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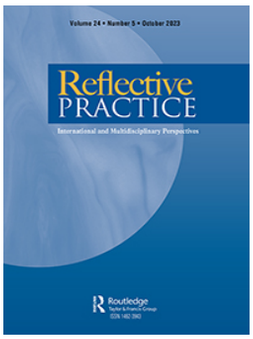

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Using design thinking to explore teaching problems in Chilean schools

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ABSTRACT

Educational systems face increasingly complex demands, confronting teachers with multidimensional people-centred problems rarely solved by linear or standardised solutions. Nevertheless, teachers must juggle multiple variables simultaneously in their daily work. This can lead to routine and unreflective decisions that do not consider unique situations. Considering that designers' abductive reasoning could support problem-framing skills, this article discusses how a design thinking approach can contribute to developing reflective teaching practice. This case study explores how 20 Chilean teachers define, frame, and re-frame their pedagogical problems in a design-based teacher professional development programme. Findings revealed three problem-framing triggers that support teachers' reflection: (a) collaborative discussions, (b) awareness of people and their context, and (c) visualising, making, and testing ideas. Combined, they articulate action and promote reflection, demonstrating the value of a design thinking approach in supporting teachers' pedagogical decisions.

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Introduction

Globally the educational system faces growing complex demands, and teaching is increasingly considered a professional activity. The professional character of teachers is recognised as a central aspect of achieving the improvements promoted by educational reforms (Darling-Hammond & Bransford, 2005; OECD, 2005; Ruffinelli, 2016). Schön (1983) suggests that problems are not an a priori reality but are constructed by professionals as unique cases in a reflective process in which they *frame* an incomprehensible, worrisome, or uncertain situation they seek to change. To do this, they establish limits, select and rank information, and impose a certain coherence that enables them to identify what is wrong and clarify the ends they hope to achieve and the means to achieve it. They do not look for clues to a standard solution; on the contrary, they progressively discover the specific characteristics of each situation and design interventions accordingly. Schön highlights designers' way of solving problems as a process that could serve other professionals to develop problem-framing skills.

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In school education contexts, the excess of variables that teachers must consider simultaneously leads them to develop routines that desensitise the particularities of each situation, producing unreflective and standardised decisions, which could threaten the promotion of pedagogical innovation and curricular flexibility (Korthagen & Vasalos, 2005; Orgoványi-Gajdos, 2016).

A better understanding of how teachers define, frame, and reframe pedagogical problems and identifying the factors contributing to this process is relevant to guide teacher professional development by enhancing reflective practices. In this scenario, how do teachers define and frame their pedagogical problems? How might a design-thinking approach contribute to framing and reframing their pedagogical problems in a reflective, contextualised, and practicable way? To answer these questions, we conducted a case study to explore the structure and evolution of pedagogical problems defined by 20 Chilean teachers before and during a 7-month design thinking teacher professional development programme.

Struggling with reflection in teaching

Reflection has been a critical element in the teaching profession for almost three decades. Sarramona Lopez et al. (2009) have suggested that teacher reflection is highly valued by reforms to improve the quality and effectiveness of education and educators. Reflective teachers can: improve their pedagogical knowledge and professional practices, positively affect teachers' agency and autonomy in decision-making, and expand their field of action, opening perspectives for professional development (Kramer, 2018; Ruffinelli, 2017).

Moreover, teachers' ability to anticipate prospectively towards their future practice is highlighted by several authors, and emerging dimensions, such as reflection focused on the future and collective reflection, are being valued (Beauchamp, 2015; Postholm, 2008; Urzúa & Vásquez, 2008; Wilson, 2008). It has been suggested that sharing concerns with other teachers makes it possible to collectively identify and discuss problematic teaching situations and support teachers in feeling less isolated (Collin & Karsenti, 2011; Loughran, 2010).

The reflection process is often described as a cyclical model. Williams (2020) proposes a three-phase reflective cycle: I) Initial framing: naming or setting a problem; II) Reframing: understanding the problematic situation differently; and III) Resolution: the problem is resolved but can at any time be reconsidered. Leijen et al. (2012) recognise different sources of reflection: technical, practical, and sensitising. The first deals with the instructional or management aspects, the second with contextual teaching issues, and the third with the teaching's social, moral, ethical, or political aspects.

Despite the evidence on the importance of reflective teaching practice, the complexity of variables teachers must consider simultaneously in their work can lead them to develop routines to maintain mental effort at feasible levels and manage them cognitively (Mason, 2002). These routines can be desensitised to students' particular needs and contexts, generating unreflective, uncritical, and standardised decisions that do not fit the flexibility demands of current educational reforms and hinder the exercise of reflective teaching (Korthagen & Vasalos, 2005; Orgoványi-Gajdos, 2016). This problem is made worse when

time and resources for reflection are limited, impacting individuals, organisations, and communities of practice (Nutt & Keville, 2016).

In Chile, the notion of teachers as professionals underlies the latest education policies, which demand teachers' autonomy in making pedagogical decisions, collaborative work, creativity, and flexibility in their pedagogical practices to address students' diversity, vulnerability, and demotivation (Ministerio de Educación, 2015, 2016). However, Chilean school teachers are constantly stressed by the complex socio-economic, cultural, and political context that affects their capacity to deal with extreme inequalities and vulnerabilities in the educational system (Ávalos, 2013; OECD, 2017; Ruffinelli, 2016; Santiago et al., 2017; UNESCO, 2020). Besides, they show low levels of collaboration and feel frustrated by their limited agency to influence decisions that affect their work (Cabezas et al., 2017; Elige Educar, 2018). This lack of autonomy challenges implementing inclusion policies and teacher professional development training programmes (Gaete et al., 2017).

