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Developing a Model for Sustainable Development in Education Based on Convergence Education*

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Abstract: Education for sustainable development (ESD) refers to education on the values and behaviors necessary for a sustainable future and society where everyone receives high-quality benefits. In the era of the fourth industrial revolution, convergence thinking is emphasized as a method of ESD. Therefore, this study aims to derive a model for developing open convergence subjects for ESD. The idea for this model was derived by combining the process of establishing a Convergence Department at Rey Juan Carlos University in Spain and the unit activities of Kyoto University in Japan. The challenges of failing to achieve the original goal and purpose of convergence due to emphasizing specific majors were solved by defining requirements for the model. Convergence subjects that meet the requirements are developed by following the order of the proposed model. In the future, a convergence subject pilot model will be applied using the proposed model to present and operate a course development process called “technology and future are seen through the window of currency”.

Keywords: *Convergence, convergence subject, education for sustainable development, horizontal convergence, open convergence education.*

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Introduction

In 2015, the United Nations (UN) established sustainable development goals (SDGs) as a part of the 2030 Agenda to commemorate its 70th anniversary. Through the pledge to ‘leave no one behind’ (LNOB), the UN declared 17 SDGs and 169 associated targets, categorized into five critical dimensions: people, prosperity, planet, peace, and partnership. Among them, the fourth goal is to ensure inclusive and equitable quality education and promote lifelong learning opportunities for all. The associated specific targets include substantially increasing the number of youth and adults who have relevant skills, including technical and vocational skills, for employment, decent jobs, and entrepreneurship and ensuring that all learners acquire the knowledge and skills needed to promote sustainable development, including, among others, through education for sustainable development and sustainable lifestyles, human rights, gender equality, promotion of a culture of peace and nonviolence, global citizenship and appreciation of cultural diversity, and culture’s contribution to sustainable development (Ministry of Environment, 2019; Shulla et al., 2022).

Education for sustainable development (ESD) is the practice method to achieve such SDGs in education. In 2021, the United Nations Educational Scientific and Cultural Organization (UNESCO) adopted the ‘2030 Berlin Declaration on Education for Sustainable Development’ at a meeting in Berlin, Germany (Hyesuk, 2021; Hyunjeong & Sungdo, 2021). ESD refers to education that aims for a society where everyone can receive high-quality benefits and learn the values and behaviors necessary for a sustainable future and society. Its core concepts are: 1) innovative practices for a better future through personal change, 2) structural changes toward sustainable development by overcoming unsustainable development, and 3) critical thinking and utilization of future technologies that can solve or cause sustainability issues (Nari, 2021; UNESCO, 2007). Overall, the ‘2030 Berlin Declaration on Education for Sustainable Development’ emphasizes convergence thinking to create a sustainable world (Misuk & Sunjin, 2020).

In particular, the fourth industrial revolution has already become an important topic. This is a sign that humanity is at an inflection point of significant change. The problem is that the impact of this change is not limited exclusively to the

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fields of industry or technology. Its effect will inevitably bring about disruptive innovation across society, and the field of education is no exception. The boundaries between industries are closing in, and convergence between academic fields with different characteristics is also being actively discussed. Today, learning in limited spaces called schools with textbooks is insufficient. Experts agree that we need a comprehensive educational innovation to nurture talents with creativity, humanity, and emotion, in addition to experiential knowledge. Therefore, this study aims to achieve the goal of ESD as a convergence discipline that integrates multiple academic fields by presenting a model for developing an open curriculum that converges disciplines.

Literature Review

Convergence Education

Convergence can be defined as the melting of different kinds to create a new form indistinguishable from each other (Sanghoun, 2018). Convergence education is used interdisciplinary and consilience. However, the difference is that although several academic fields are integrated, the final result is not a single discipline but a result of a new area. Therefore, this paper defines convergence as creating a new field by combining, integrating, and applying subdivided studies such as humanities, science, technology, and arts.

Convergence education has come to emphasize core competencies to nurture new talents in line with the development of science and technology in the 21st century. Convergence started with science, technology, engineering, and mathematics (STEM). The National science foundation has used the term since 1980, schools have used it since the 1990s, and it has been officially used as a term in education since 2001. K-12 started as a project for information education in the United States and refers to the entire curriculum from kindergarten to 12th grade. As STEM was included in this curriculum, it influenced OECD countries. In Korea, STEM was added to Arts and used as a STEAM, and the entire range of arts, humanities, and social fields was included in Arts to foster convergent thinking. Moreover, it played a big role in developing convergence education (Choonsig, 2012).

