Chapter 6
Lesson Study in Chile: A Very Promising but Still Uncertain Path

Soledad Estrella, Arturo Mena-Lorca and Raimundo Olfos

Abstract Lesson study was introduced in Chile in 2006. After a specific educational agreement between the ministries of education in Japan and Chile, some of the Chilean ministry's specialists and academics involved in teacher training programs in Mathematics received specific training on Japanese methodologies at the University of Tsukuba. Upon their return, the trainees became involved in reformulating in-service teachers' development programs. Also, a number of renowned specialists from Japan offered public lessons in many places in Chile, so that local teachers could observe lesson study and the open approach for problem-solving strategies. There were promising results, but a change in the nation's government translated into a rather abrupt lack of funding and most of the activities faded away. However, some institutions are still working with the methodology and are expecting new opportunities for a new national strategy to develop.

Keywords Lesson study · Chilean education · Educational policies
Professional development of teachers · Statistical education · Open ended approach

6.1 Introduction

In some countries, lesson study groups have formed spontaneously in different places. The evolution of such groups is varied and is shared and evaluated in ad hoc meetings. In those countries that are comparatively less developed in education, the introduction and development of lesson study tends to be the fruit of a specific cooperation of the Japanese Ministry of Education (MEXT) with the ministry or

S. Estrella (✉) · A. Mena-Lorca · R. Olfos
Institute of Mathematics of Pontificia, Universidad Católica de Valparaíso, Valparaíso, Chile
e-mail: soledad.estrella@pucv.cl

A. Mena-Lorca
e-mail: arturo.mena@pucv.cl

R. Olfos
e-mail: raimundo.olfos@pucv.cl

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secretary of education of the given country. This is so that a direct intervention in the educational system can be carried out with the collaboration of the Japanese International Cooperation Agency (JICA). This usually includes curriculum modification, specific training for local teachers with the support of Japanese experts, and the elaboration and distribution of textbooks (Isoda, Arcavi, & Mena-Lorca, 2012).

For the last 10 years a somewhat different path has been followed in Chile. In this chapter we report on the introduction of lesson study in Chile and the work of the institutions that stand out the most in this effort. We also review what has been learned in these years, as well as the possible future development of lesson study in Chile.

6.2 Lesson Study in Chile

Lesson study in Chile began in 2006. Chile is a lengthy country, over 4000 km long. It has 17 million inhabitants and over 20 universities that grant teaching degrees (Agencia de Calidad de la Educación, 2016).

Due to its interest in education progression and in joining the OECD, the country had solicited a comprehensive study of Chile's educational situation from the OECD; the results were officially provided in a report (OECD, 2004, 2009). The report provided relevant information in various respects: (1) initial teacher training was too general, lacking in sufficient knowledge of the disciplines that would be taught; (2) the disciplinary and pedagogical aspects were conducted along considerably disconnected paths with the hope, disproven by the data, that future teachers would make a harmonious synthesis of both; (3) the induction of new teachers into the educational system frustrated the eventual intents at innovation that their initial formation invited them to try, both because of the establishment culture into which they were being incorporated and because of the isolation in which they found themselves with respect to their peers; (4) educational research was scarce and did not have a great impact in educational policies; and (5) mathematics and science in the first half of secondary education were taught by teachers who didn't know the material well and lacked confidence in their own ability. It is interesting to consider already how the lesson study methodology allows for dealing with each of these elements of the diagnosis.

The following year the Global Forum on Education, organized by the OECD, took place in Santiago, Chile. On this occasion, representatives from the Japanese Ministry of Education (MEXT) and the Chilean Ministry of Education (MINEDUC) met and signed a collaboration agreement regarding the issues in the OECD Report. The agreement established the program of collaboration 'Improving Mathematics Education in Chile, with the Support of Japan' (with Mathematics considered especially delicate in the Report). Over the course of three years, this would allow for a total of three groups of 10 mathematics professors involved in initial and continuing teacher education from a total of 11 universities, and two

officials from the MINEDUC Center for Pedagogical Improvement, Experimentation, and Research (CPEIP) to travel to Japan to attend intensive courses of training in Japanese methodologies of lesson study, the Japanese open approach to problem resolution as well as other aspects of the Japanese educational system (Mena-Lorca, 2008). Once they returned to Chile, CPEIP would draft terms of reference in harmony with what was learned in Japan for post-graduate diplomas in continuing education in mathematics, and the participating academics would design corresponding programs for their respective universities according to the terms of reference. MINEDUC would finance the work of those teachers who had participated in the approved post-graduate programs.

