Articles

Discussion on Learning Content of 'Theories and Methods of Education Using Information and Communication Technology': In Terms of Consistency with 'Mathematics, Data Science and AI Education Program (Literacy Level)'

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Abstract

We firstly discussed the learning objectives of 'Mathematics, Data Science and AI Education Program (Literacy Level)' as part of a teacher training course, and we are now tasked with deciding what subjects to be included in the program 'Theories and Methods of Education Using Information and Communication Technology' which starts next academic year. As a result of comparison between the list of attainment targets in the Core Curriculum for Teacher Training and that of learning objectives in the 'Model Curriculum of Mathematics, Data Science and AI (Literacy Level)', we ascertained a certain level of commonality in both lists, as shown in the attached Table of Consistency Verification. The major task in the future will be to consider how to establish a curriculum management process for systematically enhancing ICT application skills in four-year teacher training courses.

Keywords: ICT-Related Subject, AI Literacy Subject, Core Teacher Training Curriculum

1. Introduction

The agenda at the 120th Sectional Meeting on Teacher Training held on January 27, 2021 by the Elementary and Secondary Education Committee of the Central Council for Education included 'Approaches to Facilitate the Acquisition of Skills related to ICT Use in Teacher Training Courses' [1)]. At the meeting, taking into consideration the fact that emphasis is currently being placed upon improving and upgrading the methods of instructing how to use ICT in teacher training modules, most of the subcommittee members agreed

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that public and private universities offering teacher training as well as designated teacher training institutions will be required, starting from academic year 2022, to introduce the new subject 'Theories and Methods of Education Using Information and Communication Technology' in order to ensure that teachers capable of responding to the demands of the GIGA School Concept will be produced[2], and 'understanding of how teaching performance and school operation efficiency can be enhanced by effectively utilizing information and communication technology' and 'acquisition of basic knowledge and skills for developing the abilities of children and students to utilize information (including enhancing their awareness of information ethics)' were identified as general goals.

We firstly discussed the learning content of Mathematics, Data Science and AI Education Program (Literacy Level), which is one of the 'ICT-related subjects', in each of the preschool teacher course[3], the elementary school teacher course[4] and the middle and high school teacher course[5] from the perspective of students on teacher training courses. This discussion was based on the assumption that the program would be implemented on a trial basis in academic year 2021 before applications for the 'Certification of Mathematics, Data Science and AI Education Program (Literacy Level)' start in academic year 2022. Furthermore, we are committed to applying for the certification in academic year 2022 with an aim to introduce the program by simultaneously covering the learning content of the Core Curriculum for Teacher Training in 'Theories and Methods of Education Using Information and Communication Technology'.

In this research, we discuss the consistency between the subject 'Mathematics, Data Science and AI Education Program (Literacy Level)', which students on teacher training courses are required to take upon enrollment in universities, (hereinafter referred to as 'the AI Literacy Subject') and the subject 'Theories and Methods of Education Using Information and Communication Technology', which the students are expected to complete during the first year enrollment, and furthermore we consider the focal points for learning in four-year teacher training courses.

2. Discussion on Learning Content of 'Mathematics, Data Science and AI Education Program (Literacy Level)'

(1) Main Learning Content of 'Mathematics, Data Science and AI Education Program (Literacy Level)' as Listed in the Model Curriculum

In April, 2020, the model curriculum of the 'AI Literacy Subject' was released by the Consortium for Strengthening Mathematical and Data Science Education[6]. The learning objectives of the curriculum are to 'proactively acquire fundamental knowledge for masterfully using mathematics, data science and AI for everyday life and work in the future digital society, make a rational decision to use the acquired knowledge and skills of mathematics, data science and AI for

human-centered design, voluntarily and confidently enjoy the benefits resulting from application of AI, and pass on the benefits to others'.

The model curriculum consists of the elements of 'introduction', 'basics', 'rules' and 'options'. The learning objectives are all systematically shown in Table 1.

Of the elements, the learning objectives in 'introduction', 'basics' and 'rules' are positioned as core objectives, while the objectives in 'options' are to be separately and appropriately assigned to students depending on their learning history, degree of acquired skills or other factors. Regarding the 'Mathematics, Data Science and AI Education Program for Teacher Training Courses' proposed by this research, the objectives in 'introduction', 'basics' and 'rules' are the same for all of the middle and high school teacher and nutrition teacher course, the elementary school teacher course, and the preschool teacher course, but as for 'options' different objectives are included for each of the courses according to the characteristics of each educational stage. Specifically, the objectives included in 'options' for the elementary school teacher training course and the preschool teacher training course are related to programming education, while those for the middle and high school teacher and nutrition teacher training course are associated with inquiry learning.

(2) Current Status and Issues of Teacher Training Courses

1) Programming Education at Elementary Schools

Based on the definition of computational thinking (programming thinking) in the Teaching Guidelines for Elementary Schools issued by the Ministry of Education, Culture, Sports, Science and Technology, what matters is that the goal of programming education should be set at the development of computational thinking rather than the learning of programming languages and related skills per se.

In teacher training courses, it is necessary to ensure that students on the courses will acquire the skills to successfully implement programming education in the relevant curriculum framework as specified in the '3rd Edition of the Guidelines for Programming Education (the Ministry of Education, Culture, Sports, Science and Technology)' revised in February, 2020. Particularly in the process of programming education at elementary schools, teachers themselves need to understand it is important for students to realize that programming activities rather than programming skills per se are useful for accomplishing their immediate tasks (their study of school subjects).

