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PRACTICAL TRAINING NEEDS OF TEACHERS FOR ENABLING HIGH SCHOOL STUDENTS TO IDENTIFY AN APPROPRIATE PROBLEM IN DESIGN-BASED INQUIRY LEARNING

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ABSTRACT
Following the publication of the new curriculum guidelines in 2018, a "Period for Inquiry-Based Cross-Disciplinary Study" is now offered in high schools in Japan. Because of the nature of multidisciplinary inquiry-based learning and the need to tailor lessons to the specific circumstances of schools and the regions where they are located, there are no textbooks for this subject. One of the few resources available is a booklet of worksheets developed by the Sustainable Development Goals (SDGs) Design School, Faculty of Design, Kyushu University, in collaboration with public high school teachers. This study looks at an implementation of the Period for Inquiry-Based Cross-Disciplinary Study at a high school in Japan from April to October 2023. Nineteen 100-minute lessons attended by a total of 314 third-year students were observed. During these lessons, a revised version of the SDGs Challenge Project handbook was used to try to give the students guidance on the problem-finding stage of inquiry-based learning. Both the students (n = 248) and teachers (n = 19) participated in a follow-up survey to understand the challenges they experienced. The most common process identified as difficult by the students was ideation, whereas problem finding was the process with which the teachers had the most difficulty. Based on a thematic analysis of the responses to the open-ended questions in the survey, the study finds that more training in facilitation would help enable teachers to lead students to find problems of an appropriate scope and link them to social issues.

Keywords: Design education, design process, problem identification, ideation, Japan, high school

1 INTRODUCTION
In Japan, design is not taught as a subject in the general high school curriculum [1][2]. However, under the new curriculum guidelines published in 2018 and implemented nationwide in 2022, a new "Period for Inquiry-Based Cross-Disciplinary Study" was established in high schools in Japan [3]. The process of introducing multidisciplinary inquiry-based learning in high schools is currently underway, although adequate instructional training and teaching materials are not yet available to teachers. Japanese public high school teachers collaborated with the Sustainable Development Goals (SDGs) Design School, Faculty of Design, Kyushu University, to co-design inquiry-based learning materials for high school students. These materials, which began to be implemented on a pilot basis in 2019, take the form of a booklet of worksheets in which students can describe their discussions as well as their ideas and research findings. They are intended to guide students' self-learning, help them think about the social issues around them, and seek solutions to those issues [4][5].
This study examines the introduction of these materials during the Period for Inquiry-Based Cross-Disciplinary Study at a general high school in the context of the SDGs Challenge Project. The study covered 19 lessons, the curriculum time for each of which was 100 minutes. The study was conducted from April to October 2023, and all 314 third-year students in the school participated. It was intended as part of a broader investigation into how to implement design-based skills for multidisciplinary inquiry-based learning in Japanese high schools.

2 LITERATURE REVIEW
The Period for Inquiry-Based Cross-Disciplinary Study requires each school to set its own goals and content, as each school is expected to develop learning activities according to its students' actual

situations and the characteristics of the school. There are, of course, no textbooks, as it is not possible to generalise about this type of study. In 2023, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) published a handbook on curriculum management based on the revised Courses of Study for High Schools, which explains the basic concepts, provides examples of lesson plans for Periods for Inquiry-Based Cross-Disciplinary Study, offers learning guidance and organisational systems for developing such plans, and introduces examples of excellence in practice [6]. MEXT noted the significance of addressing the goals and content of the Period for Inquiry-Based Cross-Disciplinary Study in school-wide training [7]. However, a detailed description of what this involves is unavailable. These materials alone are not sufficient for teachers. As mentioned above, each high school has its own specific objectives, and each region has its unique characteristics, meaning that no materials can perfectly match the content to be worked on in a school. Teachers must improvise or devise new plans and methods according to the situation. In other words, Japanese inquiry-based cross-disciplinary study is still in its early stages, and there is a lack of accumulation of pedagogical content knowledge by teachers [8]. As high schools need to set their own learning content individually, they are not provided with enough specific or generalised training relevant to this subject compared with others such as mathematics and languages. There is a need for training to support the development of lessons tailored to individual schools, based on analysis and discussion of precedents [9].