The program was financed by JICA and carried out at the University of Tsukuba Center for Research on International Collaboration in Educational Development (CRICED); and in Japan Prof. Masami Isoda was in charge. The courses included the observation of classes at different levels, participation in public classes and in lesson study cycles; visits to continuing education centers for teachers, textbook publishers, and producers of teaching support materials; and meetings with representatives from diverse areas of the Japanese educational system. The kindness of the hosts also allowed the Chilean guests to learn about other aspects of Japanese culture.

The participants learned Japanese teaching methods, in particular the open approach to problem-solving (Nohda, 2000). Additionally, they learned about the general system of education in Japan and its intricate, participative, and well-regulated structure, which includes continuing teacher education, curriculum development, and the publishing of textbooks (Isoda et al., 2012). The participants were able to observe that the professional development of teachers is the fruit of a collaborative effort in which the teachers play an active role.

After the program participants arrived back in Chile, they began to carry out diverse initiatives related to lesson study. First, as planned, the CPEIP professionals made suggestions for modifying the terms of reference for post-graduate diplomas financed by MINEDUC, including lesson study in particular, while the participating academics became involved in their respective universities' projects and in the implementation of these post-graduate diplomas. Additionally, each year of the program and every subsequent year, Dr. Isoda and expert teachers from Japan (K. Tsubota, Y. Hozomisu, T. Seiyama, and others) would visit Chile and teach Mathematics public classes to Chilean children at the universities of the participating academics throughout the country.

CPEIP also developed additional activities, one being a series of county workshops for primary school teachers which focused either on Language or Mathematics. The other would be the beginning of a life-long learning program dedicated to creating teacher leaders who are also working teachers and who can give workshops for preschool and early primary school teachers in their educational establishments. These workshops were aimed at designing, carrying out, observing, and analyzing a class following the lesson study methodology. About 300 schools worked on these methodologies.

Additionally, during the four years there were at least a couple of meetings every year for the evaluation and monitoring of the collaboration program. This involved all participants including in situ or virtual participation by Prof. Isoda, the director of the program from CRICED, and members of JICA—in whose Santiago office the meetings were held. There was a formal closing of the program in September 2009, a ceremony that was attended by the Chief Representative of the JICA office in Chile, other office personnel from JICA, the Chief of the General Education Division of MINEDUC, the director of CPEIP, and Prof. Isoda.

The internal evaluation of the program was communicated and commented on during the closing meeting. Both the CPEIP and the participating universities valued the contribution of the program to the primary mathematics education in Chile.

There was also a program evaluation carried out by an external organization, with equally positive results. Its recommendation was to continue the lesson study initiatives in Chile and maintain the academic exchanges with the University of Tsukuba. It proposed that the CPEIP assume greater leadership and take advantage of instances such as county workshops, the network of 'teacher teachers' (leading teachers) created by MINEDUC, and its e-learning platform in order to expand lesson study in the country. Its recommendation to the universities was to systematically employ lesson study and an open approach to problem-solving in initial and continuing teacher education, to establish agreements with local school boards, and to incorporate lesson study and the open approach to problem-solving in its research and extension programs.

With the positive evaluation of the program together with the OECD diagnosis mentioned earlier, it was deemed appropriate to continue with the continued education diplomas and even to increase their number, as there were only around 20 teaching institutions involved that provided classes for a significant percentage of a total of 63,000 teachers (cf. Sanchez et al., 2013). However, in March 2010 the government was replaced by another with a new orientation and the implementation of the post-graduate diplomas was suspended. In their place, the Singapore method (Lee, Goh, Fredriksen, & Tan, 2008) was developed (apparently without the consideration that both methodologies could be used together).

The activities at most of the participating universities became progressively less, including at some of the other institutions that had joined in the implementation of the methodologies due to the program's influence. Two institutions stand out because of their permanent development of the Japanese methodologies and development of local theory: the Pontifical Catholic University of Valparaiso (PUCV) and the Catholic University of Maule (UCM), both with their headquarters outside of the capital. A characteristic that both these institutions share is that when the program of collaboration with Japan began, they were the only institutions in the country that offered master's programs in Didactics of Mathematics.[1] We report in greater detail on the PUCV below.

[1]Currently, there are half a dozen such programs in Chile.