A design thinking approach to framing and reframing problems

Schön's epistemology of practice criticises the technical rationality model, in which solving problems translates to simply selecting the most appropriate means for the ends. Instead, professionals must frame the problematic situation and clarify the ends they hope to achieve and the means to achieve it while conjecturing possible solutions. He suggests that design professions – such as architecture, engineering and design – could be a prototype for other professionals to develop problem-solving skills.[1] Cross (2006) advocates incorporating design into general education to develop abilities to solve ill-defined problems. Analogously, Dorst (2019) claims that designers' way of framing and reframing problems is essential across the professions.

Design has been defined as a creative, exploratory, emergent, participatory, collaborative, and reflective process that begins with an open and undefined problem (Buchanan, 1992; Maher et al., 1996); finds opportunities through empathic observation of people's needs and behaviours (Brown, 2008); seeks for innovative solutions through creative ideation (Kelley & Kelley, 2013); and ends with the delivery of a concrete solution proposal. Through iterative cycles, designers refine and evolve both the problem definition and the ideas through which they seek to solve it. The information emerging from exploring a problem leads to the imagination of its solution, and the restrictions of a possible solution enable a better clarification of the problem (Dorst & Cross, 2001; Wiltschnig et al., 2013). In other words, the process followed to understand a problem is the same as in trying to solve it.

By iterative framing and reframing the problem, designers explore different ways of interpreting the situation and reflect on the unexpected consequences of their actions and their possible implications. During this process, they define the scale and redefine problems reflectively and iteratively, becoming part of the situation they seek to change; they interpret and construct them from their contexts, experiences, capacities, and resources (Lloyd, 2013).

The designer´s abductive reasoning relates to the ability to speculate and make conjectures by trying to answer questions like 'What would happen if . . .?' (Cross, 2013). According to Kolko (2011), abductive reasoning is shaped by trying to make sense of

incomplete data in the form of an insight that guides decision-making. In this process, hypotheses of ways to confront problems are generated as ideas or possible solutions.

Collaboration through productive dialogue has been highlighted as the most crucial aspect of designers' thinking to frame and reframe problems and guide them toward a design proposal. It can focus on sketches and prototypes, facilitating communication between people, as a self-dialogue, or as an internal conversation with the situation (Lloyd, 2013). Approaches such as Design Thinking for Educators (IDEO, 2012) consider collaboration as one of the essential mindsets of designers, arguing that the design process benefits greatly from others' perspectives and creativity.

Finally, design is a reflective process in and of itself, with a well-developed set of practices and theories to support what is quite a complex 'ecology' of reflective practice (see, for example, Beck & Chiapello, 2018; Ramage, 2017; Schön, 1995, 1983). Hence, when design practitioners engage in design, they also engage in reflection and reflective practice, allowing both to take place more efficiently than if treated as separate activities.

Teachers as designers dealing with pedagogical problems

Laurillard (2012) built on Simon's notion of the artificial sciences (Simon, 1996), stating that teaching is a design science focused on imagining how the world should be. Consequently, design thinking approaches and methods have been used by teachers as a working model and an accessible structure to guide decision-making and the resolution of pedagogical problems in the context of instructional design of lessons (Hutchinson & Tracey, 2015; Kali et al., 2011; Tracey et al., 2014). Several authors have reported experiences in the last decade where design methods and tools are used to address pedagogical issues (Bravo & Bohemia, 2021). According to those experiences, design approaches broaden the understanding of the problem allowing teachers to see it as a symptom of a more significant issue (Goodyear, 2015), enabling them to be more flexible, adaptive, and open to exploration (Jordan, 2016); providing a structure to solve the variety of problems that teachers must face creatively (Henriksen et al., 2017); and help them to think holistically about the special educational needs of their students (Goldman et al., 2020). Likewise, Chambers and Chambers (2018, 2021) has brought design thinking to Physical Education. She defines this approach as a 'multi-stage iterative process' which allows teachers to adopt sophisticated choices on curriculum, teaching and assessment issues to create customer learning experiences for students. Mintrop et al. (2018) observed that design principles support school leaders to elaborate on more precise problem definitions and contextualised solutions.

Design thinking to solve teaching problems is an emerging field of study, generating significant interest (e.g. Lloyd, 2011; Lloyd, 2013). However, more evidence is needed around specific contributions, such as framing and reframing complex teaching problems. Teachers as designers face uncertain, complex, and ever-changing challenges where constant thinking, reflecting, decision-making and acting occur (Cortés et al., 2020). They require support translating their pedagogical problems into actionable practices and mindsets to manage, provoke, mediate and co-design meaningful responses to their daily challenges.

When the affordances and opportunities offered by design practice approaches are related to the problems faced in the Chilean teaching context, a series of

specific opportunities emerge, namely: ways of approaching and responding to complex problems, identifying grounded actions in response to these (teacher agency and power to effect change). In addition, specific conditions that support good design practice also align with developing more time-effective practices and professional communities of practice. Hence, a motivation for this study was to explore how design thinking approaches support teaching practices and how practical implementations can be replicated and expanded as part of general teaching practice.