Information Technology (IT) is developing rapidly in Korea. The Ministry of Education is conducting a national convergence curriculum with the goal of 'Creative and Convergent Human Resources' in the '2015 revised curriculum'. As the COVID-19 pandemic began in 2020, convergence education became an issue, and most universities are showing changes in the establishment of convergence curricula and convergence education departments (Science Times, 2023). Information technology (IT) is developing rapidly in Korea. As IT technology began to combine with industry and various fields such as broadcasting, media, and manufacturing, convergence began to be activated (Gyeongyong, 2006).

In the UK, Excellence in Education, a national-level curriculum, was announced in 2004. The purpose of education was to grow into successful learners, dignified individuals, responsible citizens, and effective contributors. In order to achieve this goal, it was judged that a comprehensive learning experience was essential, and convergence education was emphasized as a critical idea in the excellent curriculum. At Oxford University, the PPE program was developed in the 1920s, and until the 1970s, subjects in philosophy, politics, and economics were taught individually. After that, surface area bonding was finally improved in the form of convergence. As a result of this change, the PPE program is being benchmarked worldwide by other universities in the UK, Canada, the US, Australia and the Middle East (Sun, 2019). Early American university education focused on practical application and research and development. In the 1960s, the United States, which fell behind in the space race during the Cold War, invested large-scale research funds into universities and concentrated on developing advanced science and technology. However, despite some achievements, this policy appeared as a side effect of neglecting the university's original function of education. In particular, as the world economy moved from a traditional industrial economy to a knowledge economy society after the 1990s, the limitations of the performance-oriented pragmatic academic tradition were revealed. The 2008 financial crisis in the United States was a de facto 'sentence of bankruptcy' for education that only delivers knowledge.

The elites, who received the best education at world-class private universities and grew up to become financial experts, enjoyed a favorable meal with astronomical performance bonuses even in the face of the global economic crisis with the financial products they designed. The importance of education with a 'human face' has grown, and the movement to find the answer in the humanities, such as liberal arts and classics, has become more active. At this time, the need to nurture 'convergence-type talents' who were good at both technology and humanities was raised. Steve Jobs, the best model created by combining the humanities and technology, and Mark Zuckerberg, the founder of Facebook, have changed the global economic paradigm by pouring out world-class products and services. In response, Harvard University completely reorganized liberal arts courses that had been operated for 30 years in 2007 and changed liberal arts by discipline to interdisciplinary liberal arts, which is now becoming a model for convergence liberal arts (Sanghun, 2012).

Current Status and Limitations of Convergence Education

Recognizing the necessity of convergence education in various studies, many domestic and foreign universities are attempting to cultivate convergence thinking. Above all, what stands out is that these universities are establishing new colleges, departments, and centers dedicated to convergence education. These methods were proposed by recognizing

that convergence education cannot be systematically implemented within traditional academic fields and identifying the need for education on convergence education.

For example, Oxford University's convergence education program consists of integrated courses in Philosophy, Politics, and Economics (PPE), and Psychology, Philosophy, and Linguistics (PPL). It induces an approach to philosophy subjects as a meta-epistemological tool to analyze the conflicts of interest and various premises inherent in visible phenomena. For this reason, students at Oxford University cannot learn philosophy alone and must take an integrated course combined with other disciplines (Sun, 2019).

The recent reforms of undergraduate curriculums in Japan are also focusing on the convergence of liberal arts and science departments or related majors. For example, the University of Miyazaki established the Faculty of Regional Innovation to cultivate social innovators to revitalize the local economy in 2016. In the same year, Shiga University established the Department of Data Science. Yokohama National University established the College of Urban Sciences in 2017, and Kyushu University established the Department of Interdisciplinary Science and Innovation in 2018 (Myungseong, 2016).

The next attempt was to acquire knowledge in multiple academic fields while acknowledging traditional independent academic disciplines. In theory, cultivating convergence knowledge and thinking without confusion exhibits merits as it does not cause any major changes to the traditional academic systems of universities. However, it is questionable whether this method faithfully achieves its original goal. For example, although liberal arts colleges implemented convergence by discipline and convergence free-majors, there was little evidence that any part broke traditional frameworks.

For example, Harvard University requires students to take one course in four areas: (a) aesthetics and culture; (b) histories, societies, and individuals; (c) social science and technology; and (d) ethics and civics. Four distributional requirements complement these courses. Students have to take one departmental course each in the arts and humanities, the social sciences, and the natural and applied sciences. By allowing students to select and complete major courses in each department of the three faculties as liberal arts courses, Harvard broadened the scope of choosing subjects. The university maintains other liberal arts requirements, such as composition and foreign languages (Heyyoung, 2013).

The limitations of traditional lectures are: First, lectures are conducted with content centered on the instructor's major. Second, it is a form of integrating the majors of several professors. Third, the format of special lectures by CEOs or experts helps in understanding real problems or situations. However, it is challenging to secure consistency in the contents of lectures. Fourth, the form of convergence in Korea is an omnibus method, but it is difficult to secure the consistency of the subject (Youngju, 2013).

