

# PLURALISING THE PRODUCT DESIGN PROCESS TO CREATE INCLUSIVE DESIGN-BASED TEACHING AND LEARNING OF GENERAL COMPLEX PROBLEM- SOLVING IN HIGH SCHOOL EDUCATION

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## ABSTRACT

This study adopts a human-centred approach to pluralise the design process by involving Japanese high school teachers. This research aimed to determine the critical factors for pluralising the design process by first focusing on the *investigating and defining of needs* in the design process. The outcome of the research is to empower non-design-trained teachers to apply design thinking in complex problem-solving. The key ideas consolidated from this study are as follows. Firstly, design-based strategies used by design practitioners must be unpacked for non-design-trained teachers to apply for general educational purposes. Secondly, design vocabulary should not be used in the design-based strategies to allow non-design-trained teachers and students to comprehend the design process easily. For complex design-based strategies, the process has to be broken down further into sub-tasks to match students' abilities and prior knowledge. Lastly, the design-based strategies used for general complex problem-solving should be scoped to the extent that they can be implemented at the school level.

*Keywords: Design process, pluriversal design, complex problem-solving, design education*

## 1 INTRODUCTION

Design-based teaching and learning is defined as applying design methods used by practitioners and the pedagogy of design education in general education to teach various subject concepts [1]. In recent years, Japanese public high schools have been using a cross-curricular learning subject called the *Period for Inquiry-Based Cross-Disciplinary Study* to introduce complex problem-solving (CPS) in the school curriculum. In this subject, students are often taught to use design-based approaches, such as design thinking and the design process, to solve real-world problems. Since 2021, the authors have collaborated with High School F to implement a CPS project in the *Period for Inquiry-Based Cross-Disciplinary Study*. In this CPS project, teachers taught students to use design-based approaches to solve real-world problems in a human-centred approach [2].

Working with High School F, the authors found that high school teachers are often unfamiliar with and confused by the design-based approaches, as there are currently different ways of defining and articulating the design process by design practitioners and academics. Similar issues were reported by Meredith and Littlejohn, where the varied definitions of design thinking can be confusing to teachers unfamiliar with design-based approaches [3]. In addition, support for teachers commonly comes from design practitioners outside the educational system or informal learning context. Knowledge transfer is low, causing programmes to discontinue when external support is discontinued. The design process is generally described as an iterative process that transverses between phases that involve finding and understanding the problems to be solved and the solutions to solve the problems. In *Design & Technology* subjects offered in public school education in Europe, Oceania, and Asia, the design process is articulated as an iterative process that often involves a) *investigating and defining of needs*, b) *generating ideas to address the needs*, c) *developing and producing the ideas as prototypes* and d) *evaluating the prototypes* [4][5]. In addition, some notable articulations of the design thinking process by university institutions and design practitioners are those developed by Hasso Plattner Institute of Design at Stanford University, UK Design Council and IDEO. While existing literature explains the

different articulations of the design process, these are for a particular context and purpose. It can be challenging for schoolteachers to unpack the different articulations of the design process. The ideas of pluriversal design advocate that there can be more than one way to design. This opens the possibility that there can be more than one way to articulate the design process, other than the currently available views of the design process. However, the considerations when re-articulating the design process are relatively unclear, as design research for articulating the design process for non-designers is relatively underexplored. The current study is the first part of a larger study that aims to determine the critical factors for pluralising the design process by first focusing on *investigating and defining the needs* in the design process. The research outcome will enable non-design-trained schoolteachers to understand the design process and empower them to teach design thinking in CPS.

## **2 PLURALISING DESIGN PROCESS**

The theoretical ideas for pluralising the design process in this research mainly stem from the pluriversal approach to design and design education and the multiple intelligences (MI) theory.

Winschiers-Theophilus et al. define pluriversality as accommodating the ‘multiple ways researchers and practitioners are finding their critical position within Participatory Design to represent their geographical regions, local and Indigenous communities and collaborations’ [6]. In design education, pluriversality should be prioritised to dismantle the power structures of Eurocentric design pedagogy frameworks such as Bauhaus and Ulm [7]. Moving away from outcome-based design education, design education can accommodate different worldviews and approaches that focus on identities, developing thinking skills, and cultures. Learners of design should be aware that there is no one way of learning design [8]. Pluriversality thus entails exploring epistemologies within the Global South and integrating marginalised voices through art-based and more-than-human methodologies into design curricula within the Global South that challenge colonial power structures [9][10]. The emergent pluriversality paradigm acknowledges and sustains an ontological multiplicity [11].