Methodology

We conducted an exploratory case study to understand the structure and evolution of pedagogical problems defined by Chilean teachers. The case study approach aims to investigate in-depth contemporary phenomena within real contexts empirically (Yin, 2018); it can follow either realist or relativist perspectives, all approaches commonly taken in design research (Koskinen et al., 2011) and that have similarities and overlaps with action research methods applied in education (see Arefian, 2022). As a 'bounded system' (Cohen et al., 2007, p. 253), this case study included data from a teacher professional development programme that applied design thinking approaches to deal with the teaching problems of 20 Chilean school teachers.

Training programme

An interdisciplinary research team with expertise in design education, primary school curriculum, and professional teacher development created the programme consisting of five sessions of four face-to-face hours each, carried out over seven months. Its contents and activities were structured by integrating resources and stages described in design thinking models developed by the Design Council (2021), the d.school[2] (Carroll et al., 2010), the design and consulting firm IDEO (2012), and the global organisation Design for Change (2017) (Figure 1). Our approach was to organise the sessions based on the key stages of the design thinking process without explicitly teaching or following a particular model. Our goal was to guide participants through each stage and encourage collaborative reflection to grasp the holistic nature of the design thinking process fully. The sessions included short instructor presentations, practical activities, open discussions, and feedback from instructors and peers. Teachers also carried out assignments or practical activities between sessions in their work contexts. Two researchers of the team observed these activities in each case. Participants' work was registered using worksheets designed for each session (Table 1).

To support the exploration and evolution of problems, various group and individual design-related activities were carried out: rewriting the problems using a 'How might we . . . ' question; representing the problem through mind maps; brainstorming practical solutions; prototyping implementation plans, designing, and delivering small interventions aimed at solving the problem.

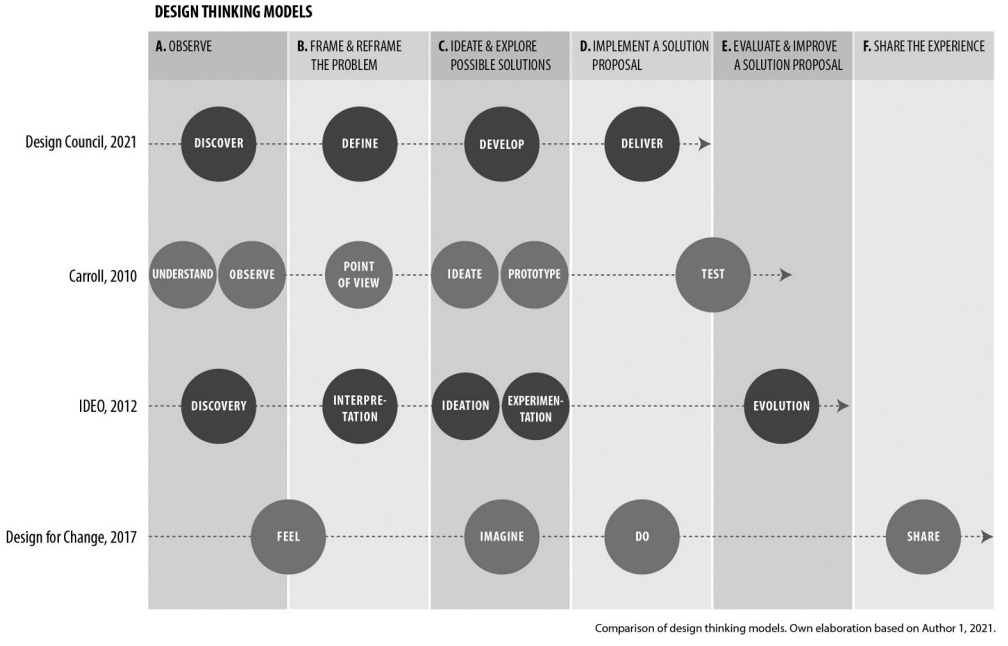

Figure 1. Design thinking key stages. Based on Bravo & Bohemia, 2021.

Participants

To recruit participants, we sent an invitation to participate in a professional teacher development programme to the school network of the school of education at a Chilean university. Twenty teachers-eight male and twelve female – from six charter schools and two paid private schools in the Metropolitan Region accepted the invitation. Sixteen participants were classroom teachers of different levels (1st to 4th grade) and subjects (Mathematics, Language, Technology, History, Science, Chemistry and English); two were school principals and two academic coordinators who were not teaching. The participants' age ranged from 23 to 65 years old. All participants signed a letter of consent agreeing to participate in the research project. Consents were reviewed and approved by the university's ethics, privacy and data collection policies.

Data collection and analysis

Information was collected throughout the training programme, including worksheets filled during the workshop sessions, open conversations, and photographic records. Through the worksheets, the various activities were monitored, which served as evidence to build a prospective vision of the work trajectory of each teacher. In the last session, we conducted a semi-structured interview (Flick, 2018) using a Learning Path timeline (Kraft et al., 2021) in which participants registered events, milestones, thoughts, and turning points in their framing and re-framing processes. This interview aimed to capture the teachers' perception of their trajectory and identify the activities and resources that helped them frame and reframe their problems. Hence, each teacher self-reported the

Table 1. Contents and activities carried out in the programme sessions.

