Texas Mathematics Teacher

Volume LVIII Issue 2 Fall 2011

Find the Mathematics...

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... in public places

see page 17

Student Activity *see page 23*

Geometry Scavenger Hunt *see page 17*

Puzzle Corner and Quotes *see page 16*

Texas Mathematics Teacher

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Article

18 Low-Tech, Low-Cost, High-Gain, Real Time Assessment?

Features

8 CAMT Board Update
9 Voices from the Classroom
10 NCTM 62st Delegate Assembly
11 Factoids
12 2011 TCTM President's Grant Recipients
12 2011 TCTM Mathematics Scholarship Recipients
12 2011 TCTM CAMTership Recipients
13 2011 TCTM Leadership Award Recipient
13 2011 E. Glenadine Gibb Award Recipient
14 PAEMST (Presidential Awards)
14 Recommended Readings
15 Legislative Update and Advoacy
16 Puzzle Corner / Quotes for Thought
17 On the Cover
17 Geometry Shape Scavenger Hunt
23 Checkerboard Squares Student Activitiy
24 Volunteer for CAMT 2012

Departments

2 Map of TCTM Regions
4 Letter From the President
5 Lone Star News
6 TEA Talks
26 Advertising Guidelines
27 TCTM Mission Statement

TCTM Applications

15 2012-13 Mathematics Preservice Teacher Scholarship
15 2012 President's Grant
15 2012 CAMTership
15 NCTM Membership

All applications (including TCTM membership) are available online at <*www.tctmonline.org*>.

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The official 2011 CAMT hotel had an unmistakable Texas motif. Under its cavernous glass dome, the climate-controlled air carried a steady rotation of country music, including Taylor Swift's top-10 country hit "Mean" (which was released -- on 2011 Pi Day! -- from her 2010 multiplatinum album *Speak Now*). By the fourth time I heard it, I noticed its potential to be rewritten about how the statistical mean is generally an inappropriate summary of highly skewed data. Feel free to sing this with your students next time you discuss examples such as housing prices or household incomes!

"Mean" (lyric © 2011 Lawrence M. Lesser)

You.....with your words like mean and mode and symbols that you use against me.

Mu.....stands for a population mean and x bar for the sample.

Who…...knows what symbol to use for other measures of data location.

You……..pickin' each time the mean.

But it can get pulled off with just one single point,

And you don't know what you don't know....

Sometimes, data have a real asymmetry

Or values that are really quite extreme.

In those cases, better use the median

If what's typical is what you need--

That's not gonna be the mean!

That won't be the mean with outliers, just forget it,

Do you see just what I mean and mean and mean and mean.....

Sometimes data have a real asymmetry

Or values that are really quite extreme. Yeah, yeah.

In those cases, better use the median

If the middle is what you need--

Not gonna be the mean!

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COLLEGE OF EDUCATION

Low-Tech, Low-Cost, High-Gain, Real-Time Assessment?

It's all in the cards, easy as ABCD!

BACKGROUND

During my years teaching high school in Houston, I tried experimenting with a class set of small (about the size of typing paper) dry erase memo boards and markers I would pass out to my students each period. Then I could pose a question (e.g., "Draw an isosceles obtuse triangle" or "Sketch the graph of $y = -x^2$) and pan the room and instantly see not only what fraction of the class was obtaining the correct answer, but also see who was not and what types of errors they were making. I can't say the experiment was a complete success because marker pens would often need to be replaced and there were always a few students in each class who had to be reined in for drawing unrelated doodles. Still, there was a noticeable shift in energy during those class sessions by having everyone involved in exchanging feedback with me in real time.

When I began my university position in 2004, my class sizes were twice what they were at the high school and I searched for ways to make these larger classes interactive and engaging for all students, not just for those who were raising their hands to answer questions, for example. Classroom voting has recently provided an attractive option for this purpose and there have been many articles, books, and symposia on the topic. An excellent collection of resources for classroom voting in mathematics and statistics is *<mathquest.carroll.edu/resources.html>*.

I began hearing about electronic clickers (also known as classroom response systems, personal response systems, audience response systems, or student response systems) and became intrigued by their potential for interactive learning and assessment, but without some of the challenges that I faced with the markerboards in my high school classroom. I even co-supervised a master's thesis (Dashley, 2010) that explored the relationships between using electronic clicker devices, making predictions, and certain probability misconceptions. Mateo (2010) shares the (mostly positive) results of introducing this technology in large introductory statistics classes. Further background appears in Caldwell (2007).

However, I was personally wary about the dependence on classroom scheduling (not all classrooms are equipped for it) and technology platform (with its inevitable setup and troubleshooting) as well as asking financially-strapped students (especially in my high-poverty geographic region) to pay as much as $35 or more for a electronic "clicker" device that they might not use in any other class.

