STATISTICS AND PROBABILITY CURRICULUM DEVELOPMENT FOR FUTURE ELEMENTARY TEACHERS IN CHILE: COLLABORATION AMONG COUNTRIES

Eugenio Chandía Muñoz[1], Anita Araneda[2], M. Alejandra Sorto[3] and José Luis Abreu León[4]
[1]Universidad de Chile, Chile
[2]Pontificia Universidad Católica de Chile, Chile
[3]Texas State University, USA
[4]Universidad Nacional Autonoma de México, México
sorto@txstate.edu

During 2003, the Chilean Bureau of Education decided to include statistics and probability as one of the main areas of the curriculum for elementary and secondary schools. This scenario poses new challenges to universities that need to prepare future teachers in these subjects. One of these challenges is the lack of textbooks and materials to support teacher educators. A multidisciplinary and international team of statisticians, mathematicians, and teacher educators joined efforts to test and develop curriculum materials aimed to provide future elementary teachers with learning opportunities related to content and specialized knowledge. In this presentation, we will describe the process of working together, the different international perspectives that enriched the development of the materials, and findings from pilot testing in 16 universities with elementary teacher preparation programs throughout the country.

CONTEXTUAL BACKGROUND

The current educational system in Chile has a high number of undergraduate programs designed to prepare future teachers: 656 teacher education programs housed in 51 four-year universities and 12 professional institutions. According to the Educational National Council of the Minister of Education, in 2013, there were 88 teacher preparation programs at the elementary level across the country housed in 42 universities with a total enrollment of about 11,659 students. During the last decade, the Minister of Education has implemented educational policies aimed to improve the quality of elementary teacher education programs. These include the development of teacher education content and pedagogical standards, a diagnostic standardized assessment (Prueba Inicia), academic excellence scholarships, and development grants aimed to improve the performance of the Colleges of Education. The content standards in the area of mathematics have four different strands: Numbers, Geometry, Algebra, and *Data and Probability*. These standards were developed with the notion that future elementary teachers need to acquire understanding of concepts, procedures, representations, strategic thinking, reasoning, and mathematical and statistical language. As a result of these important policy changes and the need to implement the new teacher preparation standards in mathematics and statistics, an international team of mathematicians, statisticians, and educators proposed to develop the first set of school mathematics-based materials in Chile. The project was entitled *Elementary Teacher Preparation Resources in Mathematics* (ReFIP Matematicas) and it was funded by the Science and Technological Development Foundation (FONDEF – CONICYT D09I023, 2011 – 2014). The main purpose of the project was to develop a collection of resource materials for future elementary teachers and teacher educators which were aligned with the professional standards and integrated content with pedagogy. To this end, four separate textbooks with a common vision were developed: Numbers, Algebra, Geometry, and *Data and Chance*.

CURRICULUM MATERIALS DEVELOPMENT

The Interdisciplinary and International Team

Unlike many textbooks for future elementary teachers this collection was designed to have a large number of professionals involved in the process. The team consisted of 15 authors, five advisory board members, three editors, and eight external reviewers. Members were associated with seven universities and three countries: Universidad de Chile, Universidad Andrés Bello, Universidad del Desarrollo, Universidad Santo Tomas, Universidad Católica de la Santísima Concepción, Universidad Nacional Autonoma de México and Texas State University. Authors

In K. Makar, B. de Sousa, & R. Gould (Eds.), *Sustainability in statistics education. Proceedings of the Ninth International Conference on Teaching Statistics (ICOTS9, July, 2014), Flagstaff, Arizona, USA.* Voorburg, The Netherlands: International Statistical Institute. iase-web.org