Session	Contents and activities	Type of activity
Session 1 *Design thinking process and features* (A, B, C)	"Introduction to design thinking" • Write a teaching problem faced daily • Select the most representative problem by consensus. • Collaborative definition and framing of other group's problem. "The creative process" • Ideate individual solutions • Group and rank peer's ideas according to their similarities • Select the three ideas with the highest potential for implementation. • Prototype ideas and share them with the whole group.	Instructor presentation Practical activity Open discussion Instructor presentation Practical activity Open discussion Feedback from instructors and peers
Assignment 1 *Observe and frame the problem in the participants´ work contexts* (A, B)	• Observe and talk with the people involved in the problem • Reframe the problem	Practical activity
Session 2 *Frame & reframe the problem, Ideate & explore possible solutions* (B, C)	"The problem as a design challenge" • Share problem 2 with peers. • Transform peer's problem using the structure "How might we… to…?". • Incorporate peers' suggestions to reframe the problem "Prototyping to communicate and test ideas" • Ideate solutions to solve the problem using brainstorming, memoing and mind maps. • Collaboratively generate varied ideas to address the problems. • Represent proposals (or some aspect of them) through fast low-resolution prototypes. • Present prototypes to the group.	Instructor presentation Practical activity Open discussion Instructor presentation Practical activity Open discussion Feedback from instructors and peers
Assignment 2 *Ideate, explore, and test possible solutions in the participants´ work contexts* (C, D, E)	• Describe proposal and define indicators of success for the intervention. • Define aspects of the proposal to test, test them and record the testing. • Evaluates the proposal by pointing out aspects achieved and aspects to be improved.	Practical activity

(*Continued*)

Table 1. (Continued).

Session	Contents and activities	Type of activity
Session 3 *Communicate the testing conclusions and reframe the problem* (B, D, E)	• Present the results of the testing to peers. • Reframe the problem, incorporate improvements to the proposal and define an action plan for its implementation.	Practical activity Open discussion Feedback from instructors and peers
Assignment 3 *Implement and evaluate the solution proposal in the real context* (D, E)	• Implement the solution proposal in the real context. • Evaluate the implementation of the solution proposal	Practical activity
Session 4 *Present and evaluate the solution proposal implementations* (E, F)	• Share the results of the proposal´s implementation. • Reflect on the programme experience. • Identify activities and tools favouring the problem's framing and reframing.	Open discussion Feedback from instructors and peers
Session 5 *Present the proposals* (F)	• Closing Seminar	Communication of results to a larger audience of assistants.

most relevant decision, action and insight moments that defined the evolution of their work. The collection of various information throughout the project made it possible to capture various situations that evidenced the richness of the phenomenon studied, facilitating temporal and methodological triangulation (Cohen et al., 2007).

To address the research questions, the analysis had two focuses: (1) to analyse the first problem written by each participant at the beginning of the first session and (2) to analyse the problem evolution of the teachers throughout the whole programme. Both included five stages of a case study analysis: (1) create and organise files for data; (2) read through the text, make margin notes, and form initial codes; (3) describe the case and its context; (4) use categorical aggregation to establish themes or pattern; and (5) use direct interpretation and natural generalisations (Creswell, 2009).

For the second analysis, we selected cases with complete and varied trajectories regarding technical, practical and sensitising focus (Leijen et al., 2012). We got the following cases to analyse:

- *Carolina (C)* is a teachers' coordinator for 3rd and 4th grade in a private urban school. The teachers, under her direction, dictate language, mathematics, science, and history.
- *Fabiana (F)* is a 5th-grade headteacher in a charter school. A high percentage of her students live in an environment of increased vulnerability.
- Gabriel (G) is a young teacher who teaches various subjects: language, mathematics, science, and history. He is the headteacher of the 4th grade at a private urban school.
- *Karina (K)* is the Director of the Junior Section of a charter school in a vulnerable urban neighbourhood. She is an experienced foreign teacher who directs and evaluates teachers' performance.
- *Will (W)* is a young history teacher who taught high school students before attending his urban charter school to teach 5th-grade students.

Findings

Findings from the case study are presented in two sections focused on the two research questions that guide the study:

How do Chilean teachers define and frame their pedagogical problems?

To characterise how participants framed their teaching problems, in the first session, we asked them to write down a problem they had to face daily with the expectation to work on it during the training programme. We obtained 18 responses that were analysed considering criteria extracted from the literature (Table 2). With the literature criteria, we constructed analysis matrices through which we fragmented and codified the problems (Table 3). Two researchers performed this coding separately and then compared the results. We refined the definitions and revised the coding where there needed to be more consistency. Finally, a third investigator audited the analysis.

Among the eighteen initial problems we analysed, thirteen alluded to a negative situation. Of them, eight focused on deficits, shortcomings, or conditions of the students or the school that could be addressed through pedagogical interventions by the teacher. These are the

Table 2. Operationalised analysis criteria extracted from the literature.

Literature references	Analysis criteria
Professionals imagine actions aimed at changing existing situations into preferred ones (Simon, 1996). They build problems from incomprehensible, worrying, or uncertain situations. To do this, they frame the problematic situation, defining limits and clarifying the ends they hope to achieve and also the means to achieve it (Schön, 1983). Professionals become part of the problematic situation (Schön, 1983) framing the problems from their own contexts, experiences, capacities, and resources (Dorst & Cross, 2001). Focus of teaching reflection (Leijen et al., 2012).	(a) The problem refers to a negative, incomprehensible, worrying, or uncertain situation that is expected to change. (b) The problem refers to an end or purpose that is expected to be achieved. (c) The problem refers to a means, action, or intervention that enables to generate a change. (d) The means, action, or intervention, is or seems to be attainable or feasible to be carried out by the educator from his/her professional attributions. (e) Technical: Refers to instructional, practical or organizational aspects of teaching. (f) Practice: Refers to contextual issues of teaching. (g) Sensitizing: Refers to social, moral, ethical, or political aspects of teaching.