2) Programming Education in Preschool Teacher Training Courses

Although it seems to be generally agreed that the programming activities during infancy are the important first step for children in the AI age to get in contact with the digital world, there are not only questions about the necessity of such activities but also concerns about the adverse effects on children's eyesight. In terms of the 'qualities and abilities of

Table 1: Summary of Model Curriculum of 'Mathematics, Data Science and AI (Literacy Level)' (by Imada, 2021)

Learning Objectives	・To proactively acquire fundamental knowledge for masterfully using mathematics, data science and AI for everyday life and work in the future digital society ・To make a rational decision to use the acquired knowledge and skills of mathematics, data science and AI for human-centered design, voluntarily and confidently enjoy the benefits resulting from application of AI, and pass on the benefits of the application to others
Basic Concept for Implementation	1. To focus on teaching students the 'joy' of utilizing mathematics, data science and AI, and the 'meaning of learning' of the related skills, and to provide classes that are attractive and unique enough to enhance students' curiosity and interest, in a bid to create a 'synergistic learning environment' which develops human resources who 'love' using mathematics, data science and AI, and who encourage and motivate themselves and others to proceed to the next learning level 2. For implementation of this model curriculum in a university or technical school, to flexibly identify and select learning objectives from the options of the curriculum, and provide education in an organic manner, taking into consideration the educational purposes of the university or technical school, the characteristics of the technical field, each student's learning history and degree of skill, and other factors. 3. To include in the curriculum learning of the methods to apply mathematics, data science and AI in the context of real life situations through application of related skills using actual events in society as learning materials, including exercises using data and themes on the real world 4. For literacy level education, to focus on comprehensibility in giving classes.
Elements of Literacy Level Model Curriculum	
・The elements of the model curriculum are divided into 'introduction', 'basics', 'rules' and 'options', as shown below. ・The learning objectives in 'introduction', 'basics' and 'rules' are positioned as core objectives, while the objectives in 'options' are to be separately and appropriately assigned to students depending on their learning history, degree of acquired skills or other factors	
Introduction	**1.Utilization of Data and AI in Society** (Learning Objectives) 1-1 Changes Occurring in Society 1-2 Data Utilized in Society 1-3 Domains for which Data and AI are Utilized 1-4 Technologies for Data and AI Utilization 1-5 Fields where Data and AI are Utilized 1-6 Latest Trend for Data and AI Utilization
Basics	**2.Data Literacy** (Learning Objectives) 2-1 Data Reading 2-2 Data Explanation 2-3 Data Handling
Rules	**3.Focal Points for Utilization of Data and AI** (Learning Objectives) 3-1 Focal Points for Handling Data and AI 3-2 Focal Points for Data Protection
Options	**4.Options** (Learning Objectives) 4-1 Statistics and Basic Mathematics 4-2 Basic Algorithm 4-3 Data Structures and Basic Programming 4-4 Time-Series Data Analysis 4-5 Text Analysis 4-6 Image Analysis 4-7 Data Handling 4-8 Practical Data Application (Learning with Teachers) 4-9 Practical Data Application (Learning without Teachers)

preschool teachers', on the other hand, it is also necessary to highlight the fact that many achievements made by preschool teachers with basic programming knowledge in improving childcare services have been reported.

It can be envisaged that, although there may be few opportunities to use the cutting-edge digital equipment in the process of childcare, the basic skills of programming, which is a source of all digital services including AI services, help provide access to the digital world, thus contributing to childcare practice, and then to real life.

For the purpose of further research, we are currently conducting a program, as a proactive approach, which allows students on a preschool teacher training course to experience programming.

3) Data Science

The industry-government-academia joint study report 'Training of Professional Personnel for Big Data Management' issued by the Research Organization of Information and Systems in 2015 said that 'in order to realize a super smart society by effectively using data science and AI' in Japan, 'it is essential to enhance the data literacy of all the people who receive the benefits brought by professionals'.

In 2016, Rikkyo University included in its course Global Education as a minor subject, and in 2018, the Center for Statistics and Information and other groups affiliated with the university introduced Data Science also as a minor. The theme 'Seven Aspects to be Learned by Citizens in Statistics Education' proposed by Utts (2003), whose point of view is highly valued by the university, is noteworthy[7]. The seven aspects are ① the difference between randomized experiments and observational studies (knowledge on statistics confounding), ② the meaning of statistical significance (in case of large samples), ③ the meaning of insignificance (in case of small samples), ④ the cause of biases, ⑤ the meaning of accidents (accidents will happen), ⑥ causal direction and conditional probability, and ⑦ understanding of dispersion, which we should note are important factors for design of data science curricula at universities.

4) Inquiry Learning

The Teaching Guidelines have proposed for quite some time that 'inquiry learning' be taught as an important learning objective particularly in the Period for Integrated Study. In academic year 2022, the Period for Integrated Learning is introduced as a new subject in high school curricula. One of the main features of 'inquiry learning' is that students are required to propose a theme of their own choice. It is not easy for students to discover themes that they feel are necessary and important enough to continue studying, but significant practical cases in which students tackled themes such as global social problems and issues of social sustainability in the process of literacy learning have been steadily reported.

On the other hand, the Ministry of Education, Culture, Sports, Science and Technology prepared the final report on 'Roles of Universities as Flagship Teacher Training and Development Providers'

(issued on January 23, 2020) in response to the Society 5.0 age. The report points out that the current systems and processes of teacher training universities and faculties as well as other institutions that are playing important roles in the education of future teachers are insufficient for flexibly enhancing the education and training of teachers who can appropriately and timely respond to educational problems and needs as expected by schools, let alone for taking the next step of implementing pioneering initiatives on a trial basis, and that it is urgent to fully improve the learning processes to develop such teachers.