3 METHOD

To clarify what knowledge is necessary for teachers to teach the Period for Inquiry-Based Cross-Disciplinary Study, the following key research question is posed: "How might teachers guide students to be able to identify an appropriate problem in design-based learning?" The current study adopts a qualitative approach to build a case study around the SDGs Challenge Project in a Japanese high school. Although the SDGs Challenge Project is a comprehensive programme encompassing the entire process, from identifying a problem to proposing a solution, the current study focuses on the process of finding problems. This is because previous research has shown that teachers participating in this programme find teaching the problem-finding process to be the most difficult part. In previous SDGs Challenge Project case studies, students selected a theme of interest relevant to the SDGs during the problem-finding process, used mind maps to identify more issues related to their chosen theme, and then focused their exploration on issues. As a result, many students in these cases focused on issues of poverty in distant countries that they associated with the SDGs. However, it was difficult for teachers to teach the process because of the students' lack of real-life experience and empathy [2][10][11].

Therefore, the current study modified the worksheet used by students in the SDGs Challenge Project as follows to address the difficulties of the problem-finding process. In Step 1 of the problem-finding process, students identify 30 problems in their daily lives along the timeline of a day and describe the ideal situations wherein each of the problems could be solved. In Step 2, students write down their areas of interest and why they are interested in them, describe 10 problems, difficulties or challenges in these areas, and describe the ideal situation in which each of these challenges could be solved. They then use mind maps to expand on relevant stakeholders and concepts and to examine the issue's historical and social context. The original worksheet was changed into a scaffolding worksheet with these detailed steps and clear goals to accomplish and tasks to complete in each step.

A post-project questionnaire consisting of open-ended questions was administered to investigate the impact of this change on students and teachers. A questionnaire survey of the 314 participating students and 23 teachers was conducted. The students were asked to identify the most difficult process used in the programme. The teachers who conducted the classes were asked which processes were most difficult to teach, why they were difficult to teach, and how they thought these difficulties could be overcome. Following immersion in the data, the responses to the open-ended questions were analysed, categorised and interpreted to look for a lineage of concepts. Based on the results, the current study discusses how to enable teachers to meet students' needs in the problem-finding process.

4 FINDINGS & DISCUSSION

Of the 314 students, 248 responded to the survey. The question they were asked was, "Which of the processes used in the programme worksheet was the most difficult?" As it was mandatory to select one response to this question, all 248 students selected one process. The most common response was ideation, which was selected by 79 respondents, or 32% of the total (Figure 1). The next most popular response was idea improvement, which was selected by 10% of respondents. No other process was

selected by more than 10% of the respondents. In the current study, many student groups explored the issue of sleepiness among high school students, possibly as a result of the changes to the problem-identification process in the worksheet, which encouraged students to look to their everyday lives for problems. This modification of the worksheet reduced the difficulty of the problem-finding process for students.