In the UCM, the team of researchers in Didactics of Mathematics elaborated and implemented successful post-graduate programs with a great impact in the region. Additionally, in 2007 it created the 'Lesson study Days' and later organized several of these events, which were carried out jointly with several other universities and in collaboration with the CPEIP. At these events, MINEDUC professionals and academics who had participated in the program of collaboration gave conferences and workshops and reported on ongoing research.

Separately, a group of academics from the University of Antofagasta incorporated various problems and documents regarding lesson study centered on problem-solving into their web pages. Also, the Center for Advanced Research in Education (CIAE)[2] proposed two lesson study projects to the National Fund for Scientific and Technological Development (FONDECYT), which were accepted by FONDECYT. One of these was the work of a researcher from the University of Chile titled 'Integrated Public STEM Classes', which also included work from a Chilean lesson study researcher and invited Japanese experts. Additionally, Santo Tomás University, a private university with campuses in 14 major cities in Chile not participating in the program of collaboration, received training from an academic from the PUCV, and disseminated the methodology and incorporated it into both its program of initial teacher training and into the professional development of its pedagogy academics.

After the change in government, professionals leaving the CPEIP who received training in Japan during the program of collaboration led various projects that included the implementation of the lesson study strategy in classes from kindergarten to fourth grade in language and mathematics, in order to improve classroom practices and positively contribute to students' learning. To do so, workshops were developed with teachers where the teachers met in groups, with each group in charge of designing a class with relevant material. One group member was chosen to implement the class, observing the class in situ or, if necessary, remotely, and analyzing the class in order to determine difficulties and make adjustments to redesign it.

6.3 Lesson Study Based in the PUCV

Four academics from the PUCV Mathematics Institute participated in the program of collaboration between Chile and Japan. They have all used this training in their work within the institute and also in their relationships with schools. Two of the academics, authors of this chapter, continue to be active in this work. Additionally, various other academics from the PUCV have joined the effort based on their respective activities.

[2]The CIAE is an institution created by the University of Chile, the PUCV, and the University of Concepción (located in the southern part of the country). The authors belong to the institution.

The goals are: that lesson study be the object of research; to document the impact of lesson study in teachers' professional development and more generally in the country's mathematics education; that the methodology be part of initial and continuing teacher education; and that its use be disseminated throughout the country and where possible throughout Latin America.

It begins with an explanation of how the institute approached lesson study, it continues with a general overview of what has been done, and ends by showing two classes prepared using this methodology.

6.3.1 Lesson Study in the Institute

The philosophy of the PUCV Mathematics Institute in education comes from its development of didactics of mathematics (DM), as it offers the only doctoral program in DM in Chile and neighboring countries. The institute tries to pay attention to both the development of science and to international experiences, but its focus is always on the need to acquire one's own experience and to develop theory as a way of addressing the country's problems adequately and autonomously. A natural consequence of this philosophy is that the PUCV academics who participated in the program tried to connect lesson study with the research they were developing.

The institute understands DM as an experimental discipline, with explicit theories and methodology—such as the Theory of Didactic Situations and the Didactical Engineering (Chevallard, 1992; Douady, 1995)—that come out of reflection, study, and the search for evidence based on the phenomena that occur when people teach and/or learn mathematics. This has allowed for uncovering and dealing with a series of phenomena which had remained hidden to general mathematics education research (Douady, 1995). It also considers DM as a solid bridge that in a disciplined way unites the general pedagogical and mathematical aspects in play in learning and in teacher training, such as in the Mathematics Work Space frame (Montoya, Mena-Lorca, & Mena-Lorca, 2015).

The institute had studied and utilized the Didactic Engineering (DE) methodology of French origin, which appeared in DM in the 1980s (Douady, 1995). DE is considered fundamental to DM (Artigue, 1995) and has its origins in the consideration that the habitual methods of research in mathematics education are insufficient for dealing with the complexity of the problems that occur in a classroom (Artigue, 1995). Additionally, these methods are part of a determinist logic that runs the risk of ignoring the concrete functioning of a 'didactic system' constituted by students, teachers, school, mathematics (Chevallard, 1985), and whose validation is external based on the statistical comparison of the performance of experimental and control groups (Artigue, 1995). On the contrary, the validation of DE is essentially internal: the hypotheses formulated in research are based on the confrontation between a priori and a posteriori analysis, as defined by Artigue (*ibid.*). DE considers four stages (Artigue, 2009). 'Preliminary analysis' includes the epistemological study of the contents under consideration, its habitual teaching

and its effects, students' conceptions, the difficulties and obstacles they face, and the field of restrictions in which effective didactics will be carried out, etc. In 'conception and a priori analysis' of the didactic situations (Brousseau, 1997), the researcher decides to act upon the variables the teacher controls and that the researcher perceives as pertinent in relation to the problem being studied. The next phase is 'experimentation'. In the 'analysis a posteriori and evaluation' stage, the data collected in the experimentation stage is reviewed and often completed with others obtained through the utilization of external methodologies.