Particularly, emphasis is placed on 'individuation of learning' and 'individualization of teaching' in 'Japanese school education in the Reiwa Era', and more and more importance is being attached to 'inquiry learning' utilizing ICT under the GIGA School Concept. Many of the themes for 'inquiry learning' are associated with SDGs, and excellent relevant practical study cases have been reported. We are proposing 'Society 5.0 for SDGs' as a theme, which inevitably links ICT utilization under the GIGA School Concept to 'inquiry learning'[8].

In teacher training courses, this proposal serves the purpose of developing teachers who can teach children and students to acquire the skills for 'inquiry learning'. 'Society 5.0 for SDGs' is characteristically suitable as a theme for 'inquiry learning' which is introduced as a new subject in teacher training curricula. This is because even students enrolled in teacher training courses are usually not conscious of '*glocal* (global-local) problems' occurring in society, and there are often cases in which it is not until a theme is assigned to them in class or they are encouraged to pay attention to potential global-scale issues in their surrounding living environment or the local community (*glocal* issues) that they recognize the theme or the issues as a material for 'inquiry learning'. Consequently, it is definitely necessary for the new subject of 'inquiry learning' to be developed and implemented based on a curriculum using 'Society 5.0 for SDGs' as a learning material that connects ICT utilization under the GIGA School Concept with the subject.

As described above in cases 1)-4) of this Section, universities endeavor to develop original curriculum designed to enhance learning of required subjects in teacher training courses, but they are only initial and partial versions, and have yet to be generally accepted. Therefore, it is considered especially meaningful for students on teacher training courses to have an opportunity to experience 'inquiry learning' using data science and ICT in basic curricula in the first year of enrollment.

We have prepared the 'AI Literacy Subject' Syllabus Flow Chart, the Syllabus Text and the Model Curriculum Table, as shown below in the order of the preschool course, the elementary school course, and the middle and high school course (Charts 1-3 and Tables 2-7)

Chart 1: Flow Chart of 'AI Literacy Subject' Syllabus (Preschool Teacher Course)

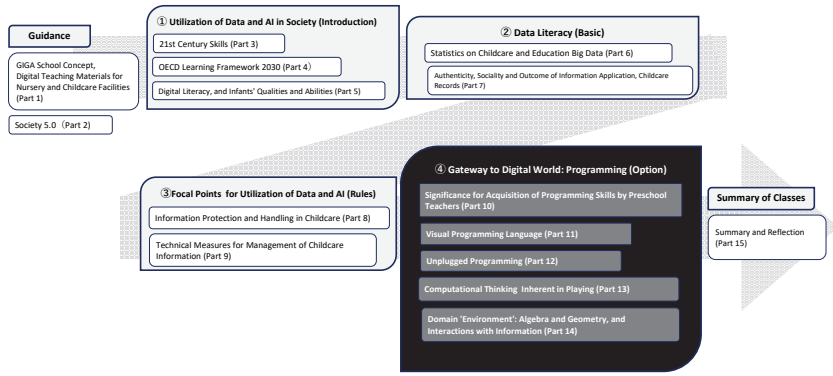

Chart 2: Flow Chart of 'AI Literacy Subject' Syllabus (Elementary School Teacher Course)

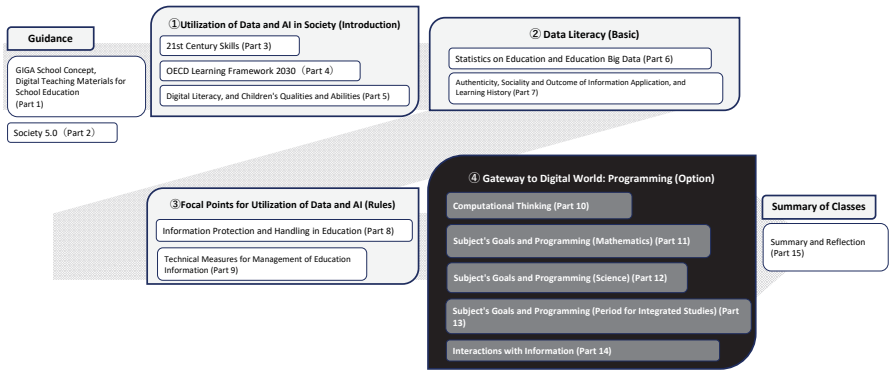

Chart 3: Flow Chart of 'AI Literacy Subject' Syllabus (Middle and High School Teacher Course)

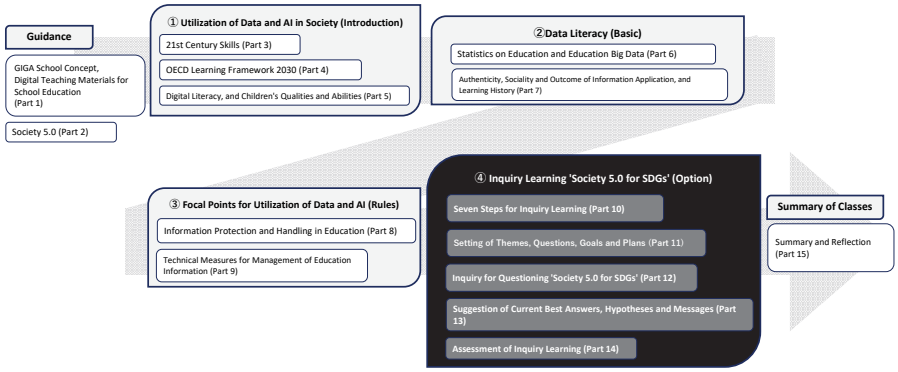

Table 2: Mathematics, Data Science and AI Education Program (Literacy Level) Syllabus (Preschool Teacher Course)

