilities can be divided into three hierarchies: the essential, the high-priority spatial, and the organizational hierarchies. The organizational hierarchy consists of colleges, departments, and departments in the series of universities, and the facility hierarchy is classified into large, medium, and small. In addition, the space classification system is linked to the room, building, and campus allocated depending on the area. These hierarchies may involve user policy. If the hierarchical order is revised horizontally, the standard of the information systems in these higher education facilities can be applied interchangeably to three factors of the commons (i.e., resources, rule in use, and communities). Through this modification, it can be applied to a space, such as a Fab Lab, that differs from the existing hierarchy of the educational institution. Furthermore, by aligning the analytical categories with international FabLab standards (Fab Charter principles), the framework can serve not only as a tool for domestic institutional reform but also as a universal guideline adaptable to diverse global contexts. The categories for shared space in the university should be divided for these reasons: the policies for space (facility) sharing form a complex system, diverse resources are available, and user restrictions and privileges are also complex and subject to various aspects. Hence, space (facility) sharing can contain a variety of subsystems and variables within Ostrom's eight principles (see Table A2) for sustainable commons management [7] and requires a policy classification framework to enable the application of these principles.

To create a conceptual framework for shared space in the university, this study divides the conceptual categories for judging the Fab Lab space into three categories related to the policies for space (facility), users (Ap), and community and governance (C/Gp).

Specifically, we developed detailed assessment indicators for each category to ensure the verifiability of the analysis. As shown in Appendix A (Table A1), the variables are derived from Ostrom's SES framework but operationalized for the university context. For example, 'Resource Unit Mobility' is not an abstract concept but is measured by 'Cross-college usage rates' derived from asset codes.

Tables A2–A5 in Appendix A provide the specific grading criteria used to evaluate the robustness of the Idea Factory's policies. This rigorous quantification moves the analysis beyond descriptive assertions. For instance, 'Monitoring' (Ap-2) is not evaluated by the presence of a security guard, but by the existence of a transparent digital dashboard (Environmental Monitoring, see Table A4), which aligns with the Fab Lab's philosophy of self-governance.

Standards of the information system for higher education facilities can be applied interchangeably to the conceptual framework of the commons. Conceptual framework for Shared space in the university and Standards of the Korean higher-education facility information system (see Table 1 and Figure 4).

Table 1. Three factors of the commons and the conceptual framework for university shared space.

Definition of Commons	IAD Framework	Three Factors of Commons	Conceptual Framework for University Shared Space
Common resources	Physical-world	Resources	(Rp) Space (facility) policy
Institutions (common practices)	Institution	Rule in use	(Ap) Actor policy
The communities (commoner)	Community	Communities	(C/Gp) Community/Governance policy

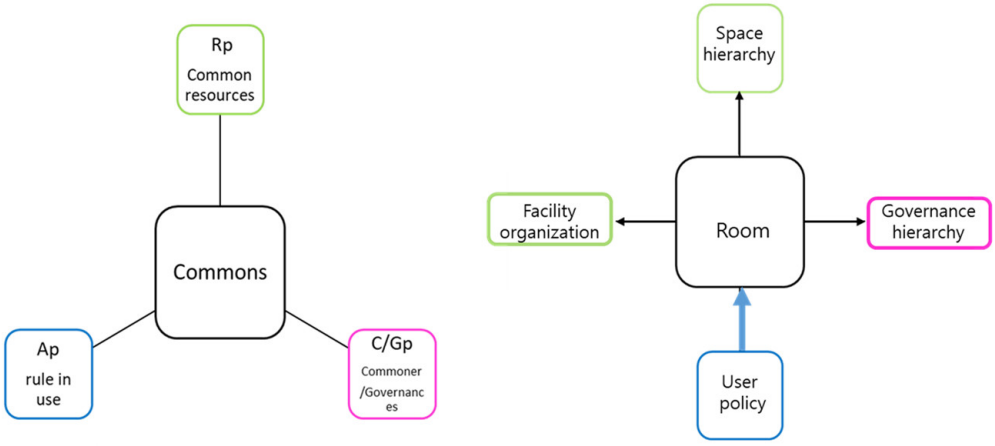


Figure 4. Standards of the information system for higher education facilities in Korea.

In this study, critical reconstruction was primarily divided into three policy categories: Resource policy (Rp), User policy (Ap), and Community/Governance policy (C/Gp). In addition, the analysis framework for complex campus systems is divided into four phases. Thus, in this framework, a variety of subsystems can be applied, and variables can be included in line with Ostrom's eight principles for managing the commons. The framework stages (see Table 2) are:

A. Policy categories (Rp, Ap, C/Gp);
B. Policy variables (applying Ostrom's eight principles);
C. Variable details;
D. Policy for applied cases (Fab Lab policy).