The researchers at the institute have reflected that DE, as well as some theories of DM, have what they call an 'epistemic vigilance device', which is there to ensure that the study is carried out without falling into unfounded speculation. As it is easy to see, lesson study possesses an analogous device with stages similar to those of DE (Miyakawa & Winslow, 2009), and the most noticeable difference between them is the purpose of research on one hand and the purpose of professional development on the other.

It is based on this perspective of studying and articulating DE and lesson study that the PUCV undertook its participation in the activities of dissemination and development of lesson study (also Clivaz, 2015). This participation aims at taking advantage of the theoretical and practical perspective that is part of the habitual instruction in undergraduate and graduate studies in education in the institute, in such a way that lesson study can also feed off of these elements. Thus, institute alumni could integrate both theoretical-experimental elements of Didactics of Mathematics and methodological elements of lesson study, so that in their in-service performances they would be able to use them in their own professional development and also to offer them to their peers.

6.3.2 Programs of Study

Since 2006, in the post-graduated diplomas of professional development—which were related to the program of collaboration between Chile and Japan and financed by the CPEIP until 2010—some elements of DM and lesson study have been offered. The teachers also work collaboratively in classes following the lesson study methodology.

At the same time, the master's degree in DM that the institute offers was changing its orientation to be less focused on research and more focused on professional development. It was decided that the students' final projects should use the lesson study method. In the third semester (of four), they are trained in lesson study and they work collaboratively in a lesson study process. During the fourth semester, they work on their individual final projects utilizing the lesson study experience and going into greater depth in some theoretical aspects, whether in mathematics, professional development, educational extension efforts, student learning, or some other topic.

In Chile, each teacher's training program is decided by the university (or sometimes other institutions) that offers it. In the case of Mathematics, the proportion of general educational and mathematical subjects varies. At the institute, students also receive training in DM. Since 2012, the curriculum includes elements of lesson study in combination with the last semester graduation activities; the 'Mathematics education workshop' and the professional practicum have been based on lesson study.

Lesson study is also a topic of study in the doctoral program in DM at the institute, which has existed for six years and has approved three theses that consider lesson study as a tool for study and intervention.

6.3.3 Research and Development

Several academics at the institute either direct or participate in projects financed by the government that utilize lesson study as a strategy for research and development. Their topics deal with teaching statistics, teaching mathematics in preschool and primary school, and tools for initial teacher training.

Currently, there are two doctoral theses in process regarding lesson study: one related to improving initial training in integral calculus, and another related to the professional development of working teachers.

Since ending their stay in Japan, the authors have also been participating in the successive instances of a long-term project financed by APEC and directed by the University of Tsukuba in Japan and the University of Khon Kaen in Thailand.

Recently, the project has dealt with emergencies and preparations for future disasters, which has led to the institute elaborating classes that make reference to earthquakes, tsunamis and fires. We comment on one of these efforts below.

6.3.4 The School System

The transfer of lesson study to the school system has been tried in a number of diverse ways. In 2007, academics from the institute presented the annual project 'County Workshops' to MINEDUC, which financed it. MINEDUC had been carrying out a project in which it highlighted the leading teachers (the 'teacher teachers') in counties throughout the country. The PUCV project consisted of providing lesson study training for more than one hundred of these teachers, from all over the country. They were convened for three periods of training in Valparaiso and Santiago, where they learned elements of DM and worked collaboratively on lesson study. On returning to their home counties, they disseminated the methodology and led the preparation of classes in teams. There was also an online support platform. Once the training periods were completed, the academics who led the workshops visited the teachers trained in the methodology, who were spread out

over 3500 km, to observe the progress of the classes whose preparation they had led in their respective counties. The work was being carried out as planned but it ended up abruptly with the change in government.

Lesson study groups still continue in schools where they began several years ago. This has occurred in three different ways. One is that a lesson study group has been formed spontaneously in a school but receives support from the institute. Another is that graduates from the post-graduate diploma have solicited support to start a lesson study group in a school in another county, a group that expands to a group of schools and eventually to specialties outside of mathematics—a primary school teacher graduated at the institute leads a multidisciplinary group at her school. The third is that an academic has introduced lesson study in a school and leads a group of teachers in that establishment.