Part	Theme	Summary and Purpose
1	Orientation	■Orientation
	Qualities and Abilities Required in the AI Age	・Purposes of Classes
		・Rules for Attendance at Lectures
		・Academic assessment and submission of assignments
2	Society5.0	■Utilization of Data and AI in Society
	GIGA School Concept	・Society 5.0
		・Competencies Required in Future Society
		・What is the Impact of AI and Data on Our Lives?
		・What is Individually Optimized Learning Based on Technologies?
3	21st Century Skills	■Data utilized for Society
		・ATC21s and Fundamental Skills for Working Members of Society
		・Information Literacy and ICT Literacy
		・Planning and Creativity Based on Data Utilization
4	OECD Learning Framework 2030	■Data Utilized for Society
		・Operation Support Systems for Childcare and Infant Education
		・Utilization and Consumption of Learning History (Study Log)
		・Data Utilization for Co-Agency
5	Digital Literacy, and Infants' Qualities and Abilities	■Childcare in New Age and Infants' Qualities and Abilities
		・Development of Qualities and Abilities from Infancy through High School Graduation (Three Pillars)
		・Ten Aspects to be Achieved during Infancy, and Digital Literacy
6	Statistics on Childcare	■Skill to Analyze Statistics on Childcare
	Education Big Data	・White Paper of the Ministry of Education, Culture, Sports, Science and Technology: Changes in Number of Children and Roles of Kindergartens
		・White Paper of the Ministry of Health, Labor and Welfare: Changes in Households and Childcare Facilities, and Changes in Needs for Childrearing with the Times
		■Education Big Data
		・Examples of Uses of Big Data on Infants' Health and Safety
7	Authenticity, Sociality and Outcome of Information Application	■Information Application
	Childcare Records	・Information Utilization for Childrearing and Childcare, and Focal Points
		・Grasp of Needs for Childrearing Supports and Provision of Childcare Services: Extended Hours Childcare and Classes for Pre-Kindergarteners
		■Records of Childcare
		・Storage and Share of Information, and Childcare Record as a Lifelong Portfolio
8	Information Protection and Handling in Childcare	■Information Handling
		・Ethics for Guardians
		・Protection of Personal Information
		・Information Disclosure and Infants' Privacy

Part	Theme	Summary and Purpose
9	Technical Measures for Managing Childcare Information	■Information Management
		・Nursery Teachers' Duty of Confidentiality
		・Establishment of Kindergarten Rules: Pictures, Videos and Children's Works
		・Methods of Storing Data
		・Information Security
10	Significance for Acquisition of Programming Skills by Preschool Teachers	■Basic Programming
		・Digital Services and Programming around us
		・Relationships between Ability for Information Utilization and Programming
		・Experience of Programming Applications for Infants
		・Summary on Implementation of Programming Education at Elementary Schools
11	Visual Programming Language	■Visual Programming Language
		・Experience of Programming Services: Scratch and CodeableCrafts
		・Programming Education Program 'Why?! Programming' (NHK for School)
		■ Let's Enjoy Making Programming Materials with Kids ①
12	Unplugged Programming	■Unplugged Programming
		・'Computational Thinking'
		・Programming Toys for Infants
		・Discovery of 'Programming' in Daily Life
		■ Let's Enjoy Making Programming Materials with Kids ②
13	Computational Thinking Inherent in Playing	■Computational Thinking Inherent in Playing
		・Programming Education Program 'Texico' (NHK for School)
		・Children Learning by Trial and Error through Computational Thinking
		・Programming Hidden in Rules of Games
		■Let's Enjoy Making Programming Materials with Kids ③
14	Domain 'Environment': Algebra and Geometry	■Relationship between Domain 'Environment' and Basic Programming
	Domain 'Environment': Interactions with Information	・Infants' Interactions with Algebra and Geometry
		・Interactions between Infants and Information
		・Consistency between Education through Environment and Computational Thinking
		■Presentation ①: Let's Enjoy Making Programming Materials with Kids
15	・Summary of and Reflection on Classes	■Summary of and Reflection on a Whole Range of Classes
		■Consistency and Systematicity of Subjects in Teacher Training Courses in the Future
		■ Ideal Types of Teachers in 'Japanese School Education in the Reiwa Era'
		■Presentation ②: Let's Enjoy Making Programming Materials with Kids

Table 3: Mathematics, Data Science and AI Education Program (Literacy Level) Syllabus (Elementary School Teacher Course)

Part	Theme	Summary and Purpose
1	Orientation	■Orientation
	Qualities and Abilities Required in the AI Age	・Purposes of Classes
		・Rules for Attendance at Lectures
		・Academic assessment and submission of assignments
2	Society5.0	■Utilization of Data and AI in Society
	GIGA School Concept	・Society 5.0
		・Competencies Required in Future Society
		・What is the Impact of AI and Data on Our Lives?
		・What is Individually Optimized Learning Based on Technologies?
3	21st Century Skills	■Data Utilized for Society
		・ATC21s and Fundamental Skills for Working Members of Society
		・Information Literacy and ICT Literacy
		・Planning and Creativity Based on Data Utilization
4	OECD Learning Framework 2030	■Data utilized for Society
		・School Leader
		・Utilization and Consumption of Learning History (Study Log)
		・Data Utilization for Co-Agency
5	Digital Literacy, and Students' Qualities and Abilities	■Education in New Age, and Children's Qualities and Abilities
		・Development of Qualities and Abilities until Elementary School Graduation (Three Pillars)
		・Ten Aspects to be Achieved before Elementary School Graduation, and Digital Literacy
		・'Individuation of Learning' through Technology Utilization
		・'Individualization of Teaching' through Technology Utilization
6	Statistics on Education	■Skill to Analyze Statistics on Education
	Education Big Data	・White Paper of the Ministry of Education, Culture, Sports, Science and Technology: Changes in Children and Students, and Roles of Schools
		・White Paper of the Ministry of Health, Labor and Welfare: Changes in Households and Changes in Education with the Times
		■Education Big Data
		・Examples of Uses of Big Data on Students' Health and Safety
7	Authenticity, Sociality and Outcome of Information Application	■Information Application
	Learning History (Study Log)	・Utilization of Education Information and Focal Points
		・Authenticity and Outcome of Data
		■Utilization and Consumption of Learning History (Study Log)
		・Storage and Share of Information, and Streamlining of School Operations
8	Information Protection and Handling in Education	■Information Handling
		・Ethics in Information Society and Information Moral Education
		・Protection of Personal Information
		・Information Disclosure and Students' Privacy