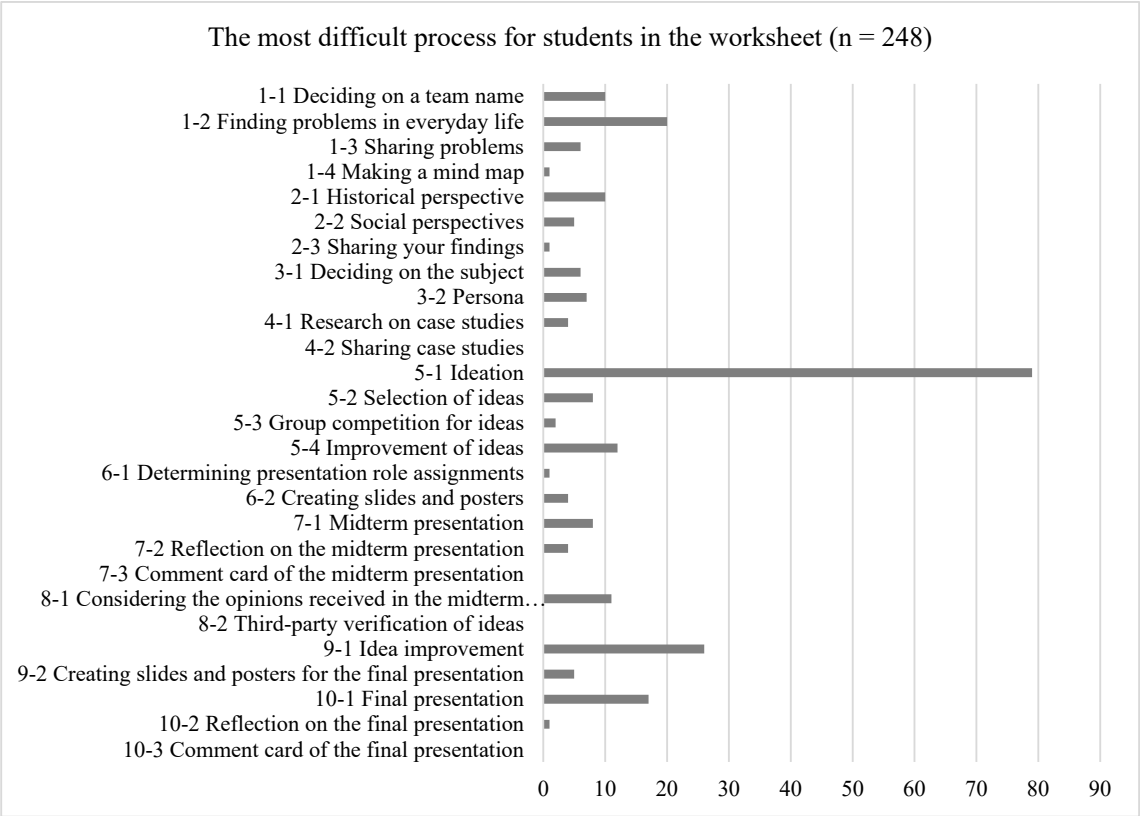

Figure 1. Students' feedback on the programme

The same questionnaire was administered to the teachers. Out of the 23 teachers, 19 responded to the survey. Finding problems in everyday life was the most common response, with 10 respondents (Figure 2). The teachers' opinions as to why this process was particularly difficult were elicited through an open-ended question (see Table 1), and the responses were sorted into six categories. The figures in brackets indicate the number of teachers who mentioned each category of reasons.

In previous studies, Japanese high school students tended to pick problems related to poverty in distant countries that they were unable to empathise with because of the distance from their real-life experiences [12]. We therefore moved the scope of the problem-finding process closer to students' familiar everyday problems and divided what they needed to do into smaller steps. We modified the problem-finding process based on the hypothesis that teachers' difficulties would be reduced if the students were able to proceed with self-learning. Although the students were less likely to identify the problem-finding process as the most difficult process in the worksheet (with the percentage of students selecting this option falling from 10% before the changes to 8% afterward), the teachers indicated that the problem-finding process was still difficult. This indicated that what is needed for teachers is not just the right scoping between students and problems. The open-ended responses indicated that the teachers ideally wanted the students to identify problems that were within the appropriate scope, not too familiar or personal, but also not too unfamiliar or distant, as in the case of a foreign country that is completely unknown to the students and therefore difficult for them to empathise with, and that still had a social impact (Figure 3). However, exploring practical problems does not help teachers in achieving their ideal goals. What teachers need is not to be able to get their students to give ideal answers, but to receive training in facilitation so that they can bring their students to the expected level. They need to be able to show their students a broader perspective if their problem scope is shortsighted and to bring them closer to the problem at hand if it is too far away.