Table 3. Problem analysis matrix (fragment).

Nº	Initial problem definition	Problematic situation[1]	Purpose[2]	Means[3].	Feasibility[4]
1	Students have lost their creative ability.	Students' lack of abilities	No	No	Does not apply
7	Difficulty starting classes. Normalize at start-up. Take as little time as possible and help students understand the value of time.	Difficulties to start class due to students' behaviour	Help students understand the value of time	Normalize at the beginning of the class in the shortest time possible	Yes
10	Be creative to plan entertaining, motivating classes and, the main thing, that my students learn.	No	Achieve or improve student learning	Plan fun classes	Yes
15	Creation of material, design of a class.	No	No	Creation of material, design of a class.	Yes
18	In 7th grade, we are in the process of designing and researching digital models for ecological housing. We rely on SketchUp software.	No	No	No	Does not apply

Note: *Problematic situation*[1]: refers to a negative, incomprehensible, worrying, or uncertain situation that is expected to change. *Purpose*[2] that is expected to be achieved to solve the problem. *Means*[3] are the action(s) or intervention(s) that would enables to generate the expected change. *Feasibility*[4] the actions or interventions are or seem to be possible be carried.

following: lack of interest (№ 8), motivation (№3 and 4) or creativity (№1) of the students; problems of 'normalisation' (behaviour) of the students that affect the beginning and development of classes (№7 and №13); the presence of students with different characteristics and educational needs in the classroom (№9), and the lack of pedagogical innovation in the school system (№6). Of the five remaining problems, three referred to contextual problems at the school level or the educational system that teachers cannot change by the attributions of their position and role, for example, a large number of students in their classes, excessive workload, and almost no time to plan their lessons (№ 2, 14 and 16), and two problems referred to very complex social problems that far exceeded the possibilities for teachers to intervene, such as the social and economic vulnerability of their students' families (№5 and 12). Five problems did not refer to any negative or uncertain situation that needed change. Among them, two

alluded to quite broad and unspecific pedagogical purposes, such as 'planning enjoyable classes' (№10) and 'generating pedagogical strategies to improve learning' (№17), and three did not even refer to a possible intervention or purpose at all (№ 11, 15 and 18).

Of the total number of problems, only five stated goals or purposes that the teachers hoped to achieve (№3, 7, 9, 10, and 17), for example, capturing the attention and maintaining the students' motivation throughout the class (№3). In general, these purposes were feasible to achieve through interventions done by the teachers, although some were raised comprehensively and generically, such as 'that my students learn' (№10) or 'improve learning' (№17).

Of the total number of problems, five referred to specific means or actions within the sphere of attributions of the teachers (№7, 10, 11, 15, and 17), such as 'normalising' the course at the beginning of each class and in little time (№7), plan entertaining classes (№10), general pedagogical strategies (№17). However, two of them did not allude to any problematic situation or purpose to which these actions were oriented, for example: 'evaluate with criteria and achievement levels and convert to grades from 1 to 7' (№11) and 'creation of material, and design of a lesson' (№15).

Only two problems (№3 and 9) were stated in more complex terms to reflect contextual elements of the situation within which the problem might be resolved and refer to a purpose expected to be achieved. One of them (№3) was also structured as an open question, which suggested the possibility of devising possible solutions.

In more substantive terms, the problems raised by participants in the first session emerged mainly as complaints about the conditions they generally face in their teaching work, whether at the level of students or their families, as well as the school or the educational system. Some of the problems refer to the context and the purpose expected to be achieved. References to the means or actions were only sometimes accompanied by a purpose, which could demonstrate little reflection or reflection that remains at an implicit level.

How might a design-based approach contribute to framing and reframing teachers' pedagogical problems in a reflective, contextualised, and practicable way?

To observe how the design thinking approach triggered participants' reflective problem-framing, we organised the data of the five selected participants according to the moments in which each new problem-framing definition appeared for each case. We developed a digital visualisation of this process using a Miro board (https://www.miro.com/) to compare each trajectory, as the participants identified critical moments and methods during the programme that influenced their reflective process with a focus on the iteration between problem and solution. We identified codes in text fragments, organised them into emerging categories, later grouped them into themes, and found the following implicit patterns: (a) collaborative discussions: engagement in collaborative activities through iterative and productive discussions, which gave teachers new perspectives by looking at their problems from different standpoints. (b) Awareness of people and their context: understanding the problems through the perspective of people involved and considering the context favoured more adequate definitions of problems; and (c) visualising, making, and testing ideas: using visual resources supported several reflection, discussion and

Table 4. Codes, emerging categories and themes.