Part	Theme	Summary and Purpose
9	Technical Measures for Managing Education Information	■Information Management
		・Teachers' Duty of Confidentiality
		・Establishment of School Rules: Pictures, Videos and Children's Works
		・Methods of Storing Data
		・Information Security
10	Computational Thinking	■Development of Computational Thinking
		・Definition of Computational Thinking
		・Qualities and Abilities Nurtured by Programming Education
		・Ability to Think, Judge and Express
		・Scratch Programming
11	Subject's Goals and Programming (Mathematics)	■How to Draw a Regular Pentagon by Programming
		・Positioning of Learning
		・Aims for Use of Learned Skills
		・Assessment of Programming Education
		・Reflection for Extending and Deepening Knowledge
12	Subject's Goals and Programming (Science)	■How to Understand Nature and Function of Electricity by Programming
		・Positioning of Learning
		・Aims for Use of Learned Skills
		・Assessment of Programming Education
		・Reflection for Extending and Deepening Knowledge
13	Subject's Goals and Programming (Period for Integrated Studies)	■Programming Education as an Inquiry Task
		・Positioning of Learning
		・Aims for Use of Learned Skills
		・Assessment of Programming Education
		・Reflection for Extending and Deepening Knowledge
14	Interactions with Information	■Computational Thinking, and Ability for Information Utilization
		・Information Moral and Information Security
		・Curriculum Management
		・Classification of Programming-Related Learning Tasks
		・Assessment of Programming Education
15	・Summary of and Reflection on Classes	■Summary of and Reflection on a Whole Range of Classes
		■Consistency and Systematicity of Subjects in Teacher Training Courses in the Future
		■Models of Teachers as Facilitators (Advanced Assignment)
		■Teachers who Emphasize Reflection rather than Teaching (Advanced Assignment)
		■ Ideal Types of Teachers in 'Japanese School Education in the Reiwa Era'

Table 4: Mathematics, Data Science and AI Education Program (Literacy Level) Syllabus (Middle and High School Teacher Course, and Nutrition Teacher Course)

Part	Theme	Summary and Purpose
1	Orientation	■Orientation
	Qualities and Abilities Required in the AI Age	・Purposes of Classes
		・Rules for Attendance at Lectures
		・Academic assessment and submission of assignments
2	Society5.0	■Utilization of Data and AI in Society
	GIGA School Concept	・Society 5.0
		・Competencies Required in Future Society
		・What is the Impact of AI and Data on Our Lives?
		・What is Individually Optimized Learning Based on Technologies?
3	21st Century Skills	■Data Utilized for Society
		・ATC21s and Fundamental Skills for Working Members of Society
		・Information Literacy and ICT Literacy
		・Planning and Creativity Based on Data Utilization
4	OECD Learning Framework 2030	■Data Utilized for Society
		・School Leader
		・Utilization and Consumption of Learning History (Study Log)
		・Data Utilization for Co-Agency
5	Digital Literacy, and Students' Qualities and Abilities	■Education in New Age, and Children's Qualities and Abilities
		・Development of Qualities and Abilities until High School Graduation (Three Pillars)
		・Ten Aspects to be Achieved before High School Graduation, and Digital Literacy
		・'Individuation of Learning' through Technology Utilization
		・'Individualization of Teaching' through Technology Utilization
6	Statistics on Education	■Skill to Analyze Statistics on Education
	Education Big Data	・White Paper of the Ministry of Education, Culture, Sports, Science and Technology: Changes in Children and Students, and Roles of Schools
		・White Paper of the Ministry of Health, Labor and Welfare: Changes in Households and Changes in Education with the times
		■Education Big Data
		・Examples of Uses of Big Data on Students' Health and Safety
7	Authenticity, Sociality and Outcome of Information Application	■Information Application
	Learning History (Study Log)	・Utilization of Education Information and Focal Points
		・Authenticity and Outcome of Data
		■Utilization and Consumption of Learning History (Study Log)
		・Storage and Share of Information, and Streamlining of School Operations
8	Information Protection and Handling in Education	■Information Handling
		・Ethics in Information Society and Information Moral Education
		・Protection of Personal Information
		・Information Disclosure and Students' Privacy