The four stages of the framework enable judgments to be made about the share plans for the university shared spaces, such as the Fab Lab.

This rigorous quantification moves the analysis beyond descriptive assertions. For instance, 'Monitoring' (Ap-2) is not evaluated by the presence of a security guard, but by the existence of a transparent digital dashboard (Environmental Monitoring, see Table A4), which aligns with the Fab Lab's philosophy of self-governance.

Table 2. Analysis framework for university shared space.

A. Policy Category Rp (Resource (Space) Policy)	B. Policy Variables (Ostrom's 8 Principles for Managing a Commons)	C. Variables Details	D. Fab Labs policy (IDEA Factory)
Rp-1	Boundaries of users and resources are clear. (Resources boundary)	Resource unit Mobility	Clear system of equipment room/other rooms
		Distribution a_ temporal heterogeneity	Various and multiple deployments of each piece of equipment make it possible for bookers to choose from them
		Distribution b_ spatial heterogeneity	Shared using efficient equipment via the timetable and deployment time. Available 24 h a day 365 days a year.
Rp-2	Boundaries of users and resources are clear. (Users boundary)	Group size	All members can use the building even though it belongs to the engineering college.
		Technology used	Fabrication technology—a certificate of completion of safety education is required for all members to enter.
Policy category Ap (Actor policy)	**Policy variables (Ostrom's 8 Principles for managing a commons)**	**Variables details**	**Fab Labs policy (IDEA Factory)**
Ap-1	Congruence between benefits and costs.	Location	It is included in the engineering college due to its location, so management and workforce distribution are carried out within the engineering college student and system.
		Property-Rights regime	It belongs to a college, but all members use it regardless of time, in line with the fab lab's basic purpose.
		Provision	The status of facilities and spaces available on the website can be seen.
		Appropriation	Members can schedule bookings through the website.

Table 2. *Cont.*

Ap-2	Regular monitoring of users and resource conditions	Sanctioning	A user's reservation status is monitored in the timetable
		Monitoring	Equipment usage status can be monitored by equipment
Ap-3	Nested enterprises.	Governance Rules	It is classified as a Basic educational facility, but has self-governing rule in use.
		Ownership	The administrative office of a university
		Network Structure	University offices and adjuncts
Ap-4	Graduated sanctions.	History of Use	Restrictions on the use of "No show" more than three times
Policy category C/Gp (Community/Governance policy)	**Policy variables (Ostrom's 8 Principles for managing a commons)**	**Variables details**	**Fab Labs policy (IDEA Factory)**
C/Gp-1	Collective-choice arrangements	Operational rules	There is a separate policy from the space use regulations of this university or the Ministry of Education.
C/Gp-2	Conflict resolution mechanisms	Conflict resolution	Arbitration through regulation
C/Gp-3	Minimal recognition of rights by government	Collective-choice rules	Reflections of actual user's opinion in the space planning stage with a student-led space cooperation team and the university's space use regulations

4.2. Analysis of Fab Lab Shared Scheme

The robustness of the Idea Factory's governance was evaluated using the indicators defined in Appendix A. Table A2 summarizes the achievement levels for each policy domain.

4.2.1. Resource (Spaces and Facilities) Analysis

The framework comprises three policy categories. The Rp category represents the boundary setting for resources (space/facility). Category Rp is divided into two parts (Rp-1—Resources boundary, Rp-2—Users boundary). Rp-1 establishes boundary principles of spatial resources, and Rp-2 establishes clear boundary principles for membership (a certificate of completion of safety education). Consequently, boundary setting for units and ranges enables analysis to be made according to the boundaries of the systems. To rigorously evaluate this flexibility, we applied the specific assessment criteria defined in Appendix A (Table A5). The primary indicator, 'Resource Unit Mobility' (Rp-1), measures the count of boundary crossings—such as mobility across college boundaries, spatial hierarchies, and facility classifications. Based on the analysis of the Idea Factory's operational data, the facility achieved a high mobility score because it technically decoupled the physical space from the exclusive 'College of Engineering' asset code. This allows the resource unit to serve not just a single department but to be reallocated dynamically across user definitions (Score: Robust), fulfilling the criteria for a sustainable commons.

The following are the policies of the Idea Factory related to this category: (details about variables: Idea Factory policy).

- Resource unit mobility: clear system of equipment room/other rooms;
- Distribution a_ temporal heterogeneity: various and multiple deployments of each piece of equipment make it possible for bookers to choose among these pieces;
- Distribution b_ spatial heterogeneity: efficient shared use of equipment via the timetable and deployment time; available 24 h a day, 365 days a year;
- Group size: open to all members although it belongs to the engineering college;
- Technology used: fabrication technology (all members must have a certificate of completion of safety education training to enter the space).