6.3.5 Dissemination Activities

Thanks to generous invitations from Prof. Masami Isoda, the authors up to now have been visiting scholars at the University of Tsukuba and have written several books. One such book describes lesson study and the open approach to problem-solving from various perspectives (Isoda et al., 2012). It is a commented version of an original Japanese text that continues with experiences carried out principally in Chile and in other Latin American countries (which were accumulated over the course of three successive editions) and analysis of public classes taught by Japanese teachers in Chile. Another is about teaching under an open approach to problem-solving (Isoda & Olfos, 2009), and the third is about teaching multiplication (Isoda & Olfos, 2011). These books have been distributed in various Latin American countries and have been used in courses for introducing teachers to the lesson study methodology.

Additionally, together with another researcher from the CIAE, a book on mathematical thinking and its development in the classroom (Isoda & Katagiri, 2014) was translated. The authors also collaborated on Spanish versions of Japanese primary school textbooks published in Mexico (Isoda & Cedillo, 2012).

Beginning in 2006, a dozen public classes were organized in the region with visiting Japanese teachers, and later more public classes were elaborated by Chilean teachers and academics from the institute.

Additionally, the authors as a group have presented conferences about lesson study in more than 20 universities in Chile and in half a dozen other Latin American cities. Another important activity is the permanent presence in national and Latin American conferences, from Argentina to Mexico, in which the methodology is presented and research advances are reported on.

6.4 Lesson Study and Statistics Education in Valparaiso

Here we focus on one of the lesson study groups formed around the Mathematics Institute, which develops statistics classes in preschool and primary school, and classes prepared by Valparaiso school teachers and academics from the PUCV.

The teaching proposal adopted by the teachers participating in lesson study groups in Chile has been in concordance with the recommendations of the *Statistical Education of Teachers* (SET) report of the American Statistical Association, Franklin et al. (2015) and others that preceded it (Franklin et al., 2007; Ben-Zvi & Garfield, 2004), which are to develop *statistical reasoning*, promoting the knowledge of statistical contents and pedagogical content knowledge necessary for teaching statistics. As Franklin et al. (2015) indicate, ideally, statistics education should propose the development of statistical thinking and conceptual understanding through active learning and the exploration of real data. The report recommends that the fundamentals of statistical literacy should begin in the first years of school, from pre-K to fifth grade, when student begin to develop data sense—the understanding that data are not simply numbers, categories, or images, but entities in context that vary and that can be useful for answering questions about the world around them.

Various experiences of teaching statistics have been carried out in different schools in Valparaiso with the lesson study methodology. In these experiences, the groups of teachers have integrated teaching models specific to statistics content, such as that proposed in Tukey's (1977) *Exploratory Data Analysis* (EDA) and the investigative cycle known as PPDAC (Wild & Pfannkuch, 1999), in a lesson study cycle that contemplated three implementations of the lesson over a period of two months with weekly meetings. All the lessons have been planned for a duration of 45 min and the courses in which they were implemented have an average of 35 students.

The groups of teachers and researchers have worked together in a lesson study PPDAC cycle in which they collaboratively formed the goals for the students' learning and development. The researchers have encouraged the inclusion of cross-curricular goals (healthy eating, physical activity, sleep, among others) and the awareness of Chile's climatic, geographic, and geologic characteristics, according to general recommendations given by the Chilean Ministry of Education (MINEDUC, 2009).

Each of the lesson study groups specifically planned a lesson to put the learning goals into practice. A school teacher then administered and implemented the lesson as planned, and evidence was gathered about the students' learning and development. After the lesson had been implemented, the group of teachers reflected on and discussed the evidence gathered during the lesson, using this evidence to improve the lesson and their teaching practices and to implement the lesson again (Estrella & Olfos, 2013; Isoda et al., 2012; Isoda & Mena-Lorca, 2009; Isoda & Olfos, 2011).

6.4.1 Integrating Teaching Models in Lesson Study Cycles

Exploratory data analysis and the PPDAC (problem, plan, data, analysis, and conclusions) investigative cycle were the teaching strategies that would allow the teachers to involve themselves and the students in learning experiences with data in order to develop number sense and data sense. The goal of EDA is the exploration without restrictions of the data, in search of interesting and unsuspected regularities; the conclusions obtained are informal as they are based in what is perceived in the data and are only applicable to the specific subjects and circumstances which provide the data. EDA uses numerical representations and summaries to describe the variables of a data set and their relations (Moore, 2000). Figure 6.1 shows the lesson study cycle as actually formulated (as a variation of the one given in Isoda et al., 2012), and used by the group of teachers who supported each other in their considerations regarding learning statistics and mathematics and made professional decisions in order to design their lesson plan.