Howard Gardner’s MI theory pluralises the learning of concepts in more than one way [12]. The MI theory indicates that each person possesses eight different intelligences, namely, 1) linguistic intelligence, 2) logical-mathematical intelligence, 3) visual/spatial intelligence, 4) bodily-kinaesthetic intelligence, 5) musical intelligence, 6) interpersonal intelligence, 7) intrapersonal intelligence, and 8) naturalist intelligence. As such, Gardner suggested that to teach a certain topic for understanding, there can be different ways of approaching the topic. Gardner considers these different ways as entry points, or “windows” to reach the same room. Some of the entry points are a) using narration (story), b) logical rational approach, c) through role play and debates, d) asking basic kinds of questions, and others. Similarly, based on MI, it is hypothetical that the design thinking and design process can be articulated in different forms to help schoolteachers better understand design concepts.

## **3 RESEARCH METHODOLOGY**

### **3.1 Research Question and Research Method**

To achieve the research purpose, the key research question (RQ) is constructed as below.

RQ. What are the key considerations when articulating the *investigating and defining the needs* in the design process as a process for CPS in a way that high school teachers who are not design-trained can understand clearly?

This study applied a qualitative inquiry strategy based on the principle of purposeful sampling to create a single significant case study. This study builds on the previous findings based on how design-based approaches have been incorporated into the CPS project in High School F since 2021. As a build-up for a longitudinal study, this case study will take the approach of an exemplar of a phenomenon of interest as the purposeful sampling strategy. An exemplar of a phenomenon of interest can be a programme that is a single case that offers an in-depth examination of issues over a period that manifests the important dimensions of the issues [13]. As a follow-up study of High School F over the last four years, this study can significantly contribute to design practitioners and academics interested in implementing design-based learning as general education in high schools.

In School F, the CPS project called the SDGs (Sustainable Development Goals) Challenge Project is a school flagship programme that all Year 2 high school students will take. About 320 students are divided into eleven classes, and two teachers are allocated to facilitate each class. The project consists of 12 periods with 100 minutes per period. In this project, students are tasked to identify a real-world problem within their community.

### 3.2 Research Design, Scope of Research, and Implementation

Designed as action research, this study included Planning, Prototyping, Focus Group Discussion, and Reflection phases. In the Planning phase, the key issues identified from the authors' previous studies on the project were consolidated as key design considerations to revamp the processes *investigating and defining of needs* in the SDGs Challenge Project. In the Prototyping phase, the authors attempted to articulate the design process as a general CPS process for a non-design-trained audience. Focus group discussions were conducted with the team to solicit qualitative feedback from the project coordinating team in High School F. In the Reflection phase, the authors analysed the qualitative feedback and identified the key considerations required to improve the articulation of the design process. The authors analyse the content of feedback to elucidate meanings. As a form of qualitative interpretation based on the authors' perspective and understanding, the authors attach significant meaning to the feedback, making inferences and extrapolating lessons to be learned.

## 4 FINDINGS AND DISCUSSIONS

The *investigating and defining the needs* was implemented over 6 periods. The lessons in the CPS project were planned by vaguely referencing the UK Design Council's Double-Diamond interpretation of design thinking and the design process applied to Design & Technology subjects. The project started by introducing the SDGs to students in Lesson 1. In Lesson 2, students went through the divergent process of exploring problems around them through brainstorming and mind-maps. Then, students used a variety of design-based strategies to select one problem to solve in the project. In Lessons 3 to 5, students conducted research and group discussions to understand the problem better, identify potential stakeholders and users, and identify possible existing solutions. Refer to Table 1.

Table 1. Programme plan for investigating and defining the needs

Program for the SDGs Challenge Project (1 period of 100 minutes per week)	
Key Stage and Duration	Tasks
Problem Exploration and Identification (4 periods)	Lesson 1: Learning about SDGs Lesson 2: Thinking about the challenge (problem exploration and selection) Lesson 3: Explore the background (understanding the problem and its background)
Target users and existing solutions (2 periods)	Lesson 4: Identifying stakeholders and Target users Lesson 5: Research on existing solutions

In the Planning Phase, based on previous research on this project, the key issues faced by teachers when facilitating the *investigating and defining the needs* during the CPS project were as follows.