4.2.2. Actor (Rules for Users) Analysis

The Ap category represents the policies (rules in use) applicable to the actors, such as monitoring and sanctions. The Ap category is divided into four: Ap-1 (congruence between benefits and costs), Ap-2 (regular monitoring of users and resource condition), Ap-3 (nested enterprises), and Ap-4 (graduated sanctions). This policy category includes appropriate rule schemes related to the space allocation to users and the related policies to establish rules about such allocation, autonomous monitoring and permission-free use by spatial information sharing, and progressive systems to prevent overuse. It comprises the principles to determine the time, place, etc. (Ap-1) in which a user appropriates (uses) resources and to apply rules, practices, and laws that correspond to each situation. Monitoring (Ap-2) relates to the actual use of the space to the analysis principles about whether practices and regulations are used and whether the legal aspects of campus legislation or education or higher institutions are consistent (Ap-3); and to sanctions for violating rules or overusing quotas (Ap-4).

Based on the criteria in Table A3 (Appendix A), the Idea Factory represents 'Level 1' monitoring. Unlike traditional labs that rely on 'Social Surveillance' (Level 3 or 4) by professors, the Idea Factory utilizes an 'Environmental' system where reservation logs are visible to all users, creating peer pressure that enforces rules autonomously.

The following are the policies of the Idea Factory for this category (variables' details—Idea Factory policy):

- Location: It is included in the engineering college owing to its location, and therefore, its management and workforce distribution are conducted within the engineering college student system.
- Property Rights Regime: It belongs to a college, but all members can use it, regardless of time, in line with the Fab Lab's basic purpose.
- Provision: The status of facilities and spaces available are displayed on the website.
- Appropriation: Members can schedule bookings through the website.
- Sanctioning: User reservation status is monitored through a timetable.
- Monitoring: The usage status of each piece of equipment can be monitored.
- Governance Rules: It is classified as a Basic educational facility but has self-governing rule in use.
- Ownership: The administrative office of the university is the owner.
- Network Structure: The university offices and adjuncts are included in the network.

4.2.3. Community/Governance Analysis

The C/Gp category represents the community/governance policy concerning the governance hierarchy and the networking system. This category is divided as follows: C/Gp-1 (collective choice arrangements), C/Gp-2 (conflict resolution mechanisms), and C/Gp-3 (minimal recognition of rights by the government). Self-governing organizational

rights, and collective selection devices for the collaborative community's right to modify rules or form necessary spatial consultative bodies, are included in the C/Gp category. This classification is a set of institutional principles essential for self- and shared governance. In the case of campus space commons, it is also related to establishing a horizontal governance system for coordinating committees inside universities and self-governing space management. In Fab Labs, a successful commons principle is that conflict resolution devices are collectively adjustable to the users of each unit rather than to headquarters-oriented organizations (C/Gp-2). Self-governing organizational rights belong to C/Gp-3 as a principle that an organization for sharing is more sustainable only when it is self-governing rather than under central headquarters or national influence.

Analysis of Rule Negotiations (The "No-Show" Conflict):

While the formal Actor Policy (Ap) dictates a "Three-Strike Out" ban for repeated no-shows, our analysis of the log data revealed a significant gap between the formal rule and the rule-in-use.

Conflict: Engineering students engaged in long-term capstone projects frequently violated reservation time limits, arguing that rigid 2 h slots disrupted their workflow.

Negotiation: Rather than strictly enforcing the ban, the student-led governance body (C/Gp) introduced a "Probationary System" and allowed "Overnight Storage" for verified project teams.

Result: This demonstrates that sustainability in a university commons is not achieved by rigid adherence to written regulations, but by the flexibility of the Actor Policy to adapt to the academic cycle of its users.

The following are the policies of the Idea Factory related to this category (variables' details—Idea Factory policy).

- Operational rules: A policy separate from the space use regulations of the university or the Ministry of Education is used.
- Conflict resolution: Arbitration is conducted through regulations.
- Collective choice rules: The actual users' opinions are reflected in the space planning stage with a student-led space cooperation team and the university's space use regulations.

5. Discussion

5.1. Defining Institutional Sustainability

In this study, "sustainability" is operationalized not merely as financial viability or equipment maintenance, but as Institutional Robustness. Within the proposed Rp/Ap/C/Gp framework, this is defined as the capacity of the Fab Lab to: (1) maintain physical resources through flexible boundary setting (Rp); (2) regenerate the user community continuously despite the natural turnover of the student population (Ap); and (3) resolve internal conflicts autonomously without requiring constant external intervention from university headquarters (C/Gp). This definition shifts the focus from simple resource management to the resilience of the governance structure itself.