The lesson's learning goals concerned the statistics domain of the mathematics subject in the Chilean curriculum for primary school, which were related to the construction of representations from data and decision making based on data analysis. As part of the process foreseen by the teachers, the students began with the exploration and ended with the presentation and explanation of their representations of the data to their classmates. All the lessons implemented by the teachers in the lesson study group have activated the students' modeling competences, which include the capacity to identify the relevant question, the variables in play, relations in the real context and the translation, interpretation, and validation of the solution with respect to the variables' context.

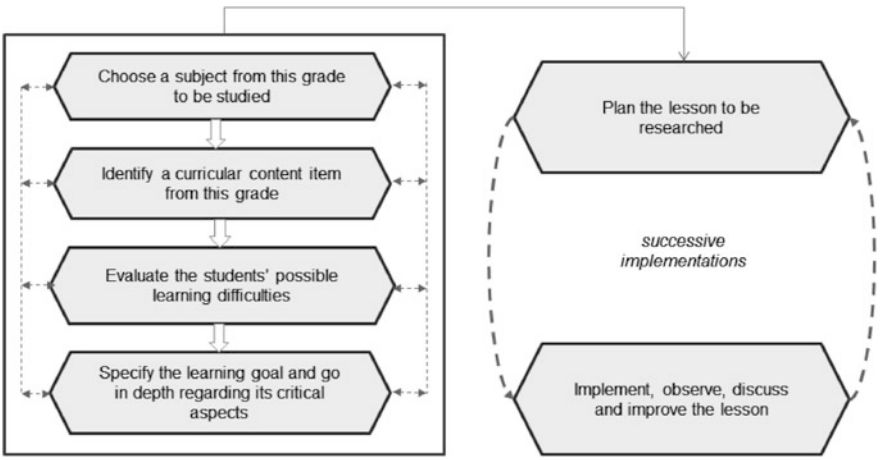

Fig. 6.1 The lesson study cycle implemented

The following details two of the statistics lessons studied. One carried was out in 2015 on the physical activities in kindergarten, and the other in the fifth grade in 2012 on the tsunami that affected Chile in 2010.

6.4.2 *Preferred Recreational Physical Activities Lesson in Kindergarten*

The preparation of the lesson was carried out by four teachers, who were all from the same school, and four researchers. The lesson's central question was, "How can we organize the data about our preferred recreational activity in order to know which are the preferred physical activities of kindergarten B?"

The lesson, integrating EDA and the PPDAC cycle, was designed by the teachers. They also created a problem situation that incorporated some of the key ideas in statistics education: real and motivating data and representations, with the particularity of being able to see the data as an aggregate (from the individual data to the group data). The students were grouped in teams of three children who organized the data, constructed representations, and argued for their conclusions with respect to the aggregate data, managing to understand data as numbers in context. This showed that some children are able to achieve statistical reasoning (Ben-Zvi & Garfield, 2004) early in the preschool classroom.

The teacher provided an environment of free work and investigation, and although not all the children in the kindergarten related the data to the question, as they could only represent part of the data set in a disaggregated manner and did not achieve the step from the individual data to group data, two of the eight groups of students were able to see the data as an aggregate and correctly graphically represent it. These six students (from a total of 27) were able to create a representation and compare the data, make a count, write the frequency and indicate the cardinal of a variable category as the frequency in order to respond to the central question and communicate it to the whole class. In Moment 1 (see Fig. 6.2) the students give evidence of categorization of the variables and therefore of implicit comprehension of the variable (the class's favorite sports activity) by showing their data representation through six activities classified by type (jumping, running, skating, bike riding, and playing both basketball and football).

Communicating to the other students of their findings and reasoning based on the representation and frequency allowed the other students in the class to be able to give meaning to numbers and data. The representation and the frequency allowed them to answer a question that they were interested in with their own preferred activities, and in doing so recognize the class's favorite recreational activity and allowing them—as previously offered—to have a special recess at class.