were divided among the different content areas and consisted of at least one mathematician or statistician, one mathematics or statistics educator, and one teacher educator. The team of authors for the *Data and Chance* materials was the most diverse in terms of international and disciplinary perspectives. The statistician in the team works at Universidad de Chile's Statistics Department. She was responsible developing and presenting the statistical content, as well as, maintaining the integrity and correctness of the content. The statistics educator works at Texas State University's Mathematics Department. She was mainly responsible for bringing the pertinent research and international perspective related to preparing future elementary teachers, in particular, research related to students' conceptions. The teacher educator works at the Laboratorio de Educación del Centro de Modelamiento Matemático de la Universidad de Chile. He was mainly responsible for connecting the materials to the statistical content that is taught in elementary grades, making sure the content was integrated with the appropriate pedagogy. In addition he was part of the team that field-tested the materials in pre-service teacher classrooms. Finally, the team had an applied mathematician from the Universidad Nacional Autonoma de México who was responsible in creating multimedia resources closely related to the content of the textbook. He brought to the team his experience with these type of resources in countries like Spain and Mexico, however this was a unique task in the sense that new technologicial tools had to be created to meet the vision and principles of the resources as a whole.

Guiding Developmental Principles

The first phase of the project focused on identifying the principles that guided the curriculum materials development of all the mathematical content areas. This was an interactive process with the participation of the multidisciplinary and international team of collaborators. Multiple panel discussions were held via ITV and face-to-face format. Part of the process was to become familiar with related existing materials from other countries like the US and Mexico. Below are the five guiding principles the project was based on to develop the curricular materials.

1. Curriculum materials and resources are in alignment with the professional standards.
2. Content knowledge is in alignment with current school national curriculum
3. Textbooks focus on the development of mathematical knowledge for teaching (Hill, Ball, & Shilling, 2008) which promotes the integration of content and pedagogical knowledge.
4. Include activities that promote inquiry and reflection (*Para Pensar*).
5. Develop interactive resources to complement textbooks.

Data and Chance Textbooks

With the guiding principles established, the authors of the *Data and Chance* materials aligned the content with the professional standards as the second phase of the process. Table 1 shows the alignment with the content standards, the pedagogical standards that establishes that teachers need to have knowledge of teaching techniques and learning issues is addressed within each chapter according to the topics.

Table 1 Alignment of Professional Standards with Material Coverage

Professional Standards for Data and Probability	Outline of the Data and Chance Textbook
• Formulate appropriate questions, design investigations, collect, analyze and interpret data.	• Chapter 1: The investigation Cycle 1.1 Phases 1.2 Investigation Cycle in the Chilean School Curriculum
• Understand the scope of the information extracted from a sample and therefore recognizes when a sample characteristic can be extrapolated to the entire population.	• Chapter 2: Population, samples, and statistical variables 2.1 Population and samples 2.2 Related teaching and learning issues 2.3 Parameter and statistic 2.4 Statistical variables
• Construct and utilize appropriate tables and graphical representations of the data to communicate results.	• Chapter 3: Data organization and information representation 3.1 Frequency tables 3.2 Graphical representations 3.3 Choosing appropriate type of representations
• Compute and interpret measures of central tendency, variation, and association.	• Chapter 4: Measures o summary statistics 4.1 Measures of central tendency and relative position (quartiles) 4.2 Measures of dispersion 4.3 Related teaching and learning issues
• Solve problems related to probability	• Chapter 5: Probabilities antifying uncertainty ›bability allocation

The integration of the content and the pedagogy was explicitly covered in the teaching and learning subsections. Figure 1 shows and example of the design of a concrete representation of a bar graph where the frequency of the categories is clustered in groups of five due to a large sample size. One of the main purposes of the example is to make teachers aware that concrete models have limitations and when dealing with large samples, other alternatives are available.

