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Statistics and Probability in High School

Carmen Batanero and Manfred Borovcnik

Statistics and Probability in High School

Carmen Batanero

Universidad de Granada, Spain

and

Manfred Borovcnik

University of Klagenfurt, Austria

Statistics and probability are fascinating fields, tightly interwoven with the context of the problems which have to be modelled. The authors demonstrate how investigations and experiments provide promising teaching strategies to help high-school students acquire statistical and probabilistic literacy.

In the first chapter the authors put into practice the following educational principles, reflecting their views of how these subjects should be taught: a focus on the most relevant ideas and postpone extensions to later stages; illustrating the complementary/dual nature of statistical and probabilistic reasoning; utilising the potential of technology and show its limits; and reflecting on the different levels of formalisation to meet the wide variety of students' previous knowledge, abilities, and learning types.

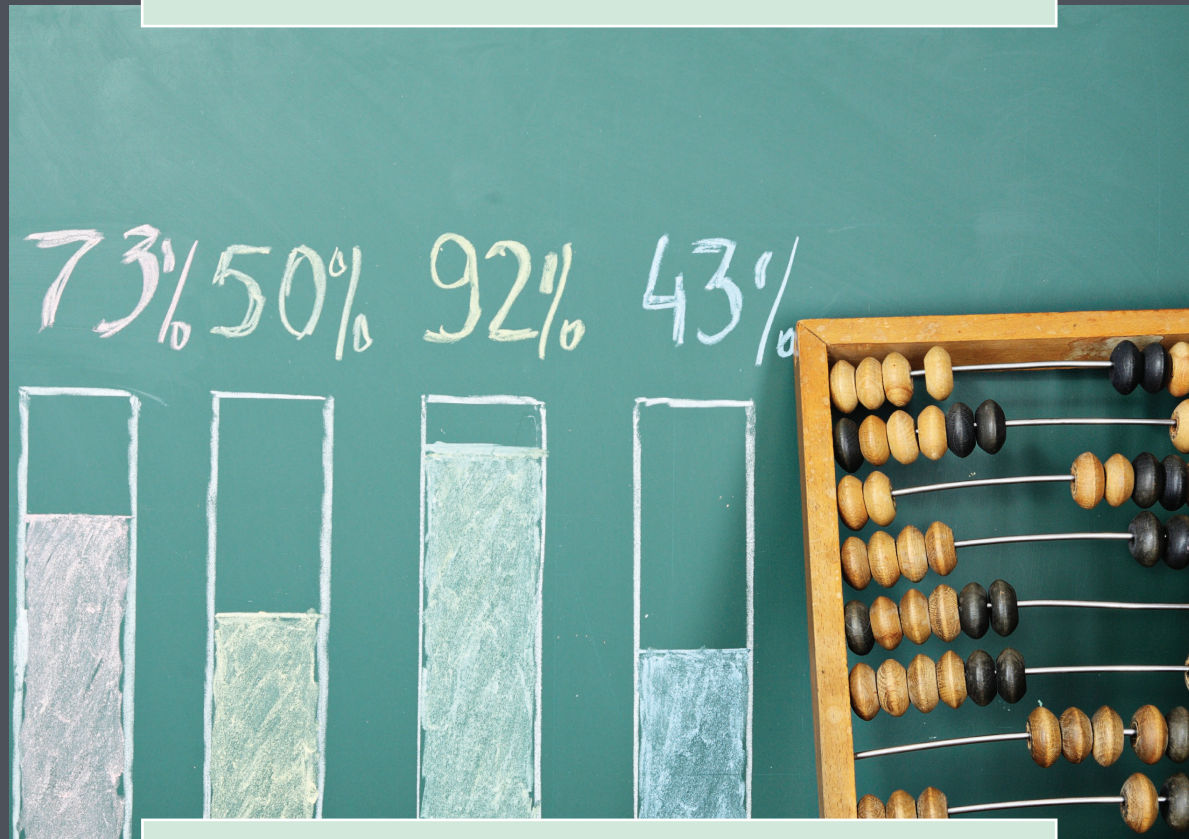
The remaining chapters deal with exploratory data analysis, modelling information by probabilities, exploring and modelling association, and with sampling and inference. Throughout the book, a modelling view of the concepts guides the presentation.

In each chapter, the development of a cluster of fundamental ideas is centred around a statistical study or a real-world problem that leads to statistical questions requiring data in order to be answered. The concepts developed are designed to lead to meaningful solutions rather than remain abstract entities. For each cluster of ideas, the authors review the relevant research on misconceptions and synthesise the results of research in order to support teaching of statistics and probability in high school.