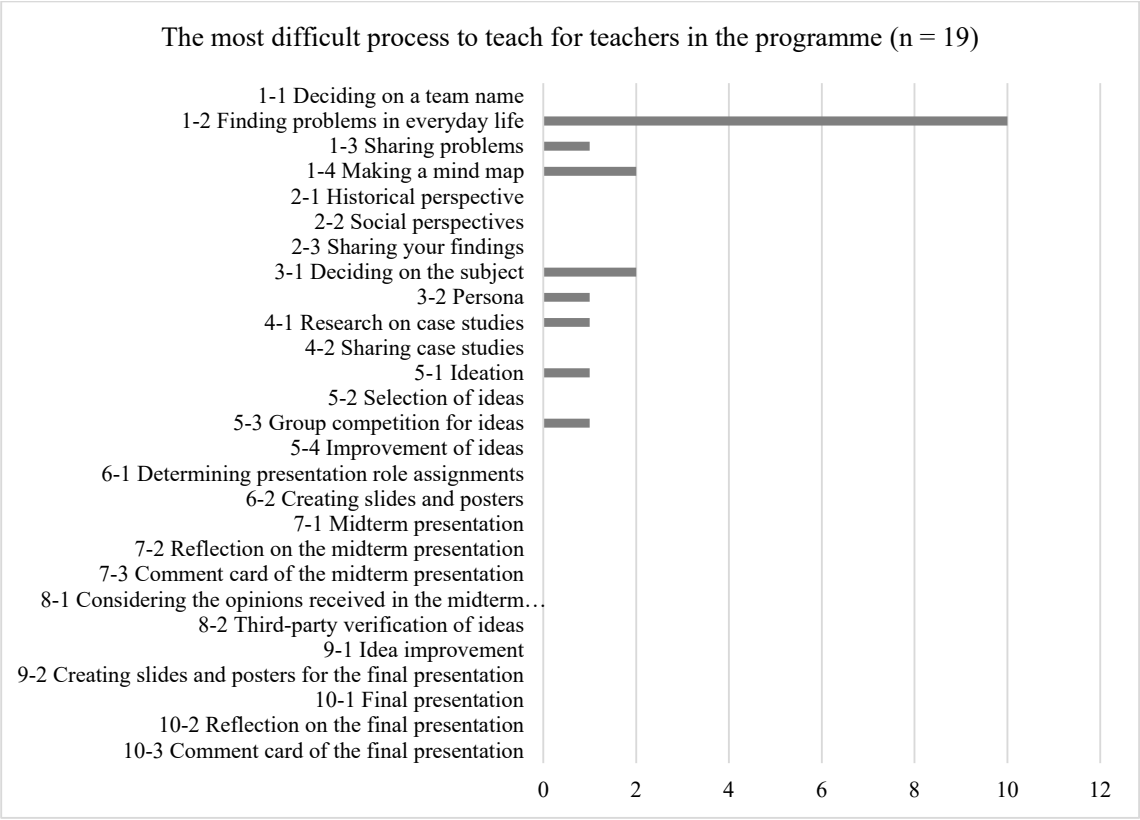

Figure 2. Teachers' feedback on the programme

Table 1. Reasons for teachers' difficulty with the problem-finding process

Categories of Reasons	Indicative Answers
Because teachers are unable to link everyday problems to wider issues, e.g. SDGs (4)	It was difficult because I could not link the topics in which the students were interested with their daily problems. The group interested in the economy explored topics such as truancy and disaster prevention in terms of everyday issues. It would have been nice if I could have connected them to the economy from there, but I didn't have enough teaching skills, and we didn't get that far. I think it is easy to think about issues from everyday life, but I felt it was necessary to link them to topics of interest.
Because everyday problems are too narrow in scope to be expanded (3)	If the initial work is limited to familiar problems, the rest of the work will not be extensive.
Because more groups choose similar problems when they explore problems taken from everyday life (2)	Considering everyday life and familiar matters, many problems and issues to be solved can be identified, but many groups tend to select similar problems.
Because students do not have real experience (1)	It is difficult to find problems to solve when working only in the classroom without fieldwork
Because the problem is not suitable for exploration or presentation (1)	Many problems were not suitable for exploration or presentation
Because the time for exploring the problem is too short (1)	I think there are many troubling situations in their own lives, but when I asked students to write them down, it seemed difficult for them to come up with them. I thought it would be a good idea to make it a homework assignment for a week or two, asking them to write down any 'troubling' situations they encounter.