Part	Theme	Summary and Purpose
9	Technical Measures for Managing Education Information	■Information Management
		・Teachers' Duty of Confidentiality
		・Establishment of School Rules: Pictures, Videos and Children's Works
		・Methods of Storing Data
		・Information Security
10	Practical Data Utilization (Learning with Teachers) ①	■Seven Steps for Inquiry Learning
		・Significance Attached to the 'Period for Integrated Studies' in the New Teaching Guidelines
		・Research and Life (Philosophical Questioning and Philosophical Dialogue)
		・Emphasis on Dialog and Cooperation
		・Society where Emphasis is Placed on Tasks that cannot be Achieved by Artificial Intelligence
11	Practical Data Utilization (Learning with Teachers) ②	■Setting of Themes, Questions, Goals and Plans
		・Discovery of Themes and Questions about them
		・Establishment of Hypotheses
		・Demonstration and Verification of Hypotheses
		・Planning for Presentation of Achievements
12	Practical Data Utilization (Learning with Teachers) ③	■Answers, Hypotheses and Messages
		・Establishment of Hypotheses
		・Demonstration of Hypotheses
		・Verification of Hypotheses
		・Broad Planning for Presentation of Achievements
13	Practical Data Utilization (Learning with Teachers) ④	■Inquiry for Questioning 'Society 5.0 for SDGs'
		・Process of Digging into Questions (Research Questions)
		・Changes to Plans (for Whom and What Outcomes are Ultimately Intended)
		・Debate on Sustainability (Philosophical Dialogue)
		・Interim Report and Critical Thinking
14	Practical Data Utilization (Learning with Teachers) ⑤	■Assessment of Inquiry Learning
		・Final Empirical Research
		・Report and Presentation of Achievements
		・Digital Portfolio (Records of Learning Processes)
		・Philosophical Dialogue in Terms of Life or Lifestyle
15	・Summary of and Reflection on Classes	■Summary of and Reflection on a Whole Range of Classes
		■Consistency and Systematicity of Subjects in Teacher Training Courses in the Future
		■Models of Teachers as Facilitators (Advanced Assignment)
		■Teachers who Emphasize Reflection rather than Teaching (Advanced Assignment)
		■ Ideal Types of Teachers in 'Japanese School Education in the Reiwa Era'

Table 5: Literacy Level Model Curriculum in Preschool Teacher Training Course

	List of Leaning Objectives in Model Curriculum		Classes in Preschool Teacher Training Course	Consistency
Introduction	**1Utilization of Data and AI in Society**			
	1-1	Changes Occurring in Society	Part 2 Society 5.0 Part 3 21st Century Skills	◎ ○
	1-2	Data Utilized in Society	Part 3 21st Century Skills Part 4 OECD Learning Framework 2030 Part 6 Statistics on Childcare	○ ○ ▲
	1-3	Domains for which Data and AI are Utilized	Part 1 ICT Teaching Materials and Related Services for Nursery and Childcare Facilities	◎
	1-4	Technologies for Data and AI Utilization	Part 5 Digital Literacy, and Qualities and Abilities during Infancy Part 6 Application of Education Big Data Part 7 Authenticity and Social Outcome of Information Application	○ ○ ▲
	1-5	Fields of Education where Data and AI are Utilized	Part 1 ICT Teaching Materials and Related Services for Nursery and Childcare Facilities	◎
	1-6	Latest Trend for Data and AI Utilization	Part 1 GIGA School Concept Part 1 ICT Teaching Materials and Related Services for Nursery and Childcare Facilities	○ ○
Rules	**2.Data Literacy**			
	2-1	Data Reading	Part 6 Application of Statistics on Childcare Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Childcare Records and Statistics	○ ○ ◎ ○
	2-2	Data Explanation	Part 6 Application of Statistics on Childcare Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Childcare Records and Statistics	○ ○ ▲ ▲
	2-3	Data Handling	Part 6 Application of Statistics on Childcare Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Childcare History and Statistics	○ ◎ ○ ○
Points of Attention	**3.Focal Points for Utilizing Data and AI**			
	3-1	Focal Points for Handling Data and AI	Part 8 Information Protection in Childcare Part 8 Information Handling	○ ○
	3-2	Focal Points for Data Protection	Part 9 Management of Childcare Information Part 9 Technical Measures for Information Management	○ ○
Options	**4.Options**		**＜ Gateway to Digital World: Preschool Teachers and Programming ＞**	
	4-1	Statistics and Basic Mathematics	−	−
	4-2	Basic Algorithm	−	−
	4-3	Data Structures and Basic Programming	Part 10 Significance for Acquisition of Programming Skills by Preschool Teachers Part 11 Visual Programming Language Part 12 Unplugged Programming Part 13 Programming Thought Process Inherent in Playing Part 14 Domain 'Environment': Algebra and Geometry, Interactions with Information	○ ◎ ○ ▲ ◎
	4-4	Time-Series Data Analysis	−	−
	4-5	Text Analysis	−	−
	4-6	Image Analysis	−	−
	4-7	Data Handling	−	−
	4-8	Practical Data Application (Learning with Teachers)	−	−
	4-9	Practical Data Application (Learning without Teachers)	−	−

Table 6: Literacy Level Model Curriculum in Teacher Training Course Elementary School Teachers