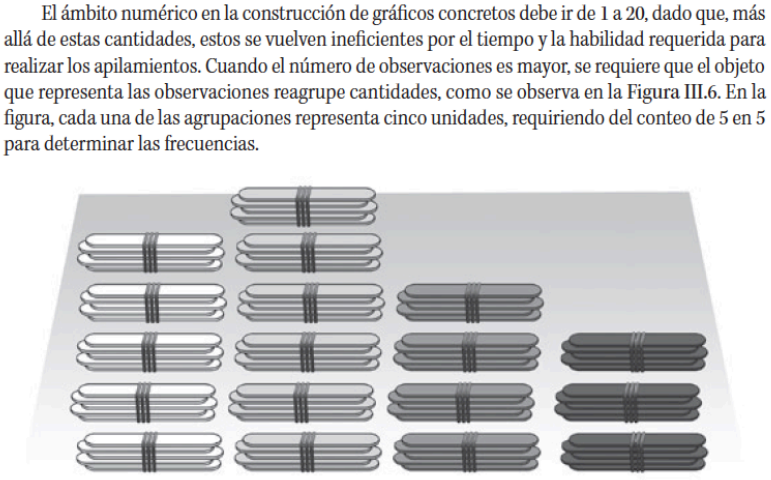

Figure 1. Example of concrete data representation for large sample

Another unique feature of the textbooks is that it challenges future teachers with reflection questions or arguments that addressed an important issue. These "*Para Pensar*" activities are also included to promote classroom discussion and participation around key ideas. The answers are provided later in the text. Figure 2 illustrates one of these activities which translates to "The difference of 4 observations between absolute frequencies of two given categories, would it have the same importance if the total number of observations is 15 than if it is 2,000?"

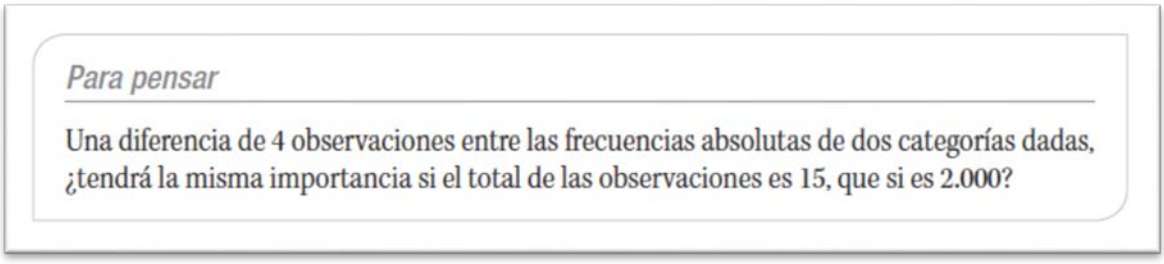

Figure 2. Example of "*Para Pensar*" reflective activity

Finally, we present an example (see Figure 3) of an interactive applet designed to illustrate the law of large numbers and connect related concepts of frecuencies with probabilities. The resource also aims to illustrate future teachers new ways to intuitively introduce abstract probability concepts to schoolchildren.