Extract or quote/field observation	Descriptive code	Categories	Framing trigger/ description
'Initially I tried to formulate a very limited and precise problem, then *with talks with others* in the school *I realized (. . .)*' (K)	Talk with others	Sensemaking through dialogue with others	*Collaborative discussions*
´Then *together we create a common thought* that goes far beyond individual thought' (C)	Create a common thought	Getting a common understanding of the problem	
'Incredible when we give ourselves the chance of *incorporating others in our process, in my case, it gave me new ideas* (. . .)' (G)	Incorporate others' perspectives generates new ideas	Including others´ perspectives broadens the vision of the problem and enhances creativity	
'I realised after the workshops that in my meetings with my team *I had a new perspective, another way to analyse . . . '* (K)	Discussing with others broadens the vision of the problem		
'It was a bit of thinking, reflecting, listening to *what the teachers were saying in their comments and trying to understand* (. . .)' (K)	Understanding the concerns of the people involved in the problem	Considering the context and sensemaking with people involved in the problem gives new perspectives on the problem.	*Awareness of people and their context*
' . . . Putting myself in the place of another, (I wondered) *why do they feel this way?*' (K)			
Using graphic organizers and memos, teachers could establish relationships between different elements of the problem and think of possible interventions to solve the problem (Fieldnotes researchers).	Visually reflecting on the problem		*Visualising, making, and testing ideas.*
Showing thoughts and ideas through visual and physical models with others facilitated discussion and generated opportunities to incorporate new perspectives and a new understanding of the problems (Fieldnotes researchers).	Using models to generate discussion and incorporate other's perspectives		
'What I liked best was *jumping into action*, not getting stuck in thinking (. . .) Go ahead, *no matter if you do not have everything tidy, all calculated, it is going to work as a way to give order to the topics in time'*. (W)	Testing possible interventions in the real context is a way to better understand the problem		

Note: The four columns in the table present: the extract or quote or field observation, the descriptive code, emerging categories and finally, the problem framing trigger.

ideation dynamics. Prototyping possible interventions in the natural context specified teachers' problems and solutions in an iterative reflective cycle. Table 4 displays representative examples of each pattern.

While analysing the data we collected, we identified the implicit patterns described above. However, we also noticed that each participant's implementation had unique particularities and differences. The way they framed and reframed their problems was influenced by several factors, including their past experiences, teaching styles, personal flexibility, and problem types. To illustrate these particularities within the described patterns, we would like to share some examples in the specific context of the participants.

Karina's empathy journey

Karina's approach involved gradually developing empathy for the team she led at her school. She was a foreigner and had cultural communication obstacles, especially with language. She initially framed her problem as follows: How could we accompany the teachers to provide support in the precise moment of everyday situations in the classroom? Discussing with peers during the sessions, she realised that she had never thought about the problem from the teachers' perspective: 'I discovered that we have to think about how we operate as a school, our structures, and processes. After the first session, she returned to her school to inquire about the teachers' and coordinators' reactions when evaluated in person during their classes. This was her first time approaching them to ask about their feelings: 'I realised after the workshops that in my meetings with my team, I had a new perspective, another way to analyse and view how we are living, and much about putting myself in the place of another, why do they feel this way?'. During session 2, her peers suggested including the terms: 'communication', 'support', and 'confidence' in her problem framing. She considered generating a more direct, efficient, and empathetic communication channel with her team. Her problem formulation evolved to the following: *How can we develop relational confidence between the leadership and teachers to build a community of learners/apprentices?* A relevant moment for Karina was when she created her Visual Learning Path Timeline. This visual tool helped her make sense of the experience by reviewing her process and supported her planning to define her ultimate purpose and future actions (Figure 2).

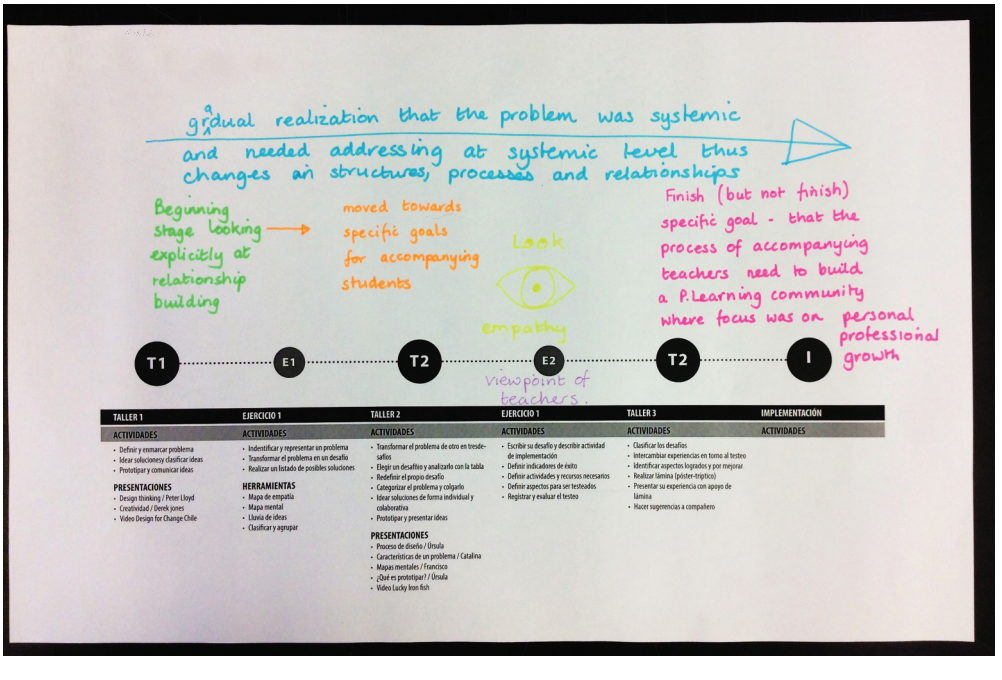

Figure 2. Karina's visual learning Path timeline.