	List of Leaning Objectives in Model Curriculum		Classes in Teacher Training Course	Consistency
Introduction	**1Utilization of Data and AI in Society**			
	1-1	Changes Occurring in Society	Part 2 Society 5.0 Part 3 21st Century Skills	◎ ○
	1-2	Data Utilized in Society	Part 3 21st Century Skills Part 4 OECD Learning Framework 2030 Part 6 Statistics on Education	○ ○ ▲
	1-3	Domains for which Data and AI are Utilized	Part 1 Utilization of Digital Teaching Materials and ICT for School Education	◎
	1-4	Technologies for Data and AI Utilization	Part 5 Digital Literacy, and Students' Qualities and Abilities Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application	○ ○ ▲
	1-5	Fields of Education where Data and AI are Utilized	Part 1 ICT Teaching Materials and Related Services for School Education	◎
	1-6	Latest Trend for Data and AI Utilization	Part 1 GIGA School Concept Part 1 Utilization of Digital Teaching Materials and ICT for School Education	○ ○
Basics	**2.Data Literacy**			
	2-1	Data Reading	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ○ ◎ ○
	2-2	Data Explanation	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ○ ▲ ▲
	2-3	Data Handling	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ◎ ○ ○
Rules	**3.Focal Points for Utilizing Data and AI**			
	3-1	Focal Points for Handling Data and AI	Part 8 Information Protection in Education Part 8 Information Handling	○ ○
	3-2	Focal Points for Data Protection	Part 9 Management of Education Information Part 9 Technical Measures for Information Management	○ ○
Options	**4.Options**		**＜ Gateway to Digital World: Computational Thinking and Programming ＞**	
	4-1	Statistics and Basic Mathematics	−	−
	4-2	Basic Algorithm	−	−
	4-3	Data Structures and Basic Programming	Part 10 Computational Thinking Part 11 Subject's Goals and Programming (Mathematics) Part 12 Subject's Goals and Programming (Science) Part 13 Subject's Goals and Programming (Period for Integrated Studies) Part 14 Interactions with Information	◎ ○ ○ ○ ○
	4-4	Time-Series Data Analysis	−	−
	4-5	Text Analysis	−	−
	4-6	Image Analysis	−	−
	4-7	Data Handling	−	−
	4-8	Practical Data Application (Learning with Teachers)	−	−
	4-9	Practical Data Application (Learning without Teachers)	−	−

Table 7: Literacy Level Model Curriculum Teacher Training Course in Middle and High School Teachers, and Nutrition Teachers

	List of Leaning Objectives in Model Curriculum		Classes in Teacher Training Course	Consistency
Introduction	**1Utilization of Data and AI in Society**			
	1-1	Changes Occurring in Society	Part 2 Society5.0 Part 3 21st Century Skills	◎ ○
	1-2	Data Utilized in Society	Part 3 21st Century Skills Part 4 OECD Learning Framework 2030 Part 6 Statistics on Education	○ ○ ▲
	1-3	Domains for which Data and AI are Utilized	Part 1 Utilization of Digital Teaching Materials and ICT for School Education	◎
	1-4	Technologies for Data and AI Utilization	Part 5 Digital Literacy, and Students' Qualities and Abilities Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application	○ ○ ▲
	1-5	Fields of Education where Data and AI are Utilized	Part 1 ICT Teaching Materials and Related Services for School Education	◎
	1-6	Latest Trend for Data and AI Utilization	Part 1 GIGA School Concept Part 1 Utilization of Digital Teaching Materials and ICT for School Education	○ ○
Basics	**2.Data Literacy**			
	2-1	Data Reading	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ○ ◎ ○
	2-2	Data Explanation	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ○ ▲ ▲
	2-3	Data Handling	Part 6 Application of Statistics on Education Part 6 Application of Education Big Data Part 7 Authenticity, Sociality and Outcome of Information Application Part 7 Utilization of Learning History and Statistics	○ ◎ ○ ○
Rules	**3.Focal Points for Utilizing Data and AI**			
	3-1	Focal Points for Handling Data and AI	Part 8 Information Protection in Education Part 8 Information Handling	○ ○
	3-2	Focal Points for Data Protection	Part 9 Management of Education Information Part 9 Technical Measures for Information Management	○ ○
Options	**4.Options**		＜ **Inquiry Learning: Society5.0 for SDGs** ＞	
	4-1	Statistics and Basic Mathematics	−	−
	4-2	Basic Algorithm	−	
	4-3	Data Structures and Basic Programming	−	−
	4-4	Time-Series Data Analysis	−	−
	4-5	Text Analysis	−	−
	4-6	Image Analysis	−	−
	4-7	Data Handling	−	−
	4-8	Practical Data Application (Learning with Teachers)	Part 10 Seven Steps for Inquiry Learning Part 11 Setting of Themes, Questions, Goals and Plans Part 12 Inquiry for Questioning 'Society 5.0 for SDGs' Part 13 Suggestion of Answers, Hypotheses and Messages Part 14 Assessment of Inquiry Learning	○ ○ ◎ ○ ▲
	4-9	Practical Data Application (Learning without Teachers)	−	−

3. Consistency Verification of Learning Objectives in 'Theories and Methods of Education Using Information and Communication Technology' and 'AI Literacy Subject'

We have compared the attainment targets listed in the core teacher training curriculum of 'Theories and Methods of Education Using Information and Communication Technology', which is to be introduced as a new curriculum subject for students in the next academic year with the learning objective listed in the 'model curriculum' of the AI Literacy Subject in order to verify the consistency in learning content between both subjects. The verification results have been arranged and shown in Table 8.

As a result, it has been verified that the 'core teaching training curriculum' and the 'model curriculum' share many common objectives. That is to say, it has proved possible to include part of 'Theories and Methods of Education Using Information and Communication Technology' in the AI Literacy Subject. Furthermore, it is also possible for the learning objectives considered in the AI Literacy Subject to be reflected and implemented in 'Theories and Methods of Education Using Information and Communication Technology'.

Therefore, it is necessary to, take into account the characteristics peculiar to each subject and the consistencies of both, establish a curriculum that enables future teachers to effectively apply ICT to education. For this purpose, it is also important to maintain so-called curriculum management in place, including interdisciplinary liaison and between-subject differentiation.

4. Summary and Future Tasks

In this research, we have compared the attainment targets listed in the core teacher training curriculum of 'Theories and Methods of Education Using Information and Communication Technology', which is to be introduced as a new curriculum subject in the next academic year, with the learning objectives listed in the 'Model Curriculum of Mathematics, Data Science and AI Education Program (Literacy Level)' in order to verify the consistency in learning content between both subjects, as exhibited in the Table of Consistency Verification.