The limitations of convergence education in domestic and international domestic and international research universities are clear. Whether it is operated as a convergence education-only or credit-completion system, it is not breaking the existing academic framework. It is not a convergence form but a form of integration of various major fields. This is because there are no guidelines on how to implement convergence education. In the current system divided into academic areas, there is no standardized model to develop convergence education methods and convergence subjects to cultivate convergence thinking. Therefore, this study aims to present a model for developing open convergence subjects as a way to realize as much as the necessity of convergence education.

Prior Work on Convergence Subjects

To achieve this goal, this study focused on two items: the process of creating the Department of Convergence at Rey Juan Carlos University in Spain and the unit activities of the Center for the Promotion of Interdisciplinary Education and Research at Kyoto University in Japan. These two aspects are as follows.

The first is the model of establishing the Department of Convergence at Rey Juan Carlos University in Spain. Accordingly, the Spanish University knew that the global economy was changing into a service economy. The service scope was broadly included commerce, transportation, telecommunications, finance, health, education, and others beyond the existing service sector that produces material goods. In addition, important professionalization initiatives have emerged in developed countries, such as the service research and innovation institute (SRII) in the United States, the Business School at the University of Tilburg, or the ISSIP service sciences. Also, the emergence of services science, management, and engineering (SSME) was because service societies needed specialists with specific training who could solve the problems arising from these changes. One of the pioneers of service science, Jim Spohrer, presented ten reasons why universities are important in the SSME space, which led to the development of the SSME training program (Esperanza et al., 2020).

In response to these needs, the model of the Department of Convergence designed by the university first selected the items (disciplines) necessary to understand a specific topic. Based on this, a convergence department was composed by extracting items that must be learned related to specific topics in each department and academic field. This method

used by Rey Juan Carlos University cast significant implications for those in developing 'convergence subjects' and was also used to develop the subjects in this study (Esperanza et al., 2020).

The second aspect is the unit activity model of the Center for the Promotion of Interdisciplinary Education and Research at Kyoto University in Japan. Japan's once brilliant economy has stagnated since 1990, and Japanese national universities are also reforming their curricula. The focus was on cooperation by strengthening liberal arts through curriculum reform and adjusting the relationship between liberal arts and majors. In particular, they developed various faculties and courses to nurture human resources who can solve the social problems and challenges they face by converging the subdivided humanities and engineering. Since 2016, Miyazaki University's Faculty of Regional Resource Creation, Shiga University's Faculty of Data Science, 2017 Yokohama National University's Faculty of Urban Science, 2018 Kyushu University's Faculty of Engineering, and Kyoto University's Interdisciplinary Education Research Promotion Center have been established.

Kyoto University supports research teams divided into 'units' and 'light units' to develop convergence subjects. Units are official research groups established to develop convergence subjects, and light units are autonomous research groups that operate relatively flexibly. Units and light units are research teams that work autonomously to derive methods and content for convergence education or subjects.

The strength of using this model is that continuous research and opinions of various majors must be combined to make convergence possible. It is a method of extracting the optimal items so that it can be a subject-centered convergence subject. In particular, there is a difficulty in that various majors must be integrated into one subject, rather than simply combining their respective majors. Therefore, the term 'unit' was used in this study by referring to the unit activities operated by Kyoto University. In addition, in the study of Juan Carlos University, a method of extracting items necessary to create a subject-centered convergence subject was utilized to design a model for convergence subject development. The unit of the project being carried out in our study was used as the term 'unit'.

Proposal of Convergence Subject Development Model

Requirements of Model for Developing Open Convergence Subjects

Currently, convergence subjects in domestic and foreign universities are conducted in omnibus-type team-teaching methods or by one professor crossing the boundaries of different majors. These two types of convergence subjects have limitations in that they are constrained to a mere formality, lack consistency in lectures, or fail to achieve the original purpose or goal of convergence by emphasizing specific majors. This study aimed to develop a model for convergence subjects that can solve these issues. In this respect, the following four aspects are requirements for convergence subjects: the openness of convergence major, the openness of topic convergence, the openness of student choice, and multi-radial convergence. The contents of each aspect are as follows.

First, the openness of the convergence major (Hyuncheol, 2019). The purpose of proposing this model for developing convergence subjects is to overcome the limitations of combining majors from different disciplines, planning and educating subjects based on specific academic disciplines, and courses limited to knowledge of specific majors. This is why 'open' subjects are needed to meet this purpose. The dictionary meaning of "open" refers to 'having no enclosing or confining barriers and allowing free exchange and interaction.' An 'open convergence subject' refers to a course that can be applied to various topics beyond a university campus's interdisciplinary or spatial boundaries (Wongyeum, 2022). Therefore, these subjects should enable convergence thinking by combining various majors with various topics.