1. Teachers could not fully understand the iterative nature of the design process.
2. Teachers faced challenges in guiding students to explore design problems within a broad theme and narrow them down to identify a specific design problem to solve.

As the activities and instructions from Lessons 1 to 5 appeared to be a linear process, the authors considered several factors when re-articulating the *investigating and defining the needs* process.

1. Help teachers and students visualise and link different parts of the design process for CPS
2. Articulate the *investigating and defining the needs* processes into easy-to-understand processes
3. Provide more detailed pedagogical approaches for teachers to teach the design-based strategies used during the *investigating and defining the needs* process.

Although current available open-source models and articulations of the design process provide graphical representations and explanations for their users to engage in design thinking, these models can be challenging to understand without the help of design-trained personnel. The authors decided to take a participatory approach to involve high school teachers in co-articulating the design process in a way that non-design-trained users for general education can easily understand. During the Prototyping phase in this research, the authors first re-articulated the *investigating and defining the needs* process into a "six-step" process using simple icons, Figure 1, before conducting a focus group discussion to elucidate feedback from the team of high school teachers who are coordinating the CPS project in High School F. In each step, several design-based strategies were suggested for teachers to choose when conducting the activities (Figure 2). These design-based strategies were created with reference to available open-source design-based strategies created by design institutions and firms. The project coordinating team was asked to provide qualitative feedback based on the following areas: a) the articulation of the problem exploration process as a "six-step" process, and b) the design-based strategies suggested in each step for

students to complete the tasks required. The key points from the feedback from the project coordinator are organised and presented in Table 2.