This experience of teaching statistics in preschool allowed the students to learn significant issues about working in groups, as well as be able to organize data and represent it, and to progressively acquire more tools for representing data. The

Fig. 6.2 Preschool pupils' data representation, and the moment a boy calculate and record frequency

participating teachers indicated that this way of working allowed them to carry out an excellent class, as one of them stated, "The students were able to organize and interpret data in diverse ways, and the vast majority participated with their own ideas and presented them to the course." They considered that the successive implementations of the lesson, two in first grade and two in kindergarten, "allowed us to improve the class proposal"—as another teacher put it. They stated that in order to "improve [the lesson plan], we planned to achieve the participation of all the children, and we changed some things [materials, question] so that they were all able to organize the data and display them in the manner they chose." This is how the idea of creating a prior class to present the question and motivate the children was born among the teachers. Also, the teachers concluded that the lesson study process allowed them, as educators, to "open their minds to mathematics", to "work as a group", and that "you can always improve what you've already worked on". One of the teachers concluded this experience of planning a class in a lesson study group as "a professional challenge that motivates me to try to carry out more classes like this, to relate the subject more with subjects that are more interesting and significant for the children, to not give them the answers and not tell them what they should do."

6.4.3 Tsunami Lesson

In February 2010 Chile was badly affected by a powerful earthquake, one that is considered to be the second largest in the history of the country and one of the five most powerful on record in the world. About 35 min after the earthquake there was a tsunami. Due to errors and indecision by those organizations in charge of sounding the corresponding alarm, the country's population was not alerted to this event. The lack of (cultural) preparation in dealing with earthquakes of such

magnitude led to more deaths being caused by the tsunami than by the earthquake. Some collective Chilean myths were that 'a tsunami is just one big wave' and 'there is a fixed period between one wave and another', which led some inhabitants to return prematurely to their homes on the coast, contributing to more deaths caused by the successive waves.

Faced with the importance of education in the face of natural disasters, a lesson study group chose the topic of the tsunami with three goals: (1) that the children 'do statistics' with representations of real data, (2) that the children learn knowledge that helps their community [helps to inform to save lives], and 3) that the teachers modify or consolidate their beliefs with respect to the notion that teaching statistics is not exactly 'teaching mathematics' but rather working with data as numbers in context (Ben-Zvi & Garfield, 2004). The lesson centered on an image (see Fig. 6.3) from a news article (Diario El Mercurio, 2012) about the tsunami that affected Chile in 2010 (Estrella, Olfos, & Morales, 2014). The preparation of the tsunami lesson was carried out by three classroom teachers and three researchers with the goal of tearing down the myths cited above. During the two month period, the lesson study group met weekly to prepare the lesson plan, test and improve it, and implement it again. The meetings of the teachers participating in this lesson study group were explicitly focused in a framework that promoted planning a class centered on a real statistical problem, fomented statistical argumentation, facilitated a space for discussion and communication of results, and favored the development of a deeper and more meaningful understanding of statistics. This was proposed with clarity and drove the teachers to maintain high cognitive demands so that the students would achieve statistical reasoning, 'doing statistics'. The researchers promoted the EDA paradigm so that the teachers became aware that a statistical analysis begins with an exploration open to discovery and ends with the presentation of the results through representations of data. This exploration involved delving deeper into the context, the knowledge of the data sources, and the inspection of the data, and in an objective public communication of the results in the real context.

In the third implementation of the tsunami lesson (detailed below), the teacher began by familiarizing the fifth grade students with the tsunami and its effects. He presented the problem, saying, "I found this image in a newspaper about the natural disaster of 2010; it has a lot of data, so I'm asking you all to organize it in a simpler way." Then the professor presented and wrote about the challenge of "extracting data and organizing it to communicate to the cities that were affected and cities that could be affected by tsunamis."

The competencies of statistically modelling the presented situation allowed both the teachers involved in the lesson study group and the students to develop the ability to identify relevant questions and the variables in play, their scale and measure to establish relationships with the real world, to translate and interpret representations, and to validate the information found in the data in relation to the situation in order to communicate it as a solution to the central challenge.