Carolina's collaborative experience

Carolina engaged in collaborative discussions resulting in a shared understanding of her issue. She was concerned about the low scores that 4th-grade students obtained on national standardised reading comprehension tests. Her initial problem was: *How could we teach reading comprehension in a 4th-grade class while attending to the different levels of learning?* Initially, she was centred on the students. However, later she changed the focus to the teachers framing the following problem: *How could we provide 3rd and 4th-grade teachers with diversified strategies to improve reading comprehension to implement with their students according to their levels of learning?* This new problem framing placed her in a more active position to intervene, giving her agency as a coordinator within the problem context. She reflects: 'Surely if the process had been done individually, I would not have noticed (. . .) because in my mind it was clear, but it was not expressed in that way. My colleagues made me notice that'. Carolina utilised a tool called memoing, displayed in Figure 3, to brainstorm potential solutions with the help of her colleagues. 'This working methodology helped me a lot; it is dynamic and democratises ideas. That has an incredible value considering that in working groups, especially with teachers, there is often a tendency to monopolise thought, and there are always power groups operating'.

Fabiana's reflection in action

Fabiana initially focused on two broad and challenging issues to grasp in a problem definition: the motivation of the students and the need to work with the families to promote better behaviour. She started thinking about ways to change the lack of respect

Figure 3. Carolina's brainstorming process by memoing. **Alt Text**: Carolina used memos to brainstorm her ideas about activities that could be done to develop strategies to enhance reading comprehension in students.

among students: *How could we teach children the importance of respect so they can internalise and act accordingly?*

In the second session, her colleague proposed focusing on challenges limited to the classroom context to encourage companionship and teach them the importance of respect. Her colleague pointed out that behavioural changes take time and effort to achieve. Fabiana returned to her classroom and tried short activities with her students to test their engagement.

When we observed Fabiana in her school, she showed an advanced ability to test interventions in her classroom to try to understand her problem clearly. She performed short exercises that enabled her to change the direction of her solution several times. She did this by reflecting in action while performing the activities.

In the third session, she reframed her problem by rethinking the recipient and the purpose. She evolved to focus on improving the coexistence of the class through systematic work with students. Fabiana re-frames her challenge: *How could we implement solutions in the classroom to achieve a good coexistence among students?* This new question led her to focus on developing empathy in her students by connecting them with the realities of the school service personnel and motivating them to design solutions in her Technology class.

In summary, Fabiana's problem evolves in various dimensions, from a complex and difficult-to-approach social focus to a situational or practical focus related to contextual aspects of teaching. Throughout the programme, the problem also evolves regarding the definition of the ends (recipient and purpose) and the means (feasibility and viability).

Will's iterative prototyping and testing

Will's first approach to his problem was vague, his main goal was to encourage personal work and joy for learning in his students, but it was not focused on his subject: *How can we encourage personal work and motivation for learning?* During the framing and reframing exercises in session 2, Will appreciated the suggestions of his colleague teachers, which helped him view the problem from a different perspective: 'The contribution of my colleagues helped me adjust the definition of the problem. For example, after I received their suggestions, I reformulated the problem focusing on autonomy but through collaborative work': *How could we improve students' work in the classroom in history class to achieve autonomy and learning for all?*

Although group or collaborative work between students does not appear literally in the wording of the problem, in session three, Walter mentioned that his colleague's suggestion to work autonomy through group activities had been an 'aha' moment which mobilised his ideation process.

Unlike many of his colleagues, Will was directed towards action from the beginning of the programme, choosing to develop ideas and test them in the context of his class permanently. This way, prototyping and testing allowed him to make mistakes early and move forward. Using visual thinking techniques during collaborative work was significant in Will's case as he could use them to explain his vision to others and receive feedback. Figure 4 shows one of his activity plans.

Finally, his problem framing evolved to: *How can we implement varied activities in history classes to enhance autonomy in the students?* The consideration of creating various activities arose after he tested his first activity with students in the school context.

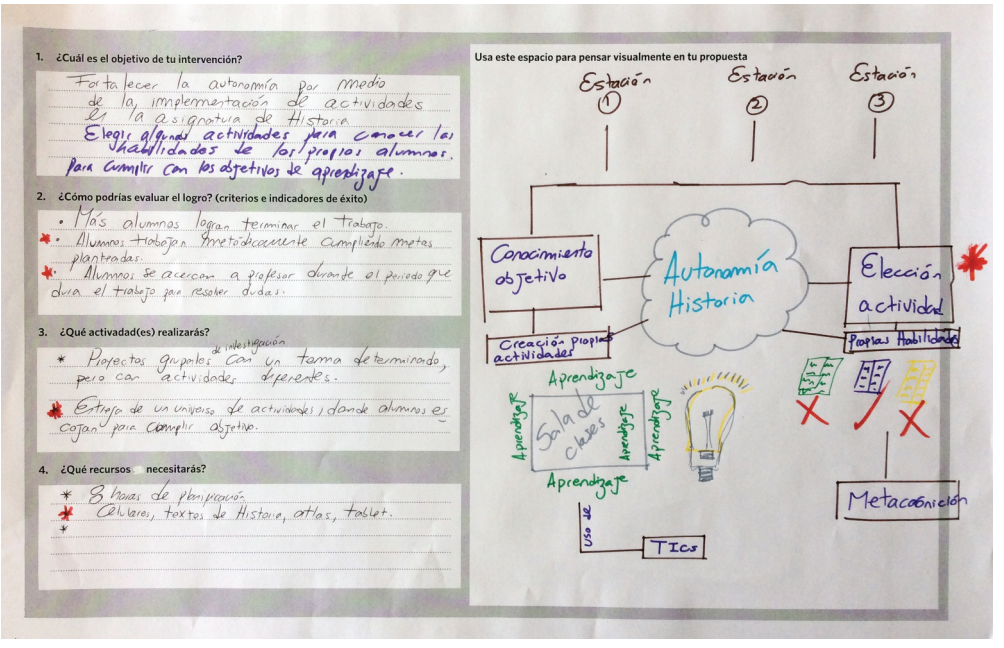

Figure 4. Will's diagram to reflect, create and prototype an activity with his students. **Alt Text**: Will developed this diagram to imagine a system of related activities during his history class. He was focused on promoting autonomy while doing group activities.