5.2. Comparative Analysis and Scalability

While validated through the single case of Seoul National University (SNU), the framework gains robustness when situated in an international context. Cross-national comparisons using the framework's indicators (boundary setting, self-governance, network participation) reveal distinct governance models:

- MIT Media Lab (USA)—Market-driven Model: Characterized by high global network participation and open governance supported by substantial corporate sponsorship.

- Tsinghua University (China)—State-driven Model: Driven by national innovation strategies and large-scale expansion directives.
- SNU Idea Factory (Korea)—Commons-driven Model: Characterized by the recycling of idle internal resources and student self-governance within a hierarchical university system.

These comparative insights illustrate that the proposed framework is not limited to a single institutional or cultural context but can bridge regional specificities and international standards, positioning FabLabs as globally recognized nodes of the university commons.

Unlike MIT's reliance on external funding or Tsinghua's state directives, the SNU model suggests that for Asian universities facing budget constraints, the critical success factor is the internal efficiency of Actor Policies (Ap). This comparative perspective highlights that the proposed framework is not bound to a single cultural context but is capable of translating regional particularities into a universally applicable governance model, bridging local experimentation with international standards (e.g., Fab Charter).

This experimental study presents an analysis framework for the shared space for responding to the rapidly changing educational environment. This framework is needed for higher educational institutions. A critical review of the literature was conducted, which informed the development of a comprehensive framework for the sharing scheme of the complex university environment. This study analyzed Fab Labs, a common resource of universities, and identified how it changes. The study performed a case analysis of the Seoul National University Fab Lab, which can be cited as an example of institutional change in innovative higher education spaces in Asia and, in particular, in developing countries. It shows that the Fab Lab is linked to multiple systems and with local and international Fab Lab organizations (see Figure 5), which influences its development. Moreover, it is characterized by self-governance and the application of clear user boundaries and rules. Idea Factory's user regulations are as follows. In the case of the progressive system of Ap, users are not allowed to reserve and use the equipment once or cancel equipment use twice, to reserve and use the equipment three times, or use the space five times. As rules to resolve conflicts if the working hours overlap, the user who made the reservation first has priority based on the date and time of application, the number of reservations per person is limited to one per day, and at least one output reservation is required per day.

Beyond the single institutional case of Seoul National University, it is important to situate the framework within the international FabLab network standards, particularly the *Fab Charter* and the operational guidelines of the Fab Foundation. These standards—open access, adherence to the Charter, provision of standardized equipment, and participation in global networks—form a globally recognized baseline for sustainable FabLab governance. By aligning the proposed analytical framework with these international criteria, the study emphasizes that university FabLabs can function not merely as local commons but as nodes in a polycentric global commons system. This cross-reference demonstrates how Ostrom's institutional principles can be integrated with FabLab's globally shared rules, thereby reinforcing the validity and applicability of the framework across diverse cultural and institutional contexts.

While the framework was validated through the Seoul National University Idea Factory, its applicability extends beyond the Korean context. Comparative analysis with FabLabs at Tsinghua University (China), Cornell Tech (USA), and MIT Media Lab (USA) demonstrates how the framework can capture both local specificities and global commonalities. Using standardized indicators—such as user boundary setting, self-governance mechanisms, and modes of participation in international networks—it is possible to reveal key differences: for instance, the challenge of *space privatization* and hierarchical governance

in Korean universities contrasts with the emphasis on *open governance* and *integration into global networks* observed in U.S. and Chinese counterparts.