To confront the myths that had cost lives in the tsunami, the teacher handed out a copy of the image shown in Fig. 6.3 to each student. He then managed the moment of discussion and observation of the representation of data through the questions: Is

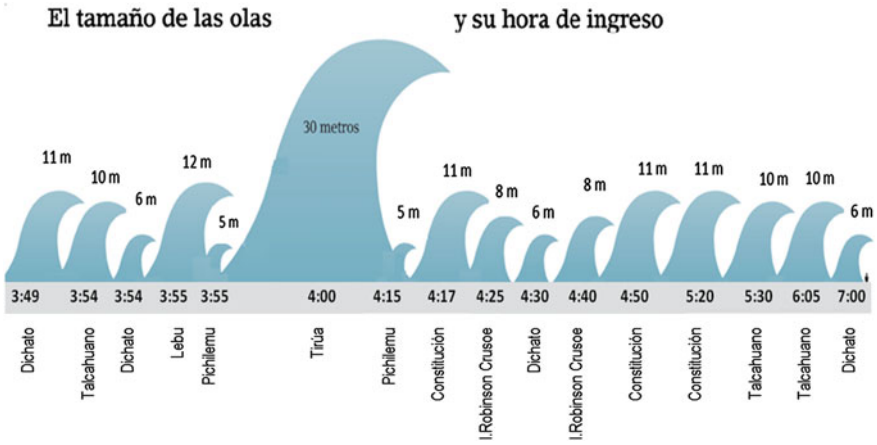

Fig. 6.3 "Size of the waves and their hour of entry" (up), by city (names down); image from Diario El Mercurio (2012), a national newspaper after the 2010 Tsunami in Chile

the number of waves per city predictable? Is the time between one wave and another predictable? Is it possible to save lives with this data? (These are open questions; the data shown in Fig. 6.3 suggest that prediction would not be accurate.).

During the lesson, all of the students constructed graphic and tabular representations of different types, explained their ideas to their classmates and argued for them. The data analysis that the students provided based on the data in the image showed that the number of waves per city was between one and five, and that the minimum time between one wave and another was five minutes, while the maximum was 180 min. With this lesson focused on tearing down myths, the teacher managed to promote informed decision making for protecting people in the face of natural disasters.

6.5 Results

6.5.1 What We Have Learned

In the PUCV we have researched what the lesson study methodology means to the teachers who participate in it and also to what degree lesson study is a response to the general diagnosis of Chilean education made by the OECD in its report (OECD, 2004). To do this, we base our work both on the testimony–either as results of questionnaires and clinical interviews—of teachers who have learned the methodology and applied it in their schools according to their possibilities, and on our own analysis of teachers' and students' learning in classes such as the ones reported on above. The relation that we make below explicitly includes the principal aspects of this report and of the Chilean experience.

- *Excessive general teacher training, without sufficient knowledge of the disciplines they teach*: The teachers declare that they learn mathematics through lesson study and that it is interesting to learn mathematics with their peers.
- *Lack of connection between discipline-specific and pedagogical aspects*: The teachers especially value that some of them know more about the discipline while others know more about the methodology of classroom management, pedagogical content knowledge, students' reactions, etc.; and they appreciate the opportunity to have discussions that do not only deal with administrative aspects of their work.
- *The induction of new teachers in the system frustrates their initiatives of innovation*: This variable is difficult to perceive directly and of course it would be necessary to have broader data. However, the experienced teachers who were consulted considered that this difficulty lies in the isolation in which a teacher works with respect to his or her peers, and they are in agreement that a strategy of collaborative work such as lesson study is the scenario that will allow for innovation and peer learning, especially in a circumstance in which there is not an evaluation they have to respond to.
- *Scarce educational research and without great impact in educational policies*: Chile has advanced significantly in educational research, and the government has financed a Center for Advanced Education in Education (CIAE), under the direction of three important universities. Although in a somewhat more limited perspective, those teachers who have had greater training in lesson study invariably ask how they can publish their experiences and collective findings to benefit the community.
- *In the first cycle of secondary education (grades 6–8), mathematics and statistics are taught by teachers who do not know the material and who lack confidence in their own performance*: While the number of teachers with lesson study training is comparatively small, they all (even those who are more proficient in Mathematics) declare that they know more mathematics after having done lesson study, independently of the level at which they work (preschool, primary, or secondary school) and that they feel more confident regarding the knowledge they are responsible for teaching.

6.5.2 Future Perspectives

The authors are convinced that allowing groups of teachers to use a few hours per week in lesson study is an alternative for professional development that greatly surpasses other strategies of continuing education for teachers, not only because of the more comprehensive and long-lasting professional learning that it brings, but also because of the horizontality of the methodology—they do not have to learn something that a supposed expert suggests, but rather create their own collaborative path among peers—and also because it generates greater reflection, confidence,

protagonism, and commitment. This is what they have made known in the evaluations of the program of collaboration between Chile and Japan, and they have insisted on it during every occasion in which the issue has been debated. Of course, they are not the only ones convinced of this, and they have the expectation, not unfounded, that the educational authorities will once again privilege the lesson study strategy for professional development of teachers in Chile.

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