Second is the openness of topic convergence (Ilwoo, 2016). True convergence subjects should be open not only to majors but also to topics. It is necessary to select topics that explore the development and sustainability of human civilization and those that enable us to examine the position of Earth and humans in the universe through mythology and science. Such topics should cover practical solutions beyond those presented in simple theoretical lectures.

A wide variety of topics can be selected, such as specific eras that affect the economics and development of modern society (e.g., the Industrial Revolution), philosophers and politicians (e.g., Plato or Hitler), events that affected the East and West (e.g., the Age of Discovery or the World War), masterpieces that represent the ideology of the times (e.g., the Mona Lisa or the Symphony of Destiny), meaningful items that enable consumption of politics and economy rather than simple materials like canned goods or money, and technologies to interpret the future society (e.g., blockchain or artificial intelligence). Such topics should enable the management of convergent and integrated curriculums.

The third is the openness of student choice (Mikyong, 2016). In the 2010s, consumer-oriented education emerged as a new subject of interest. There was a widespread perception that regulated subjects could not respond to rapidly changing societies and technologies. Moreover, as a result of rapid changes in the global economy and the reorganization of ideology, new talents were required. Many studies reported that consumer-oriented education should not merely focus on the needs and interests of students, but also foster the talents needed by learners, society, companies, and the world (Hyuncheol, 2019). Openness is not only limited to opening majors or topics but also includes opening student options and choices. Until now, education was limited to the majors of the professors, and the

students were responsible for convergence thinking. Whether it was horizontal convergence of knowledge from various disciplines or vertical convergence limited to the professor's major on a single subject, the entire education course was up to the students. Open convergence education should be learner-oriented to allow students to study the areas necessary to improve their convergence thinking.

Fourth is multi-radial convergence (Mihyun, 2022). One of the most common forms of convergence in traditional subjects was horizontal convergence. This refers to integrating multidisciplinary intellectual systems, mainly pursuing the integration of knowledge and conducting multidisciplinary education for integration. This type of convergence attempted to integrate various disciplines, such as science, language, art, and mathematics. However, it is merely a horizontal listing of differentiated studies.

Vertical convergence is the general convergence method we currently pursue. It aims for interdisciplinary integration on the premise of active activities and requires multidisciplinary knowledge to be united through self-directed activities. Through interdisciplinary thinking and operation, vertical convergence allows us to absorb and internalize knowledge, refine learning methods and processes, and experience the sensibility of learning and creation. Most methods used to implement vertical convergence focus on bringing various disciplines together to design a curriculum centered on a single topic.

The ultimate goal of convergence education is multi-radial convergence. Based on self-directed learning abilities, it restores the learner's passion and initiative and enables them to learn autonomously and become the masters of their growth. To achieve such convergence, independent inquiry skills and comprehensive learning abilities must be cultivated. Potential energy and benefits are released when learners can fully demonstrate their learning abilities through self-directed learning, integrating knowledge, and becoming accustomed to interdisciplinary thinking. Multi-radial convergence education is implemented by enabling students to learn the basic elements of a specific topic while giving them the right to choose the educational content to achieve a self-directed and active learning design and education.

Model for Developing Convergence Subjects

The main question is how to develop convergence subjects that meet these four requirements. To solve this problem, this study derived the idea of a convergence subject development model based on the two methods mentioned above: The process of creating the Department of Convergence at Rey Juan Carlos University in Spain, and the unit activities of the Center for the Promotion of Interdisciplinary Education and Research at Kyoto University in Japan.

The convergence subjects presented by this model are developed by dividing them into basic and advanced courses. Convergence subjects should start with a basic course and expand into an advanced course, and measures must be prepared to guarantee students' options during the expansion process. The difference between these two courses lies in allowing students to make autonomous choices within a specific ratio. The advanced course is developed with the same subject as the basic course by evaluating students' response, satisfaction level, or necessity to the previously opened basic course. Through this process, the students start from the basics and proceed to more in-depth learning.

In particular, advanced courses allow students to choose the class topics for each week to organize the curriculum flexibly. This can be in the form of emphasizing a specific department or academic field or obtaining information connected with the students' critical minds by autonomously mixing the class topics for each week in various proportions. However, students should not be allowed or recommended to take advanced courses without completing basic courses. The topics for each week of the convergence subject are closely related to the overall subject theme, and at the same time, they are related in a progressive order and should be carried out sequentially. These aspects must be considered in depth to develop the 16-week curriculum for the first semester.

The Ratio of Learning Basic and Advanced Courses

The figure below shows the ratio of students learning in basic and advanced courses. As shown in Figure 1, taking classes in every field concurrently can be applied to basic and advanced courses. On the other hand, as shown in Figure 2, the ratio that emphasizes a specific field (e.g., engineering /technology) can only be applied to advanced courses. Giving students the right to choose options in advanced courses implies more complex and diverse possibilities in both the course registration and evaluation method. Therefore, the full support of the university's administrative system is required to realize this in reality.