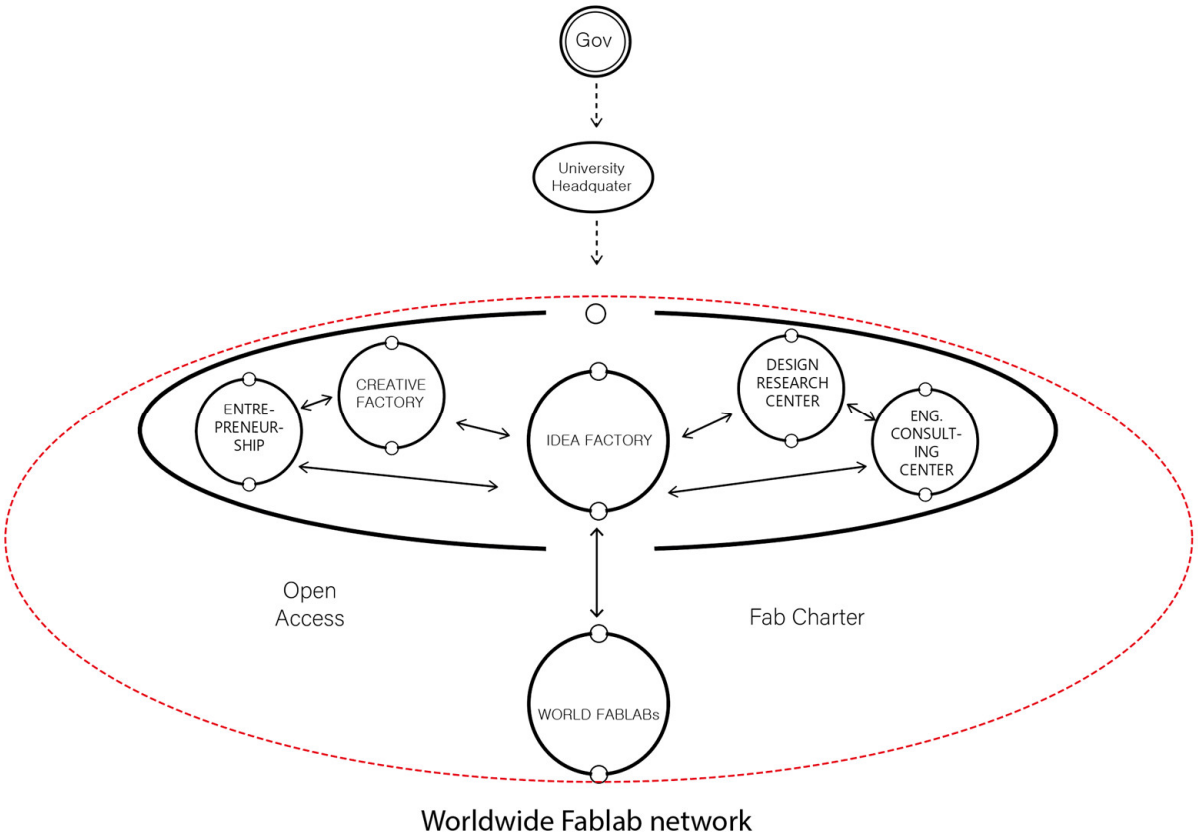


Figure 5. Relationship of University—Worldwide Fab lab with polycentric communities.

This comparative perspective highlights that the proposed framework is not bound to a single institutional or cultural context but is capable of translating regional particularities into a universally applicable governance model. In doing so, it bridges the gap between local experimentation and international standards, reinforcing the potential of FabLabs to serve as globally recognized nodes of university commons.

5.3. Institutional Tensions and Nested Enterprises

The comparative analysis reveals a structural tension between the university's centralized governance and the Fab Lab's commons-based operation. While SNU's official 'Integrated Space Management System' strictly categorizes spaces by administrative units (e.g., Department of Engineering) and enforces rigid reservation protocols managed by the Office of Information Systems & Technology, the Idea Factory operates as a 'nested enterprise' (Ap-3).

It bypasses this rigid central system by establishing its own flexible booking rules (Ap-1) that allow cross-disciplinary access regardless of departmental affiliation. This "institutional decoupling" from the central system is not a flaw but a necessary condition for Rp-1 required in a creative commons. If the Idea Factory were fully subordinated to the Integrated Space Management System, the rapid, peer-to-peer interaction vital for a maker space would likely be stifled by bureaucratic latency.

Despite the operational success of the Idea Factory, this study observed persistent tensions between the commons-based governance and the university's rigid administrative framework. Unlike a fully autonomous commons, the Idea Factory operates as a "Nested Enterprise." For instance, the student demand for complete "24 h autonomous access"

is continuously constrained by the university headquarters' safety regulations and legal liability issues. This implies that the sustainability of a university Fab Lab depends not only on internal community rules but also on its ability to negotiate compromises with the external legal hierarchy. This "institutional friction" represents a critical limitation that future governance models must address.

5.4. Implications for Future University Planning

The proposed framework is particularly relevant given the macro-context of declining school-age populations. As departmental exclusivity leads to underutilized spaces, our Resource Policy (Rp) framework offers a systematic method for universities to identify and convert these "dead spaces" into active shared commons, thereby addressing the efficiency crisis in higher education.

To develop a sustainable sharing scheme in higher education, this study offers three strategic implications:

1. Securing Flexibility of Physical Boundaries (Rp): To convert non-common spaces into commons, a flexible classification system is required. Instead of rigid space programs based on complex arithmetic systems, universities should adopt simple classification standards that allow for rapid functional changes. This is particularly relevant given the macro-context of declining school-age populations; our Resource Policy (Rp) offers a method to identify and convert underutilized "dead spaces" resulting from departmental exclusivity into active shared commons.
2. Establishing Collaborative User Policies (Ap): Abstract regulations fail in flexible environments. Rules must be specific and integrated into a "collaborative infrastructure" based on information sharing. Following Benkler's concept of "peer production," self-governing monitoring through transparent information systems is more effective than top-down "organized monitoring." When information is shared and rules are clear, compliance increases, and dispute settlement becomes autonomous.
3. Polycentric Governance Structures (C/Gp): To revitalize the knowledge community, the scope of stakeholders must expand to include users. Universities need to shift from "huge masterplans" to "mutual or partial coordination." A horizontal organizational system should be created where spatial issues are resolved through stakeholder involvement rather than solely by headquarters. Furthermore, the relationship between participation procedures and rights must be clearly stated in policy, distinguishing between ownership rights and usage rights.

