Introduction

We started working on this volume after having lunch during the Joint Meetings with a varied group of people, each using classroom voting in different ways. Each of us had developed our own techniques for using this teaching method successfully. Sometimes we had arrived at the same strategies, while other times we were using quite different approaches. We realized that all this collective experience should be gathered together in one place, so that it would be easily accessible to those wanting to begin using or extend their use of classroom voting. In this volume we have brought together perspectives from a diverse group of people with expertise in classroom voting, so that an instructor can quickly learn how to be successful with this pedagogy. Two of the papers published in this volume are reprints or updates of what has previously been published elsewhere, while most papers were written specifically for this volume, discussing the issues that someone new to the pedagogy will grapple with. The end result is a vibrant collection of papers illustrating the use of classroom voting in nearly every mathematics service course, as well as many courses taken by mathematics majors.

This volume is divided into three sections, plus a combined, single collection of references for all papers. The first section provides background information on classroom voting, including a thorough description of the pedagogy, suggestions for running a class-wide discussion, and contrasting viewpoints on issues such as whether voting should be graded and whether technology improves or detracts from the pedagogy. This section is essential for newcomers to classroom voting, and even experienced users will likely find new ideas to consider. The second section contains three papers that present results of studies carried out to determine the effects of classroom voting in mathematics. The first paper presents results from a large study at Cornell University suggesting that classroom voting is effective at improving student learning in mathematics when it is used to motivate students to participate in small group discussions. The second paper concerns a study of attempts to structure the small group discussions in order to make them more effective, and the third paper provides results from a large survey of student reactions to classroom voting in mathematics.

The heart of the volume is the third section, which addresses the use of classroom voting in several specific courses, spanning most service courses plus many courses for mathematics majors. Many of the authors of these articles have made their question banks available for public use, and these can be found at `mathquest.carroll.edu/resources.html`. While each paper describes the use of classroom voting in a particular course, each author also contributes their own style and pieces of wisdom that are transferrable to other courses. Thus, readers interested in using classroom voting in statistics may turn first to the papers dealing directly with that course, but they will still find valuable information in the other papers. In what follows, we provide a brief note on the specific contributions of each paper, beyond the course being discussed.

McGivney and McGivney-Burelle describe a project at the University of Hartford to write questions for a Math for Liberal Arts course. They discuss the question-writing process, including a paradigm shift after their first trial.

There are four papers on statistics, each presenting a slightly different view. Murphy, et al, report on their NSF-funded project at the University of Oklahoma. They present four different lesson plans for statistics courses directed towards a variety of audiences, and they discuss question-writing with a multi-disciplinary team. Gunderson and McGowan discuss three ways in which they have used clickers: as part of a regular lecture, for an exam review, and to gather data in a lab setting. Bruff touches on a variety of aspects of his use of voting, including results from two-cycle voting and ways to improve questions that don't pinpoint the desired concept. Peck discusses question-writing and presents results from an experiment with teaching two sections of statistics, one with voting and one without.

The fastest way to spread a new pedagogy is to teach teachers. The next two papers discuss using voting with pre-service and in-service teachers. Ernie, et al., present a series of voting questions designed to help pre-service teachers

think deeply about their conceptualization of probability. Serros, et al., discuss how they used clickers to promote discussion in a workshop for in-service teachers.

The next group of papers focuses on the use of voting in college algebra and precalculus. Schlatter discusses how he uses classroom voting, conducted with index cards, to help students use different modes of expression, make valid inferences, and interpret mathematical data. He also presents questions used to motivate new material. Gibson presents a multi-faceted lesson plan for slopes and average rates of change, which he uses in a large-lecture college algebra course. Lomen discusses a variety of questions that he has used in college algebra to introduce a new topic, check student understanding of a topic just presented, and review a topic. He also shares his implementation of voting without technology. Finally, Hofacker, et al., present questions they have used in precalculus, emphasizing the student responses and various strategies for leading discussions.

In her paper on calculus, VonEpps discusses in depth how to plan a lesson by writing a few of her own questions to supplement questions available in existing databases. Sharp presents a variety of questions that she has used in a large-lecture calculus course. Terrell uses vector calculus as a vehicle for illustrating how she uses voting to draw out and build on students' own preconceptions.

In "Integrating Classroom Voting into Your Lectures," Storm shares his lesson-planning technique, illustrated with two lessons from differential equations. He gives tips for maintaining content while integrating voting. Cline, et al., use statistical analysis of past voting patterns to identify the most challenging questions on fundamental concepts in differential equations, finding that these tend to produce the richest student discussions.

The two papers on linear algebra each present a complete lesson plan. Cline's paper emphasizes the student discussions following each vote. Zullo's paper focuses on the lesson-planning process, with particular attention to maintaining flexibility.

Generally classroom voting has been used in lower-level courses. In the final paper in this volume, Lock extends classroom voting well into the reaches of upper-division courses, including an introduction to proof course and abstract algebra. Lock demonstrates that multiple choice questions can have significant learning value in teaching proof and advanced concepts.

This volume would not have been possible without the contributions of the authors. We extend our heartfelt gratitude to all of the authors who contributed papers for this volume. Their willingness to share their experiences with classroom voting will be greatly appreciated by faculty just beginning to experiment with this pedagogy. We also appreciate the careful reviews by Steven Maurer and the members of the Editorial Board of the MAA Notes series. Their helpful suggestions have significantly improved this volume.

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