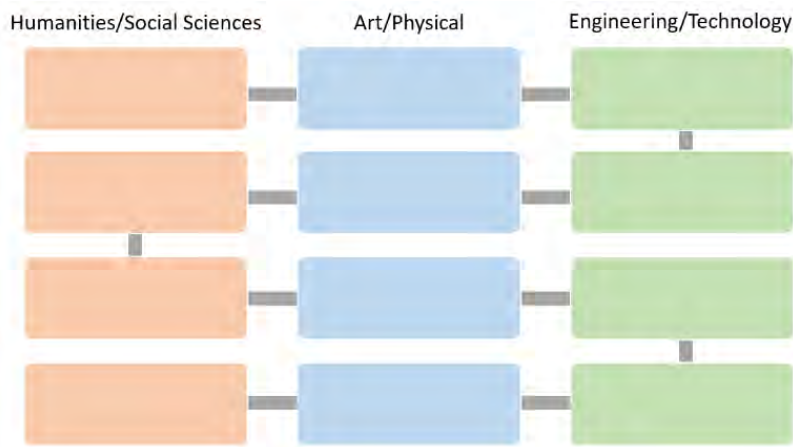


Figure 1. Type 1: Equal Ratio of Academic Fields

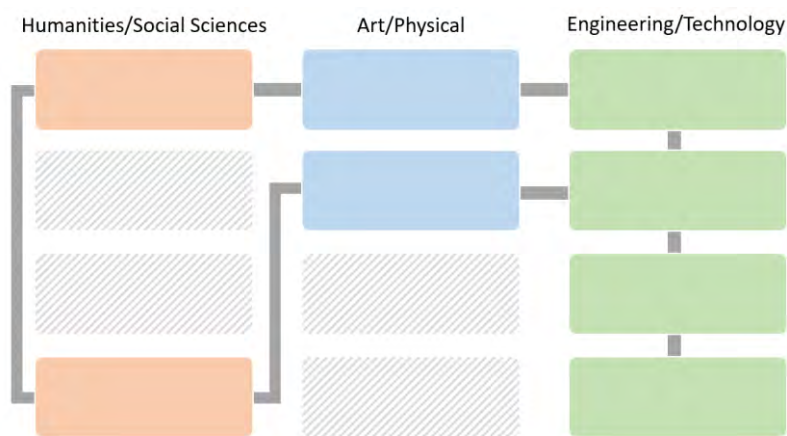


Figure 2. Type 2: Ratio to Emphasize Science/Technology

Proposed Model: Developing the Basic Course of Convergence Subjects

The basic course of convergence subjects is developed through two major processes: light unit and unit. 'Light Units' are small research groups in a very diverse field with an undetermined subject. This allows researchers to select a topic and conduct group activities. 'Unit' is a materialized group for one subject to be embodied and small groups active in 'Light Unit' to fuse with the subject. If the subject of the course to be operated is presented as a competition, researchers active in the 'light unit' can apply.

The light unit, in which students of various majors selected through a public contest participate, ends its activities by determining the lecture topics for each week, completing a preliminary weekly curriculum, and submitting a light unit activity report. This process is also a period in which various majors voluntarily form teams to think and study together to create high-quality convergence subjects.

The units that officially develop convergence subjects are selected by evaluating the submitted light unit activity reports. Convergence subjects are finally created based on these unit activities. This process includes revising and supplementing the weekly curriculum proposed in the light unit activity report, along with completing and presenting all elements related to the subject, such as specific and in-depth class contents for each week according to the curriculum, how to operate this convergence subject, and the assessment criteria and items to evaluate student grades. The model proposed in this study is shown illustrated in Figure 3.