Despite the model's success, this study observed persistent tensions between the "bottom-up" community culture and the university's "top-down" asset management regulations. For instance, the student desire for 24 h access conflicts with university safety protocols and legal liability issues. This implies that a fully autonomous commons is inevitably constrained by the legal framework of the host institution, highlighting a boundary condition that future research must address.

6. Conclusions

This study develops a framework for university shared spaces by conceptualizing the Fab Lab as a model for sustainable commons governance. By translating Ostrom's institutional principles into the administrative language of Resource (Rp), Actor (Ap), and Governance (C/Gp) policies, the framework provides a practical roadmap for converting rigid university facilities into adaptive shared resources.

Beyond theoretical reconstruction, this study offers three specific empirical insights for university administrators, derived directly from the analysis of the SNU Idea Factory case:

First, "Flexibility" must be institutionalized through Asset Classification Reform (Rp).

Our analysis of the SNU BPR report revealed that the primary barrier to sharing was the rigid "Departmental Asset Code" system. Therefore, to ensure sustainability, universities must not merely "encourage" sharing but technically decouple physical ownership (College of Engineering) from access rights (University-wide). As demonstrated by the Idea Factory's digital infrastructure, adopting a "Shared Zone" classification in the university ERP system is a prerequisite for overcoming the tragedy of the anti-commons (underutilization).

Second, User Policies must prioritize "Adaptive Sanctioning" over Rigid Enforcement (Ap).

The "No-Show" conflict analyzed in Section 4 demonstrated that applying standard administrative rules (e.g., immediate bans) to students engaged in long-term projects leads to system failure. Consequently, we recommend that university shared spaces implement graduated sanctions—such as probationary periods or overnight storage privileges—that align with the academic semester cycle. This finding challenges the conventional "efficiency-first" management style of typical university facilities.

Third, Polycentric Governance requires formalizing "Student-Staff" Roles (C/Gp).

The "Student Supporter" system (Figure 3) was not merely a volunteer group but a critical node for conflict resolution that bypassed bureaucratic bottlenecks. Therefore, sustainability depends on formally recognizing these student-managers within the governance structure, granting them decision-making power rather than just advisory roles. This confirms that a successful campus commons is created not by top-down master plans, but by bottom-up rule-making.

Future Research and Limitations

To move towards a more generalized model, this framework should be further tested against international standards. Incorporating the Fab Charter as a comparative benchmark enables the bridging of local practices with global norms. Future research should expand beyond the single case of SNU to conduct cross-national comparisons—specifically with Hong Kong universities (Residential Commons) and MIT (Market-based models)—to validate the framework's versatility across different cultural and funding environments.

Ultimately, this study confirms that the "University Commons" is not a utopian ideal but a constructable institutional system. By explicitly analyzing the invisible rules of Rp, Ap, and C/Gp, universities can transform their dormant spaces into vibrant ecosystems of innovation, responding effectively to the demographic and technological pressures of the Fourth Industrial Revolution.

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Appendix A. Analytical Variables and Assessment Indicators for University Shared Spaces

Table A1. Detailed Variables for the Analysis Framework.

Resource System (RS)									
a	**b**	**c**	**d**	**e**	**f**		**g**	**h**	**i**
Boundary clarity	size	Equilibrium properties	Location	Resource Unit Mobility	Interaction		size	Distinctive marking	Distribution
Actors (A)						**Action Situations (AS)**			
j	**k**	**l**	**m**	**n**	**o**	**p**	**q**	**r**	**s**	**t**
Group size	History of Use	Location	Leadership	Technology used	Monitoring	Sanctioning	Conflict resolu-tion	Provision	appropriation	Policy making
Governance System (GS)										
u			**v**				**w**			
rules			**Property-rights regime**				**Network Structure**			
operational rules/collective-choice rules/constitutional rules			**private/ public/ common/mixed**				**centrality/Modularity/Connectivity/Number of Level**			

Setting Variable	**Core Variable**	**Sub-components**
		(1) Operational rules
		(2) Collective-choice rules
		(3) Constitutional rules
		(1) Private
		(2) public
		(3) common
		(4) mixed
		(1) centrality
		(2) modularity
		(3) connectivity
		(4) Number of levels

Table A2. Assessment Criteria for Governance Policy.