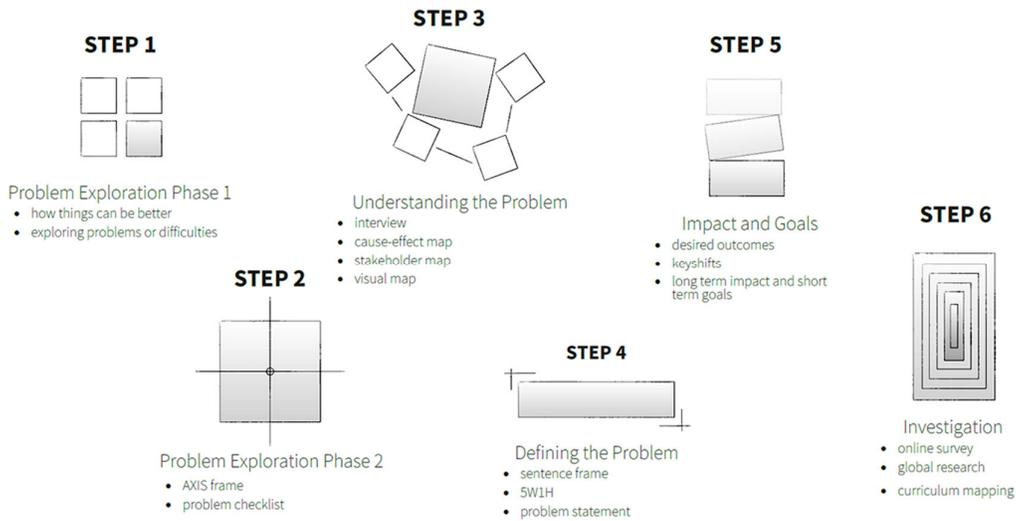


Figure 1. Articulating the Investigating and Defining the Needs process

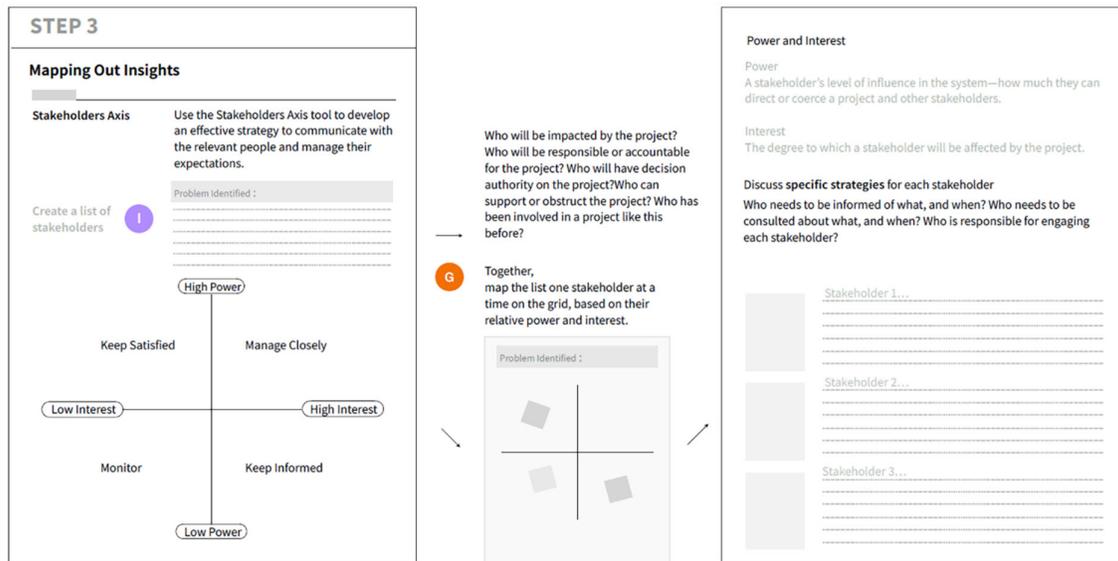


Figure 2. Example of a proposed design-based strategies to identify possible stakeholders and target users in Step 3: Understanding the Problem

From the feedback, several key interpretations can be made. In general, the design-based strategies suggested by authors need to be further unpacked and simplified for use in a general education context. Firstly, the design vocabulary used in the design-based strategies is unfamiliar to teachers and students. Using unfamiliar design terms makes it difficult for students to understand, thus resulting in a mismatch between the suggested design-based strategy and students' existing knowledge and abilities. Secondly, some design-based strategies, though familiar to the authors, were too complex for teachers and students to understand. Some of the process needs to be further broken down into sub-tasks to allow students to apply these strategies easily. In addition, pedagogical considerations need to be worked out with the teachers so that they can teach the design-based strategies confidently in the project. Thirdly, conducting research is part of the usual activities in design education, but such an activity needs to be scoped so that the school can execute it. Thus, the feedback from the teachers further suggested that design-based approaches available as open-source materials designed for a specific context cannot simply be plugged and played into a CPS project in general education. Involving teachers in a participatory approach is necessary to create design-based approaches that can be adopted or adapted in the general education.

Table 2. Feedback from the project coordinating team

Key activities in each step	Key points identified from feedback
Step 1 Exploration of Problems Phase 1 Students are to discover hidden problems in their community (Strategies suggested: writing in text about how things can be better or difficulties they faced)	1. It was useful to organise the problem exploration, problem selection and understanding the problem activities into systematic steps, but suggested activities in each step is too difficult for students in the school. 2. Students will find it challenging defining the problems to be solved given their current state of knowledge and thinking abilities. 3. In terms of Conducting Research, it is necessary for teachers to check the research plans, especially those that may involve sensitive information and human rights. There may also be a need for the school to seek external permission if the targets are external parties and not within the school. At this moment, there is not enough support system for teachers to guide students conduct intensive research. 4. There is a need to break down the current suggested processes into smaller sub-tasks. At the moment, the tasks in each step may not match the students' abilities. 5. Examples of how each activity in each step can be done are required to support students' learning as they are not familiar with the design-based process. 6. Some of the terms used in the design-based strategies are not easy for the students. Especially in Step 5.
Step 2 Exploration of Problem Phase 2 Two strategies are suggested to understand the different characteristics of 20-25 problems brainstormed within the group. Students are expected to choose one problem at the end of this step and identify a related SDGs goal with the help of a reference material/ database including detailed examples of SDGs related social problems data. (Strategies suggested: axis frame, problem checklist)	
Step 3 Understanding the Problem Different strategies and visual methods are suggested for students to identify the cause and impact, core reason for a phenomenon, and to understand the complexity of the problem. (Strategies suggested: online surveys, interviews, stakeholders axis, stakeholders map, visual map, cause and effect map)	
Step 4 Defining your Challenge Two strategies are suggested to define and elaborate the current state of the problem and the reason of choosing to work on it. (Strategies suggested: sentence frame, problem statement)	
Step 5 Impact and Goals Students are required to set up specific goals of the problem by using different impact tools. Students will write down possible changes in knowledge, motivation, emotions, attitudes, perception, measures and the solved state of the problem to get students closer to the solution. (Strategies suggested: key shifts, desired state & key verbs, long term impact & near term goals)	
Step 6 Investigation Students are to conduct deeper interviews and research on global perspectives about the problems. In addition, students are to reflect how the activities in the project required them to apply knowledge from other subjects. (Strategies suggested: online survey, global research, curriculum mapping)	