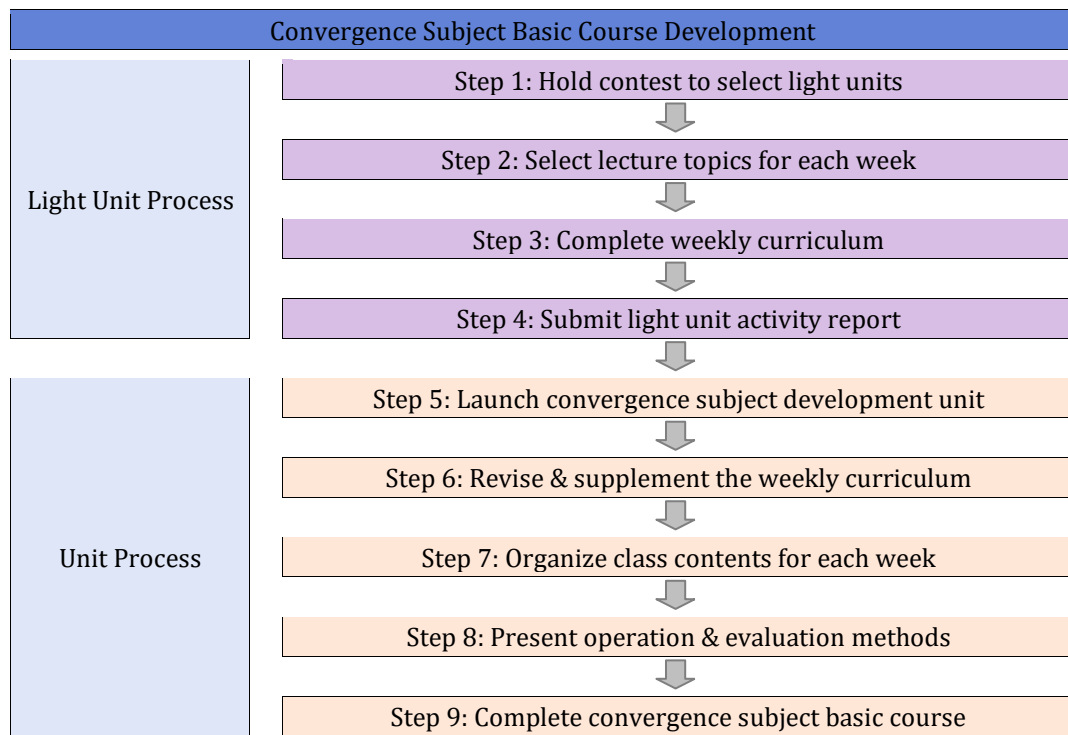


Figure 3. Proposed Model: Steps to Develop a Convergence Subject Basic Course

• *Step 1: Hold a Contest to Select Light Units*

The first step in developing convergence subjects starts with a contest to select light units, which are small student groups for developing convergence subjects in universities. Participants must present the topic of the convergence subject in the application form to participate in the contest. These topics are validated through a selection process to determine their suitability as convergence subjects.

It is also important to create an environment where various majors can study together and share discussions to develop convergence subjects. Light units support the most fundamental elements so that various majors can collectively carry out research activities. Light units are flexible and autonomous teams, and their activity goals are deriving class topics for each week suitable for convergence subjects and assessing the possibility of developing convergence subjects. Light units should be supported by university policy, and the candidates should be selected through a contest. Select light units by including at least three people and two or more discipline majors, and add other conditions, if necessary.

• *Step 2: Select Lecture Topics for each Week by Academic Field*

After selecting light units, the main goal of this step is to identify and organize class topics for each week to conduct in each academic area in relation to the core topic of the subject. Based on the method used to design the Department of Convergence at Rey Juan Carlos University in Spain, among eight academic fields (Humanities, Social Sciences, Natural Sciences, Engineering, Medicine, Agriculture, Fisheries and Oceanography, Arts and Physical Education, and Interdisciplinary Science), organize class topics for each week from the intersection between the academic fields participating in developing convergence subjects and the topics of all subjects.

As shown in Figure 4, this is a process of identifying and organizing class topics for each week that can be presented as a curriculum in each academic field participating in developing convergence subjects. The most significant aspect is identifying and organizing class topics closely related to the topic of the convergence subject to be developed in each academic field. Majors in each academic field participating in light units should carefully review the intersection between their academic field and the topic of the convergence subject they want to develop. This includes considering how the topic will be connected in developing the subject.

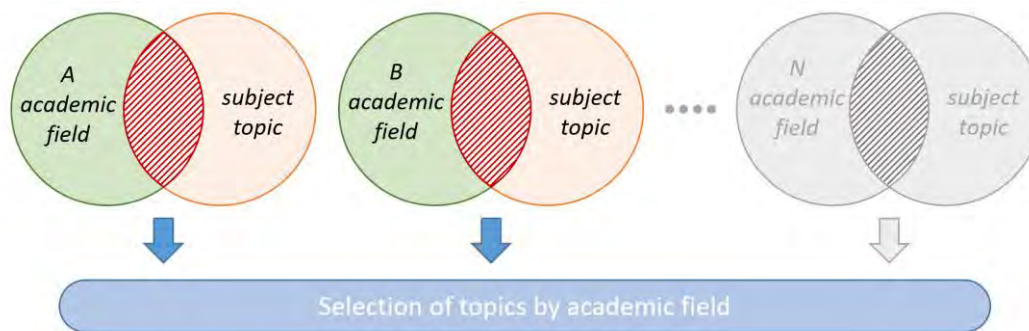


Figure 4. Select Weekly Topics for Each Academic Field and Subject Topic

The main topic of the convergence subject to be developed is shown at the center of Figure 5. Each academic field participating in developing convergence subjects must have a part that intersects with this topic. This intersection is where each academic field will have a class topic for each week to conduct in relation to the main topic. Therefore, topics unique to each academic field, with no intersection with the main topic in the center, are excluded from the class topics for each week. Each academic field must form an intersection with the main topic of the subject, but intersections with other adjacent academic fields are only recommended.