What makes this book unique is its rich source of worked-through tasks and its focus on the interrelations between teaching and empirical research on understanding statistics and probability.

Statistics and Probability in High School

Carmen Batanero and
Manfred Borovcnik



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PREFACE

Research in statistics and probability education has produced a variety of results that would be useful for both secondary and high-school mathematics teachers and the educators of these teachers. Although there are many good textbooks in different countries that describe statistical ideas with a formalisation level adequate for students, usually these textbooks are written in a sequential way so that the different concepts and procedures are introduced in turn, with insufficient connections between them and limited attention to students' underlying intuitions.

There are, of course, excellent exceptions such as the books produced by the Schools Council (1980) in Statistical Education Project in the 1980's; yet, even, these textbooks do not include a detailed summary of research related to the teaching of the concepts, which started to get shape only after the first International Conference on Teaching Statistics in Sheffield in 1982.

In the later stages of our careers and, after collaborating and corresponding for many years in different projects, we decided to write a book directed to reinforce the mathematical and didactical knowledge of high-school teachers in statistics and probability. At the same time, we wish to offer examples of potential activities useful to introduce the main statistics and probability concepts and enhance the underlying ideas at this school level.

Consequently, in this book we provide examples of teaching situations, while at the same time we review research on adolescents' stochastic¹ reasoning and literacy, with the aim to provide recommendations and orientations for teaching these topics within high-school mathematics. The expression "high school" relates to different educational levels depending on the country; in this book, we will consider students from ages 14 to 18 (grades 9–12 in the United States of America curriculum). The book is organised in five chapters:

In the first chapter, we present some principles we use to select the content analysed in the book and the approach to teach this content. These principles emerge from:

- a. Our own teaching and research experience;
- b. An analysis of stochastic high-school curricula in several countries (e.g., ACARA, 2010; NCTM, 2000; CCSSI, 2010, MEC, 2007);
- c. The synthesis of available research (as summarised, for example, in Biehler, Ben-Zvi, Bakker, & Makar, 2013; Chernoff and Sriraman, 2014; Garfield & Ben-Zvi, 2008; Jones, 2005; Jones, Langrall, & Money, 2007; Shaughnessy, 1992, 2007; Shaughnessy, Garfield, & Greer, 1996);

¹ In some countries the term *stochastics* is used to highlight the mutual dependence between probabilistic and statistical knowledge and reasoning. Throughout the book we occasionally use *stochastics* for statistics and probability to express our view that these fields are tightly interconnected and should be taught together.

PREFACE

- d. Our own conceptions of statistical and probabilistic literacy, thinking, and reasoning; and
- e. Our extensive experience with strategies that may help support student development in stochastic literacy, thinking, and reasoning.

The first chapter sets out key educational principles. Each of the following chapters (Chapters 2–5) has a focus on a group of related fundamental stochastic ideas, while taking into account that high-school stochastics should be built on basic ideas that students have encountered at primary and middle-school levels. These chapters are organized according to a common structure, including an introduction, with a short analysis of the main stochastic ideas in the particular topic and its place in the curriculum; some initial and more advanced specific examples that may serve to involve learners actively as they progress in their development of the concepts, a summary of what is known about difficulties students encounter with the related concepts, a synthesis of the main learning goals in the chapter, and finally, some additional resources that may help teachers and students. When possible, we make connections between the different chapters and include some historical notes that shed light on ways of thinking about the concepts.

We have tried to give a balanced view on probability and statistics, with a focus on the interrelated nature of the concepts, integrating probabilistic ideas at a level suitable for high school teaching, including the step from descriptive statistics to statistical inference. Where ever we could do it, we have also tried to integrate mathematical concepts and contexts so that the mathematics developed becomes meaningful for the learners. May our exposition contribute to an increase in statistical and probabilistic literacy in our societies.

We hope the book will be both useful for practising teachers, as well as for researchers in statistics education and practitioners in teacher educators (teacher trainers). The different chapters contain original materials, but build upon our extended set of publications, part of which is listed in the references.

We thank our colleagues and students who have commented several drafts of the chapters. Among them we want to name especially two who accompanied us in our research work now for decades: Juan D. Godino and, particularly, Ramesh Kapadia who was also helpful for improving the English. Finally, we would like to express our deepest gratitude to our families and friends for their encouragement and support over the years when we were writing the book.

May, 2016

Carmen Batanero and Manfred Borovcnik