The suggested articulation of the *investigating and defining the needs* process in Figure 1 took the approach of a logical and rational process for CPS. To create a more pluriversal way of understanding the design process, taking hint from MI theory's concept of entry points to explain a concept, the authors created a second prototype to articulate the entire design process as a general CPS process through a combination of narration (story), visual and logical approach, Figure 3. Presenting the design process through the story of the Explorer's Journey, teachers and students may understand the iterative nature of the design process through logical storytelling. While it will not be covered in this study, the efficacy of the Explorer's Journey as an articulation of the design process and relevant design-based strategies accompanying it will be further studied in the next phase of the research.

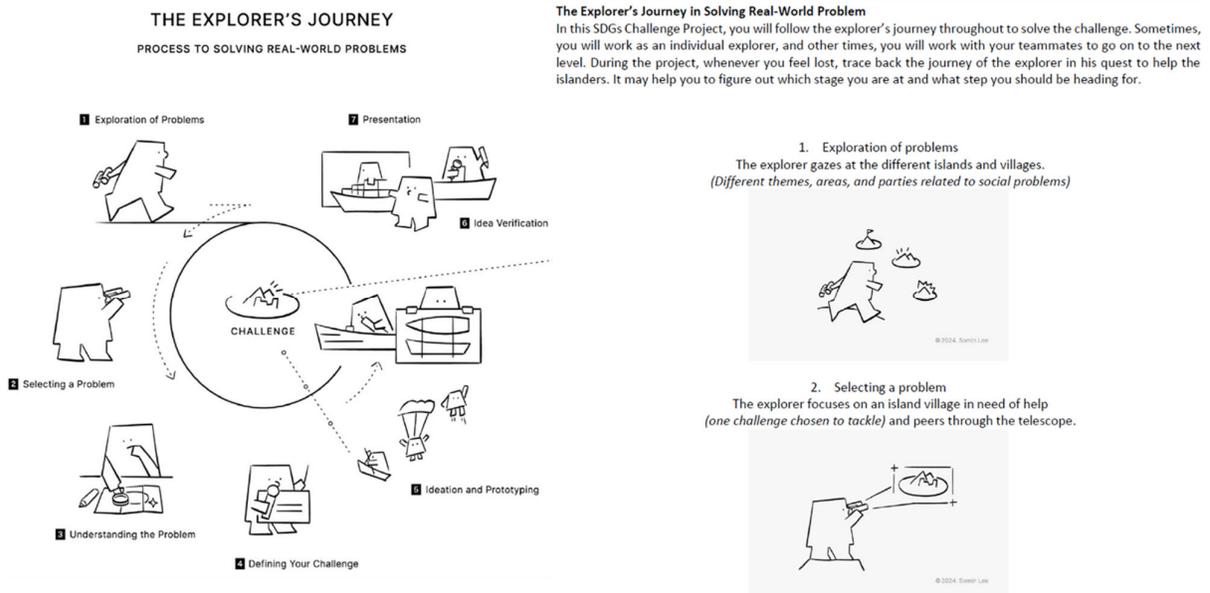


Figure 3. Articulating the design process using narration, a visual, and a logical approach

## 5 LIMITATIONS

The current paper is exploratory research limited by the scope of the pluralising part of the design process for CPS in general education. In addition, this is a single case study that only touches on the surface of the exploration of how the design process can be further articulated to allow teachers and students who are not design-trained to understand and apply a human-centred design approach for CPS in their daily lives. At the same time, this study needs to be expanded further to explore how design-based approaches can be positioned as a pedagogical approach for teaching non-design-related subjects.

## 6 CONCLUSIONS

This research aimed to determine the critical factors for pluralising the design process by first focusing on *investigating and defining the needs* in the design process. The outcome will allow high school teachers to understand the design process and apply design-based strategies in CPS. The following key ideas can be concluded when adopting a participatory approach to co-design with high school teachers. Firstly, when adapting open-source design-based materials for CPS, these strategies must be unpacked for application in general educational purposes. Secondly, design vocabulary should not be used in the design-based strategies so that teachers and students who are not design-trained can comprehend the process easily. For design-based strategies that are complex, the process has to be broken down further into sub-tasks to match students' abilities and prior knowledge. Lastly, the design-based strategies used for general CPS should be scoped to the extent that they can be implemented by the school.

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