Even when two academic fields or four or more academic fields participate in developing convergence subjects, convergence topics for each field can be selected based on this model. After organizing various weekly class topics in each academic field, select 16-week lecture topics for one semester according to the ratio of each academic field, focusing on fundamental and significant topics that should be covered.

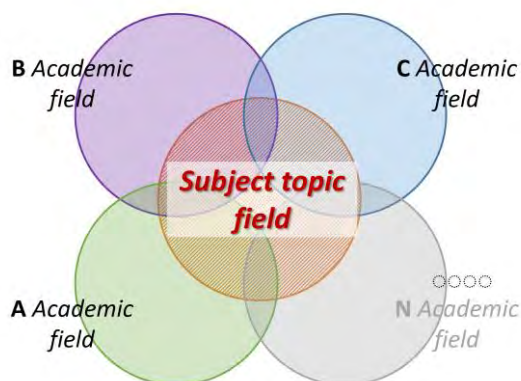


Figure 5. Standard Model for Selecting Topics When Converging Multiple Fields

- *Step 3: Complete the Weekly Curriculum*

After selecting lecture topics for a 16-week semester according to the ratio of each field, the third step is to complete the weekly curriculum. Arrange the topics for each week according to the order of lectures, and organize the teaching method and the specific contents for each class. After adjusting the ratio for each field within an appropriate range, complete the final 16-week curriculum.

- *Step 4: Submit Light Unit Activity Report*

After conducting light unit activities, submit light unit activity reports after selecting the lecture topic for each week by academic field, completing the curriculum for each week, and completing the light unit activities. These reports summarize light unit activities and are used to evaluate the conversion to unit activities for developing full-scale convergence subjects. After reviewing the submitted light unit activity reports, the university selects teams suitable for developing convergence subjects as units.

- *Step 5: Launch Units to Develop Convergence Subjects*

After evaluating the submitted light unit activity reports, if there is a high likelihood or a need to develop the relevant convergence subject, convert the light unit into an official unit to begin developing the convergence subject. Do not convert light units into units according to a specific ratio. Rather, select them based on the high likelihood or need to develop the relevant subjects.

The goal of this unit activity is to develop convergence subjects. Therefore, the activity should include completing and presenting all elements required, such as the curriculum and operation method of the convergence subject for a 16-week semester. Also, units are selected and supported after evaluating the reports submitted by the teams that worked as light units. Participants cannot apply to become units without going through the light unit activity process. This is because failure to undergo the light unit process results in the lack of in-depth discussions or research on convergence education or subjects.

- *Step 6: Revise and Supplement the Weekly Curriculum*

After becoming official units, the first action item is to re-examine the contents of the 16-week curriculum for one semester that was structured by completing light unit activities and to check whether any elements require correction or supplementation. Before developing official convergence subjects, raise the quality level and complete the curriculum by checking the class topic for each week, the class content, the ratio of each academic field during the 16-week curriculum, and the teaching method one last time. Take sufficient time to revise and supplement the details for each week.

- *Step 7: Organize Class Contents for Each Week*

After revising and supplementing the weekly curriculum, start developing class content. According to the topic by week, organize the professor in charge, academic field, lecture goal, specific lecture contents, teaching method, and related keywords. The main goal is to secure enough content and volume to conduct a class with only the contents organized through this process. Although this amount of preparation may be sufficient to open a convergence subject and conduct classes, more in-depth textbooks can be developed to provide students with more sufficient learning materials and suggest the directions for each class. Class-related materials and information may also be organized and provided to students in various forms and methods.

- *Step 8: Operation and Evaluation Method*

The main conditions of the convergence subject have already been satisfied solely by completing the previous step of organizing the class contents for each week. However, providing specific standards and methods to manage the course and evaluate grades according to the characteristics of the convergence subject is a significant element that cannot be overlooked. Therefore, present ways to operate and evaluate the subject according to the characteristics of each convergence subject.

- *Step 9: Complete the Convergence Subject Basic Course*

A convergence subject basic course is completed by going through the eight steps above and finishing all processes related to establishing a convergence subject. In the case of developing a convergence subject advanced course, follow the nine steps discussed above for developing a convergence subject basic course. However, the steps related to light units may be skipped when advanced courses are requested based on student response to the convergence subject that is opened as a basic course. Therefore, adjust the nine steps above to 6 steps in the sequence of Step 1: Select lecture topics for each week, Step 2: Complete weekly curriculum, Step 3: Revise and supplement the weekly curriculum, Step 4: Organize class contents for each week, Step 5: Present operation and evaluation methods, and Step 6: Complete convergence subject basic course.

