Elementary Mathematical Models Clicker Question Collection

Sacha Forgoston and Dan Kalman

Document Overview

This document is an ancillary resource to accompany the book *Elementary Mathematical Models: An Accessible Development without Calculus, Second Edition*. It provides an introduction to clicker questions, guidelines for their use, and a collection of clicker questions designed for use with the Elementary Mathematical Models text.

The clicker question collection is organized by chapter and section of the text. Correct answers are identified, and in many cases there are brief discussions concerning the ideas behind the questions and possible topics for class discussion.

The clicker questions are also provided separately for each chapter in a series of *slide files*. In these files each clicker question appears as a separate slide suitable for projection in a classroom.

This EMM Clicker Question Collection is an extension of our earlier work. During the Fall semester of 2008, Sacha Forgoston and Dan Kalman developed clicker questions for several chapters of Elementary Mathematical Models (first edition). In the summer of 2009, Sacha Forgoston continued work on supplemental problems including clicker questions. We gratefully acknowledge the financial support of American University through a University Curriculum Development Grant (2009), the College of Arts and Sciences, the Department of Mathematics and Statistics, as well as the Academic Support Center. In addition, we would like to thank everyone who read the problems and provided feedback.

Introduction to Clicker Questions[1]

What we refer to as clicker questions are an adaptation of ConcepTests. In the early 1990s Eric Mazur, a physicist at Harvard University, developed ConcepTests as part of a teaching method called Peer Instruction. Mazur was frustrated to find that many students who performed well in his class also showed a persistent lack of understanding of basic physical concepts. In an effort to correct this problem, Mazur began breaking his lecture period into segments. In each segment he would teach a topic in a fairly traditional way. Before moving on to the next topic, he would ask students a multiple-choice question which focused on the concept rather than a calculation. After spending one or two minutes to formulate their answer, students would vote. Finally, several minutes would be allowed for students to discuss their ideas in small groups (peer-to-peer discussion) and re-vote. These questions have come to be called ConcepTests.

Mazur found that usually, if 50-80% of the students answered correctly in the initial vote, then almost all students would give the correct answer in the re-vote [2]. Moreover, when the initial vote resulted in less than 50% correct responses, it would be beneficial to spend additional time on the topic. Using this method, Mazur discovered that students developed an increased and longer lasting knowledge of the material being taught. After using ConcepTests throughout the semester, the class as a whole showed improvement in conceptual understanding. Furthermore, the computational skills of students in classes where ConcepTests were used were comparable to the skills of students in

[1]This introduction has been adapted from Sacha Forgoston's *Clickers and ConcepTests* [1].

traditional classes [3]. ConcepTests are a remarkably efficient way to provide the invaluable benefits of active participation to each and every student.

Since the 1990s, instructors in astronomy, biology, and other subject areas have been using ConcepTests in class. In 2001, Scott Pilzer, a professor at Albright College, revealed that he had started using ConcepTests in his calculus course [4]. Now questions are available in print as well as online for use in a variety of mathematics classes [5, 6, 7, 8]. The types of questions used have been expanded beyond concepts to include definitions, computation, and review. The broader collection is what we call clicker questions; the name refers to the electronic devices often used to answer the questions.

Personal response pads, also known as clickers, were developed to foster student engagement. The attention span of a passive learner is notoriously short. Even the most motivated students often find their minds wandering during a traditional lecture. In a study performed by IBM and discussed in [9] it was found that the average number of students paying attention during a standard lecture was 47 out of 100. In order to boost students' class participation, IBM designed a prototype personal response system. When the new system was used, the number of students paying attention rose to 83 out of 100. The type of response system used by IBM in this study is now widely available. The electronic devices, however, are not essential to fostering student engagement. An alternative method is discussed below under *Using This Collection*.

Clicker questions provide an opportunity for students to perk up during class, discover misconceptions, and reinforce correct ideas through discussion. The types of questions one poses are determined by the goals of the instructor. These goals range from quickly checking students' progress to sparking an in-depth class discussion on the main concepts of the course. Clicker questions are also an invaluable real-time diagnostic tool for instructors. By using these questions, instructors can be confident that students have understood one topic before moving on to the next topic.

Using This Collection

In this collection you will find a variety of multiple choice questions. Some of these questions are definition questions, some require simple computations, and some test mastery of important concepts. All are intended for use in class to foster student engagement and provide real time feedback to instructors.

In order to communicate their answers, students will need a device. There are many electronic personal response systems available. Alternatively, index cards can be used. In this low-tech method every student has a set of 4 index cards each with one of the letters A - D. When the time comes to answer a question, students raise the appropriate card. One approach is to provide each student with a set of colored 5 inch by 8 inch cards; say a red card with a large A printed on it, a blue card with B, a yellow card with C, and a white card with D. The different colors, large size, and uniformity of printed letters makes it easy to quickly process student responses.

The questions in this collection are provided in two formats. The format of this document is meant for instructor perusal. It includes all the questions, the answers, and notes to the instructor following some questions. The notes include our goals and motivations in writing the question, prompts that

may be useful to spark further class discussion, and ideas on ways to tweak the questions in order to change the difficulty level. The other format consists of slides suitable for projection in a class. Each slide poses one question, and is followed by a slide repeating the same question and highlighting the correct answer. There are separate slide files for each chapter of the text. To preserve the integrity of the clicker question collection for other instructors, we ask that the answers not be posted or made available to students outside of class discussions.

The clicker question collection is intended to be used as an item bank. It is probably not feasible or desirable to use every included item for most sections of the text. Instead, we envision instructors selecting a subset of items to incorporate into a particular lesson. These can be displayed using the slide file for the appropriate chapter, passing over items that are to be omitted. Instructors are also free to define bookmarks for specific items in a slide file, or to extract a subset of slides into a special purpose slide file. Moreover, we invite you to modify the questions to suit your own instructional goals and classroom practice.

By design, this collection includes only questions with at most 4 possible answers, of which only one is correct. Before adopting these requirements we considered some advantages of allowing more than a single correct answer. For example, multiple correct answers can motivate students to elucidate their reasoning and challenge them to see things from another perspective. In the end, we decided to permit only one correct answer because that seems most compatible with the peer instruction methodology. In spite of our best efforts, though, we may have included some questions with more than one response that can be interpreted to be correct. If so, we hope the questions still spark valuable class discussion. And whether or not there are multiple correct answers, students should be working to justify their answers and to understand arguments in favor of other answers.

We hope you will find these questions useful in teaching Elementary Mathematical Models.