Assessment Criteria for Governance Policy			
Main Category	C/Gp	Community/Governance Policy	
Sub-category	C/G-2	Conflict Resolution Mechanisms	
Variable	v	Property-rights regime	
Evaluation			
Evaluation Purpose	To evaluate the level of user participation in the committee and the distribution of rights to induce a knowledge community		
Assessment Method	Evaluation based on the allocation of spatial rights (Access, Lease, Exclusion, etc.).		
Scoring Criteria	**Score = Weight × Points**		
Grading		Cross-level indicators	Weight
	Level 1	Common	1.0
	Level 2	Mixed	0.7
	Level 3	Public	0.4
	Level 4	private	0
Data Source			
Data Source	Governance regulations, Space management by laws		

Table A2. *Cont.*

Assessment Criteria for Governance Policy		
Rationale		
Rationale	Authority items are classified based on where decision-making power is primarily located: Public when authority is concentrated in the central administration, Private when it mainly resides in colleges, Common when shared among all stakeholders, and Mixed when authority is relatively evenly distributed between stakeholders and the central or college level.	
	Space Authority	
	a	Right to access
	b	Right to lease
	c	Right to receive revenue
	d	Right to occupy
	e	Right to generate revenue
	f	Right to exclusion
	g	Right to determine use
	h	Right to alienation

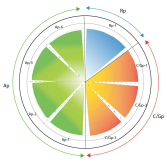
Table A3. Assessment Criteria for Actor Policy

Assessment Criteria for Actor Policy			
Evaluation Purpose	Ap	Actor Polic	
Assessment Method	Ap-2	Monitoring Activities	
Scoring Criteria	o	Monitoring (Detailed Item)	
Evaluation			
Evaluation Purpose	To assess whether monitoring is conducted via "autonomous information sharing" rather than "organized surveillance."		
Assessment Method	Evaluation based on the existence and transparency of the information sharing system		
Scoring Criteria	**Score = Weight × Points**		
Grading		Cross-level indicators	Weight
	Level 1	Environmental Monitoring exists (Digital dashboard transparency)	1.0
	Level 2	Environmental system exists, but combined with hierarchical surveillance.	0.7
	Level 3	No system; relies solely on hierarchical (social) surveillance	0.4
	Level 4	No monitoring system exists or rules are ignored	0
Data Source			
Data Source	Space information regulations, Log data from reservation systems		
Rationale			
Rationale	1. Environmental 2. Social It is evaluated based on the classification and degree of hierarchical oversight by the central administration. - Lower-level variables of the sub-category		

Table A4. Assessment Criteria for Resource Policy.

Assessment Criteria for Resource Policy		
Main Category	Rp	Space policy
Sub-category	Rp-1	Clear Boundaries and Membership
Variable	e	Resource unit mobility
Evaluation		
Evaluation Purpose	To assess the flexibility of boundaries across colleges, spatial units, and user groups	
Assessment Method	Count of boundary crossings (mobility instances)	
Scoring Criteria	**Score = Mobility Count × Points:** Mobility across college boundaries	
Grading	Indicators	Count of boundary crossings
	Level 1	Mobility across college boundaries
	Level 2	Mobility across spatial hierarchy (Building/Room)
	Level 3	Mobility across facility classification
	Level 4	Mobility across user definitions
Data Source		
Data Source	- CAFM (Computer Aided Facility Management) logs, Changes in facility standards.	
Rationale		
Rationale	Changes to CAFM (Computer-Aided Facility Management) and Ministry of Education Facility Standards	

Table A5. Assessment of Institutional Robustness: Idea Factory Case Study.

Main Category	**Rp**	**Ap**				**C/Gp**			
Sub-category	Rp Clear Boundaries & Membership	Ap-1 Rules are adapted to student project cycles	Ap-2 Monitoring	Ap-3 Nested Enterprises	Ap-4 Graduated Sanctions	C/Gp-1 Collective-Choice Arrangements	C/Gp-2 Conflict Resolution	C/Gp-3 Minimal Recognition of Rights	
Achievement Level	Robust 1	Robust 1	Robust 1	Robust 1	Robust 1	Clear Application 1+	Robust 1	Robust 1	Achievement Level Chart

Rp-1 Clear Boundaries & Membership Clearly defined boundaries for equipment rooms; Membership based on safety training certification. Robust; Ap-1 Congruence with Local Conditions Rules are adapted to student project cycles (e.g., overnight storage). Robust; Ap-2 Monitoring Automated digital monitoring via reservation dashboard (Environmental monitoring). Robust; Ap-3 Nested Enterprises Organized as a nested unit within the College of Engineering but serving the whole university. Robust; Ap-4 Graduated Sanctions Three-strike rule for no-shows; Probationary periods. Robust; C/Gp-1 Collective-Choice Arrangements Student-led committees participate in rule modification. Clear Application; C/Gp-2 Conflict Resolution Mechanisms for resolving scheduling conflicts via peer negotiation. Robust; C/Gp-3 Minimal Recognition of Rights Autonomy recognized by university HQ despite being a sub-unit. Robust.