Operation and Evaluation of Convergence Subjects

The basic and advanced courses of convergence subjects completed through the nine steps above can be operated and evaluated similarly to traditional non-convergence subjects. However, there are several points to be aware of that should be differentiated (Deokhyun & Sungkyum, 2017; Miyoung, 2021). The first point is the prerequisites for operating convergence subjects. In the past, students only had the right to choose the subject, not the right to choose the curriculum for that subject. It was challenging to diversify the weekly lecture contents of a specific subject because universities manage one semester within a predetermined curriculum of 15 or 16 weeks. In particular, the options given to students were inevitably reduced due to limitations stemming from the practicality of operating large universities.

Our research team attempted to develop a model that gives learners options and a model of convergence subjects that combine and integrate various majors. Also, the items that must be learned about specific topics of the convergence subject were allocated in basic courses, and items that need to be studied in depth were organized in the advanced course. Therefore, the basic course is a 'fixed curriculum' consisting of what must be learned about the convergence subject topic, and the advanced course is a 'customized curriculum' that gives options and the right to choose for students who have completed the basic course.

The fixed and customized curriculums correspond to horizontal convergence because they include basic courses of various majors and to vertical convergence because the faculty's majors are converged on a specific subject. They also

correspond to multi-radial convergence because they enable self-directed selective learning and integrate knowledge beyond the faculty's major on a specific topic. In this regard, basic and advanced courses are designed to encompass horizontal, vertical, and multi-radial convergence.

The second point is how to operate basic courses. Operate the basic course of convergence subjects as follows. Conduct in-person (offline) classes. Week 1 is orientation, and Week 16 is the final exam. The classes should be 3-credit courses consisting of two 75-minute classes per week. There should be 13 weekly class topics in a semester, and the instructor should give offline lectures on each topic. The topics were divided into eight academic fields, including humanities, social sciences, natural sciences, engineering, medicine, agriculture, fisheries and oceanography, arts and physical education, and interdisciplinary science. The ratio of each field should be around 30%. The faculty in each academic field should give lectures related to the field and give assignments or exams. There should be two tests. Calculate the test scores by summing the evaluations of each instructor.

The third is how to operate advanced courses. Students who have completed basic courses can select advanced courses. They should be 3-credit courses consisting of two 75-minute classes per week. There should be at least 20 weekly class topics in a semester. Divide the topics into eight academic fields: humanities, social sciences, natural sciences, engineering, medicine, agriculture, fisheries and oceanography, arts and physical education, and interdisciplinary science. Note that the proportion of each field should be around 30%. Conduct the classes weekly with video lectures made by instructors according to the subject and assign operating professors to manage the students. As the students cannot choose which topic to take each week, suggest the following two types.

Type 1 is a hybrid learning method that combines online and offline classes. The students can choose 10 out of 20 topics for online classes. After listening to lectures on three topics, they have offline discussions. Operating professors are responsible for conducting offline classes.

Type 2 comprises online classes. The students can choose 10 out of 20 topics before graduation. They listen to lectures on the subject and submit assignments. Type 2 is operated as a credit bank, so the professor of the subject prepares questions for the tests. Calculate grades by taking the sum of the results scored by the professor of the subject.

Conclusion

Although we reviewed the current status of convergence education and subjects in Korea and other countries, it was difficult to find subjects that truly embody the essence and ideal of convergence education. Most existing models simply integrate different majors in an omnibus method or arrange disciplines horizontally through team teaching. Although the omnibus method or team teaching is a convergence subject in which several majors participate in its format, it is merely an integration of classes that can be conducted in various majors as a single topic. Such convergence is at a rudimentary level, and according to our classification, it corresponds to a form of horizontal convergence.

The United Nations' sustainable development goals 2030 is a plan of action for people, the planet, and prosperity. This plan can only be realized by starting a joint journey toward a future-oriented life on Earth. Among the goals is pursuing education that fosters people to seek universal truth, rather than being confined to specific disciplines, spaces, or races. The future society will not reflect the education of the Renaissance period when various disciplines branched from the theology-oriented education of the Middle Ages. Rather, it will be an era of convergence education in which all disciplines must overlap beyond the age when academic fields were divided due to the development of capitalism. The talents responsible for our future society must possess convergence thinking capabilities. Nurturing tomorrow's talents necessitates the creation of an integrated education framework today (Okhee, 2022). Education for sustainable development will transpire within this convergence framework.

The limitation of this study is its practical applicability to convergence subjects applied to this model. An example is needed to prove it. After developing convergence subjects according to the model, we operate it in the future. Moreover, defining its role as an open convergence subject, we will conduct various analyzes of the model.

Authorship Contribution Statement

Lee: Conceptualization, writing, editing/reviewing, supervision. Bae: Statistical analysis, design, analysis, writing. Kim: Draft manuscript, admin, writing.

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