As a result, it has been confirmed that 'Theories and Methods of Education Using Information and Communication Technology', which is a 'core teaching training curriculum', and 'Mathematics, Data Science and AI Education Program (Literacy Level)' share many common learning objectives. However, regarding the objectives shared by both subjects, which will be required to be further pursued by teachers with a bachelor's degree, their degree of consistency can presumably be more accurately ascertained through analysis of their quantitative and qualitative importance not only in the first university year but also in the third year when students start to study their major.

Moreover, since 'active utilization of ICT' has been added as an assignment to the 'practical training' that students are

Table 8: Consistency Verification of Learning Objectives in 'Theories and Methods of Education Using Information and Communication Technology' and 'Mathematics, Data Science and AI Education Program (Literacy Level)'

Theories and Methods of Education Using Information and Communication Technology		Model Curriculum of Mathematics, Data Science and AI (Literacy Level)																			
		Introduction						Basics			Rules		Options								
		1. Utilization of Data and AI in Society						2. Data Literacy			3. Focal Points for Utilization of Data and AI		4. Options								
(1) Understanding about the significance of using information and communication technology, and knowledge of related theories General goal: Understanding about the significance of using information and communication, and knowledge on application of related theories (2) Enhancement of teaching performance and school operation efficiency by effective use of information and communication technology General goal: Understanding of how teaching performance and school operation efficiency can be enhanced by effectively utilizing information and communication technology (3) Instruction methods of developing the abilities of children and students to utilize information (including enhancing their awareness of information ethics) General goal: Acquisition of basic instruction methods of developing the abilities of children and students to utilize information (including enhancing their awareness of information ethics)		1-1	Changes Occurring in Society					2-1	Data Reading		3-1 Focal Points for Handling Data and AI		4-1. Statistics and Basic Mathematics 4-2. Basic Algorithm 4-3. Data Structures and Basic Programming 4-4. Time-Series Data Analysis 4-5. Text Analysis 4-6. Image Analysis 4-7. Data Handling 4-8. Practical Data Application (Learning with Teachers) 4-9. Practical Data Application (Learning without Teachers)								
		1-2	Data Utilized in Society																		
		1-3	Domains for which Data and AI are Utilized					2-2	Data Explanation												
		1-4	Technologies for Data and AI Utilization								3-2 Focal Points for Data Protection										
		1-5	Fields where Data and AI are Utilized					2-3	Data Handling												
		1-6	Latest Trend for Data and AI Utilization																		
		1-1	1-2	1-3	1-4	1-5	1-6	2-1	2-2	2-3	3-1	3-2	4-1	4-2	4-3	4-4	4-5	4-6	4-7	4-8	4-9
Attainment Targets in Core Teacher Training Curriculum	1-1) Understanding about the significance and role of application of information and communication technology in, for instance, improving classes to balance optimal individual learning and collaborative learning, and to realize proactive, interactive and deep learning in line with changes of social background and rapid technological development	◎	◎	○	○																
	1-2) Understanding about the significance of using information and communication technology for teaching children and students in need of special support, and identification of focal points for such application			○		○	○														
	1-3) Understanding of effective ways of cooperating with outside personnel such as ICT supporters and outside institutions including universities, as well as optimal ways of improving ICT environments at school					◎	○														
	2-1) Mastery of basic teaching methodologies based on understanding of not only the aspects of qualities and abilities to be nurtured but also the examples of teaching by effectively using information and communication technology (including preparing and using digital teaching materials) depending on learning situations	○			◎	○															
	2-2)Knowledge on application of education data such as the learning history (study log) to instruction and academic assessment, and understanding of importance of education information security		○					○	○	◎											
	2-3) Awareness of importance of remote and online education, and knowledge of how to use related systems				○		◎				○	○									
	2-4) Knowledge of how to enhance school operation efficiency by effectively using information and communication technology such as the integrated school operation support system							○	○	○	◎	◎									
	3-1) Understanding about the practical aspects of the abilities to utilize information for interdisciplinary education and training (including enhancing awareness of information ethics) covering school subjects, moral education, extracurricular activities and the period for integrated studies (hereinafter referred to as 'school subjects, etc.')	○				○						○									
	3-2) Mastery of basic teaching methodologies to foster practical abilities to utilize information (including enhancing awareness of information ethics) based on understanding about examples of optimal approaches to teaching each subject by considering its characteristics.					○	○					◎									
	3-3) Mastery of instruction methods of enabling children to learn the basic handling of information and communication equipment ※Elementary school teachers										○	○	○	○	◎	▲	▲	○	▲	▲	▲

※「◎」: Objectives deemed to be very highly consistent 「○」: Objectives deemed to be closely related 「▲」: Objectives deemed to be related

required to undertake in the senior year, the necessity of not only management of teaching course curricula but also curriculum management designed for 'development of the ability to systematically utilize ICT' over a period of four years has been clearly identified.

The important elements of teaching skills are 'guidance words' (explanations, instructions and questions). In teacher training courses, questions asked to make students think, instructions given to make them act, and explanations given to encourage them to both think and act are emphasized as crucial teaching techniques[9]. It is highly recommendable to improve the content and methodology used to give classes at schools by drawing on the results of prior researches on such questions and instructions. However, in the process of discussion on 'the AI Literacy Subject' and 'Theories and Methods of Education Using Information and Communication Technology' in this research, a new issue has emerged as to whether there is much room for improvement of the way in which, among the 'guidance words', 'explanations' function in the context of ICT utilization. This issue needs to be further dealt with as a future task.

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[Additional Remark]

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