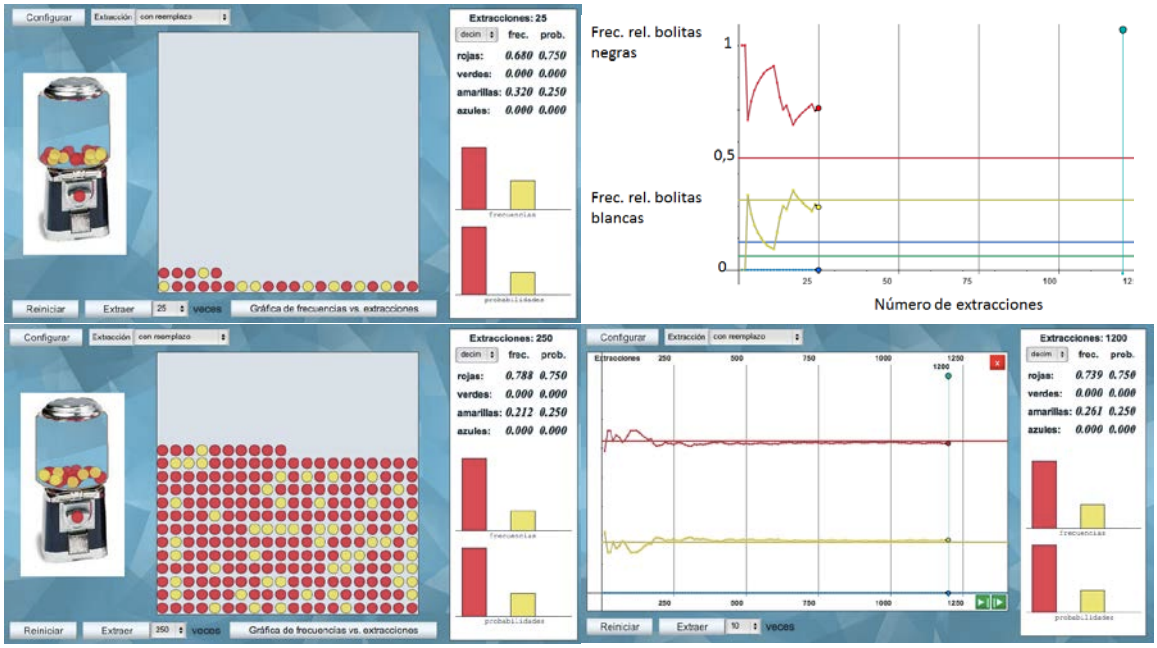

Figure 3. Interactive applet to illustrate the law of large numbers.

PILOT STUDY

During the academic years 2012 and 2013, a pilot study was conducted to field test the textbooks in the classrooms. There were 16 participating institutions covering a large range of geographical terrain (from northern to southern regions: Tarapacá, Valparaíso, Metropolitana, Bío Bío, La Araucanía, Los Ríos, Los Lagos and Magallanes). The *Data and Chance* materials were tested in 25 classrooms and with 858 future elementary school teachers. The process included workshops with the teacher educators responsible for implementing the early versions of the materials. The workshops had as a main purpose to clarify the vision and new approach by modeling the implementation of lessons based on the materials. In addition, teacher educators together with project researchers were responsible for administrating and/or responding to a set of surveys aimed to measure the impact of the materials on cognitive and affective aspects of the students and instructors. To measure knowledge for teaching and pedagogical knowledge, the research team utilized validated versions of instruments used in international studies such as *Teacher Education and Development Study in Mathematics (TEDS-M)* of the International Association for the Evaluation of Educational Achievement and the *Learning Mathematics for Teaching (LMT)* project from the University of Michigan.

Results from the pilot study indicated that there was a need to revisited the scope and organization of the content. With respect to the impact of the materials on knowledge for teaching there was positive and significant (0.2 effect size after controlling for initial knowledge) only for the Numbers textbook but not for the other three content areas including Data and Chance. There are two potential explanations for this result. First, the *Data and Chance* pilot version of the textbook was not as well developed as the other three textbooks. Second, it was detected (with classroom observations and fidelity of implementation surveys) that the participants had more exposure to the content presented in the Numbers textbooks. However, the overall impact and satisfaction with the new approach of integrating content with pedagogy was positive.

FINAL STEPS AND PRODUCTION

A specialized group of external reviewers (national and international), the main personal of the project, and designated editors conducted the final steps in the process. Their task was focused on the overall coherence within and between textbooks and materials. The final common aspects are:

- Mathematical and Statistical reasoning
- Mathematical and Statistical language
- Representations
- Problem solving
- Use of concrete materials
- Errors and difficulties
- Primary classroom activities

CONCLUSION

It is through a process of collaboration, the presence of different disciplines, participation of all parties, and international perspectives that we have come to produce a set of statistics materials unique for future elementary Chilean teachers. Although the process was extremely educational, the team faced many challenges, in particular producing materials that would be implemented by teacher educators that are themselves developing their own statistical knowledge. The materials will soon face the real test and we expect many more adjustments and revisions to maximize the usability and proper implementation.

ACKNOWLEGMENT

The authors gratefully acknowledge support from the project *Recursos para la formación inicial de profesores de educación básica* (ReFIP) under award FONDEF-CONICYT D09I-1023.

REFERENCES

Hill, H. C., Ball, D. L., & Schilling, S. G. (2008). Unpacking pedagogical content knowledge: Conceptualizing and measuring teachers' topic-specific knowledge of students. *Journal for Research in Mathematics Education*, *39*(4), 372-400.