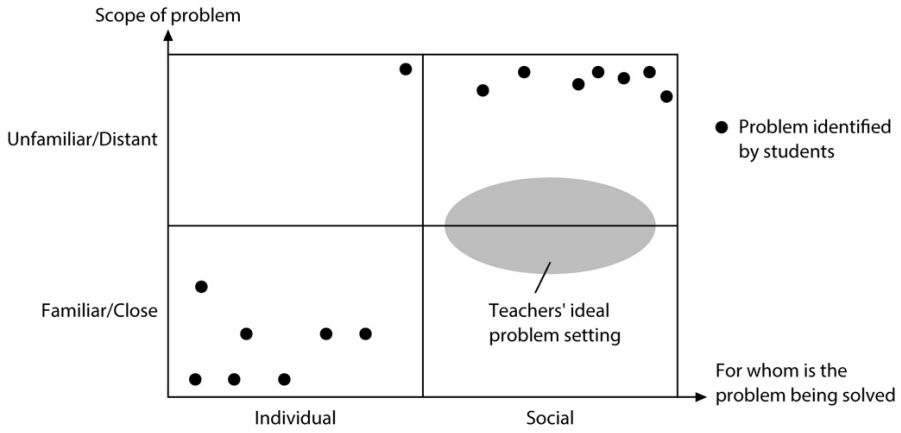

Figure 3. Conceptual diagram of problems identified by students and teacher expectations

Gaining knowledge of facilitation is important for teachers, who may have little experience guiding such discussions. Teachers need to guide students to widen the scopes of their problems if they are too narrow, and to focus them if they are too broad. In the former case, the goal is to broaden the perspective to other problems that could be caused by the problem and to link it to social issues. To take the example of sleep deprivation, this is not just a problem for high school students, so looking at for whom the problem is being solved can expand the discussion of the problem to have a social impact. Sleep deprivation among mothers raising children may be linked to their work environment and to gender inequality, or excessive workloads because of a surge in online shopping may ultimately be responsible for a sleep-deprived long-haul truck driver causing a road accident. Another approach is to collect sufficiently deep data on high school students' sleep problems so that the underlying causes can be discovered in depth. The inability to sleep may be due to too much time being spent using smartphones at night or a school curriculum that requires students to study for long hours. If students are questioned to change their perspective in this way, the same issue – sleep deprivation – can be linked to multiple different social issues, even if the starting point was the same.

Conversely, drawing on previous studies, if the scope of the problem is too remote from students' real experiences or too broad, it is essential to try to increase students' empathy for the problem, thus giving them a more concrete understanding of who the problem affects and how it affects them [13]. Empathy can be divided into two functional components: cognitive empathy, which involves deducing and understanding the other person's state of mind, and emotional empathy, which involves sharing the other person's state of mind emotionally [14]. Kikusawa showed the usefulness of anchoring experience [15], subject embodiment by persona, and mind mapping as methods for fostering these [12]. Even when the scope of the problem that students initially set is too narrow or too broad, teachers can guide them in this way, leading to a deeper understanding and a broader perspective.

5 CONCLUSIONS

This study aims to identify how teachers can guide students in identifying an appropriate problem in design-based learning through a Japanese high school programme. To answer this question, a longitudinal study was conducted on a programme implemented in a Japanese high school. As previous research showed the problem-finding process to be difficult for both students and teachers, the scope of the process was moved closer to students' familiar everyday problems and broken down into smaller steps. This reduced the difficulty of the problem-finding process for the students, although the teachers indicated that they still found it difficult. The teachers' open-ended responses indicated that they ideally want their students to set problems that are appropriately scoped – not too familiar and not too unfamiliar – and that have a social impact.

However, teachers need training in facilitation to prepare them to lead students to the expected level, because if the students explore realistic issues of a practical and complex nature, they may go beyond the scope assumed by the teacher. If the scope of the problem is too narrow, teachers can question the students to change their perspective and link it to a social issue, allowing the students to widen the scope of the problem. In cases where the scope of the problem is too broad, it is essential to increase students' empathy with the problem to allow them to understand more concretely what the impact of the issue is and who it affects. The limitation of this study is that it has not presented methods to improve teachers'

facilitation capacity in a form that can be practically used in classrooms, and it has not validated these methods. Subsequent research should aim to address the implementation of methods for enhancing facilitation skills among teachers and obtaining feedback from both teachers and students.

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