Appendix B. Interview with the Manager of Idea Factory at Seoul National University

Interviewee: Manager of Idea Factory.

Location: Idea Factory, College of Engineering, Seoul National University.

Q1. What are some ways to share a classroom and laboratory space?

Manager: At the Idea Factory, we focus on maximizing accessibility rather than exclusive ownership. Unlike traditional laboratories assigned to specific professors or departments, our space is open to any member of the university who completes safety training. We utilize a reservation-based system for both working spaces and equipment, which allows multiple users to share the same physical footprint across different time slots.

Q2. What is such a space, and what programs do you have?

Manager: The Idea Factory is a "creative factory" and a maker space located within the College of Engineering but open to the entire university. It functions as an experimental space for convergence research and student-led projects. We run various programs including 3D printing workshops, laser cutter training, and "Idea Factory-supported projects" where we provide funding and mentoring for student prototypes. We also host start-up incubation programs and design thinking workshops.

Q3. Is there a system related to space sharing?

Manager: Yes, we operate a dedicated digital platform distinct from the university's central system. We have a web-based Real-time Space Occupancy Dashboard and Equipment Reservation System. Users can check the availability of equipment (like 3D printers) and worktables in real-time online and book them. This digital infrastructure is crucial because it allows the space to function autonomously 24 h a day without constant staff supervision.

Q4. Is there a system to prevent the monopoly of colleges or members?

Manager: To prevent monopolization, we have implemented specific "Rules-in-Use" (Actor Policies). First, although we are physically located in the College of Engineering, we do not restrict access based on major. Second, we have reservation limits—for example, a user cannot book the same equipment for excessive consecutive hours, and there are caps on daily reservations. We also monitor "No-shows"; if a user fails to show up for a reservation three times, they face a temporary ban (Three-strike rule).

Q5. Is there any place where the utilization has risen sharply? What about the plan?

Manager: Since opening, the utilization of our prototyping areas and collaborative meeting zones has risen sharply, especially during mid-terms and finals when capstone design projects are due. We often see congestion during these peak times. Our plan to address this involves analyzing our log data to identify "dead times" (like early mornings or weekends) and encouraging usage during those hours. We are also considering expanding the "overnight storage" zones for long-term projects to free up daily worktables.

Q6. Are there spaces and related systems similar to the way co-working spaces are shared and utilized (to increase utilization by reducing power and increasing share rates)?

Manager: Yes, the Idea Factory operates very much like a commercial co-working space. We share resources (3D printers, scanners, tools) that would be too expensive or space-consuming for individuals to own. By centralizing these resources, we significantly increase the "share rate" of equipment. Our system automatically tracks equipment usage hours, which helps us maintain them efficiently and justify future investments based on actual demand rather than estimated need.

Q7. What sort of space is available for sharing? (Ex. Teaching space (lecture, teaching lab)/community space/Meeting room, etc.)

Manager: We offer a mix of spaces:

1. Fabrication Zone: Equipped with 3D printers, laser cutters, and CNC machines.
2. Open Studio: Large tables for team collaboration and prototyping.
3. Meeting Rooms: Enclosed spaces for brainstorming sessions.
4. Rest/Community Area: A lounge-like space for casual interaction and networking.

It's a hybrid environment that functions as a teaching lab during workshops, a community space for networking, and a workspace for fabrication.

Q8. Are there any places where space-sharing has increased through renovation? (Building name or real name)—Are there any data on utilization?

Manager: The Idea Factory itself is a prime example. This space used to be a conventional, low-utilization facility within Building 39. Through renovation, it was transformed into an open commons. While I cannot release the raw administrative logs due to privacy policies, our internal data shows a massive increase in foot traffic and diverse departmental usage compared to the pre-renovation era. We track metrics such as "number of distinct users," "equipment operation hours," and "reservation fill rates" to quantify this success.

Q9. Is there a space consultative body to resolve space disputes between colleges and universities?

Manager: Within the Idea Factory, we have a student-led space cooperation team and a governance structure that involves professors and staff. We practice a form of polycentric governance. Disputes—for example, between long-term project teams and daily users—are often resolved through community meetings or by adjusting our operational rules (like the introduction of probation periods) rather than through top-down orders from the university headquarters. We aim for conflict resolution through autonomous regulation.

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