Discussion/Conclusions

Understanding how teachers define, frame, and reframe pedagogical problems considering the high demands currently faced in their practice, is essential to transform pedagogical issues into actionable solutions for specific contexts. Besides, it can guide teachers' training and professional development programme designing. This study builds on prior research (Carroll et al., 2010; Goldman et al., 2020; Henriksen et al., 2017; Jordan, 2016; Koh et al., 2015), deepening teacher reflection and providing evidence regarding the effectiveness of using a design-based approach to frame pedagogical problems. It adds empirical evidence to exemplify how these approaches can structure and support teachers in the reflective process of framing and re-framing their problems, imagining pragmatic changes in response to them, and using reflective methods to create such change.

As a case study, its results cannot be generalised from the participant's experience to a broader population due to the particularities of the context and the number of participants, it is not easy to replicate due to its exploratory approach, and researchers' subjectivity may have influenced interpretation. Nevertheless, it provides evidence about how design-based programmes can support Chilean school teachers in framing their problems and expanding their field of action towards a more professional practice (Darling-Hammond & Bransford, 2005; Kramer, 2018; Ruffinelli, 2016).

Design thinking facilitated deep reflection on the complexity of participants' teaching problems from different perspectives, levels, and scales (Collin & Karsenti, 2011; Leijen et al., 2012; Williams, 2020). Framing and reframing problems

reveal a reflection oriented towards doing that produces and guides action while decomposing and evidencing the complexities of each challenge. An endless cycle in which the process followed to understand a problem is the same as the one to solve it. In this sense, it is not only a reflection-in-action or on-action but an abductive reflection that conjectures potential future actions, like the abductive reasoning process of designers (Cross, 2013; Dorst & Cross, 2001; Kolko, 2011; Schön, 1983).

In the first session, teachers defined vague, general problems; some were complaints about the educational system, the conditions of their work, or the students. Only some included the purpose of achievement or the context in which the problem was inserted. The following sessions provided techniques explicitly to support reflection and untangle their concerns. Activities led teachers to reframe their problems by systematising and structuring a design process. The ability to speculate and make conjectures, fundamental to all design processes, shifted from being blocked by complaints to a range of alternative framings and points of view that expanded both the problems and, thereby, the potential action teachers could take.

Three essentials 'problem framing triggers' that promoted advancement towards feasible and precise redefinitions of their problems were found: (a) *collaborative discussions*, (b) *awareness of people and their context*, and (c) *visualising, making, and testing ideas*. Combined, they articulate action through a permanent dialogue between the problem and the solution.

Our findings support the idea that design approaches and activities have significant potential to develop professional teaching practices (Carroll et al., 2010; Goldman et al., 2020; Henriksen et al., 2017; Koh et al., 2015). Similarly, the reflective practices of design (Schön's *reflective practicum*) were evidenced throughout our study. This included reflexive and reflective thinking, mainly the social and community reflection between professional peers. Coincidently, the three-phase reflective cycle proposed by (Williams, 2020) is structured similarly to the general design process models considering the initial framing of a perceived problem, the understanding of the situation in new ways, and the resolution of the problem in a way that can be reconsidered. Critically, how these elements combine in design practice marks the expert design professional (Cross, 2006, 2013; Schön, 1983). That is the intertwined relation between collaboration, reflection and action; the negotiation and switching between problem and solution; and reflective practice oriented towards action and mediated by collaboration through an iterative, abductive reasoning process. Each of these is evidence of the early stages of the development of design expertise. Seeing these emerge in the teacher practitioners in this study demonstrates the approach's potential.

As we hypothesised, using a range of design activities and methods can be a fruitful way to support teachers in reflecting and solving teaching problems. As the programme developed, we observed that teachers progressively gained a more playful, creative, and explorative attitude (Jordan, 2016), following the design process structure to reflect on their teaching. They embraced the opinions and contributions of others and learned to accept failed attempts to reach feasible solutions as part of their learning. Participants added perspective to their teaching practice broadening the understanding of their problems, and sometimes discovered, through reflective practices, that problems were clues to more significant and complex issues (Goodyear, 2015; Mintrop et al., 2018).

This study is a starting point to understand how design-based approaches support teachers' reflection and professional autonomy. Further research could include a more significant number of participants, online resources to reach them, and a more extended intervention period.

Notes

1. According to Simon (1996), all professionals 'design' when carrying out actions to change existing situations into preferred ones. Drawing on Simon, Schön (Schön, 1998) argues that the concept of design has expanded from architecture, urbanism, engineering and product design to other professions also concerned with changing a current situation into preferred, future and imagined ones.
2. The Hasso Plattner Institute of Design at Stanford University.

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