By attending a faculty development workshop in August 2010 by the University of Arizona's Dr. Ed Prather, I learned an elegant low-tech solution: color-coded ABCD voting cards made of paper (you can see one at *<astro.wvu.edu/r/download/23080>*). These cards were a low-cost solution – obtainable from the campus copy center for roughly only 1% of the cost of an electronic clicker. Prather did not merely talk about the published research (e.g., Prather & Brissenden, 2008) behind the technique, but motivated us all to experience it in a concrete way so that we would leave ready to do it the next day. And indeed, I began implementing it in my fall 2010 course, which started less than a week later!

IMPLEMENTATION

The key idea (Prather and Brissenden, 2008) is to include several opportunities each class period for students to register their answers or votes by holding up their cards anonymously (by holding the card below their necks, it's not easy to see how others are voting) and simultaneously (all vote on the count of 3, so no one is influenced by how their neighbor might be voting) on pre-written or improvised questions from the instructor.

On the syllabus and first week of class, I make it clear students are responsible for coming to each class ready to use the card they obtain by folding into quadrants the 35-cent color copy they make on regular paper from a pdf file (available at a URL I provide on the syllabus).

The use of these cards serves several roles in the classroom: it gives the students feedback on their understanding, gives the teacher feedback on student understanding (which in turn allows the teacher to make on-the-spot adjustments to how to allocate class time and what examples to discuss next), and reinforces student engagement since every student has to answer, not just the one that is called on.

By a quick visual pan of the room, I very efficiently assess if student understanding on a question is what I think it is (every week, there's a surprising result in one direction or another that I would have never noticed in a timely manner) and make an informed decision about whether to move on, to back up, or (without revealing the correct answer yet) to have students "turn to your neighbor and try to convince him/her that you're right" before doing a re-vote and followup discussion. Students are reminded that even if they have the same answer, they might both be wrong and they need to discuss their reasoning.

While the card may seem to be limited only to four-choice questions, there are creative ways to extend the capacity of the card. Holding the card fully opened, but upside down could be a choice (E), and showing the instructor the blank white side of the full page could be a way of saying "my mind is blank – I have no idea" or "I don't understand the statement of the question".

By a quick visual pan of the room, it is efficient to assess if student understanding on a question is on target (and every week, there's a surprising result in one direction or another that would have remained unnoticed that day) so that the author can make an informed decision about whether to move on, to back up, or (without revealing the correct answer yet) to have students turn to their neighbor and "try to convince them that you're right" before doing a re-vote and followup discussion.

QUESTION DESIGN

While any question, numerical or conceptual, that can be made into a multiple-choice question can be used with these cards, I tend to use them more with conceptual questions that could be efficiently posed without reading a long "setup". Here are examples of questions I ask using ABCD cards:

- "What is the most useful way to report annual average household income?"

  (A) mean,
  (B) median,
  (C) mode,
  (D) maximum

- "What does 'chance of rain 60%' mean?"

  (A) rain will occur 60% of the day

  (B) at a specific point in the forecast area, there is a 60% chance of rain,

  (C) 60% chance that rain will occur somewhere in the forecast area during the day,

  (D) 60% of the forecast area will receive rain.

- The type of statistical study reported in this news clipping is:

  (A) survey,
  (B) randomized experiment,
  (C) observational study,
  (D) case study,
  (E) metaanalysis

It is also possible, however, to ask questions that are more procedural or numerical. In these cases, it is recommended that to make best use of class time, the problem should be streamlined with simple numbers and efficient statement of the problem. Also, instructors should choose answer choices carefully to catch common misconceptions and confusions and make sure that it is not easily possible to get the right answer for a wrong reason. For example, if you are asking students about quantities such as mean, median, mode, range, etc., a dataset such as {1, 2, 3, 4, 4, 16} would be far superior to {3, 4, 5, 5, 8} (Lesser, 2011).

Another use of the cards would be for questions that could be posed in the moment. While working through or discussing an example, it is easy on the fly to assess "what if" questions such as "If I changed the units of X from inches to feet, this would make the correlation between X and Y: (A) increase, (B) decrease, (C) stay the same, or (D) no idea". Or, "If we deleted the outlier from the dataset, the correlation would: (A) increase, (B) decrease, (C) stay the same, or (D) no idea."

Yet another use of the cards would be for questions designed to assess whether students have a particular misconception, such as this one used in (Dashley, 2010) to assess the presence of what is known as the representativeness heuristic:

Which outcome of 6 coin tosses is most likely?

(A) H H H T T T
(B) T T H H T H
(C) H T T H H H
(D) A and B are equally likely
(E) all of the above are equally likely

Research (e.g., Shaughnessy 1977) shows that misconceptions can be particularly resistant and that the best chance to change them is if students can actively identify and confront them by making a prediction about a scenario, discussing it, and then having to reconcile their reasoning with the new information and solution. A useful, if not familiar, example to classroom teachers is offered by Goldman (1998) in which a series of graphs on the Texas Instruments graphing calculators can be displayed one at a time by "pausing" the graphing with the ENTER key so that another question can be posed to the students.

Voting cards can even be used for purposes not directly related to content, such as to get to know students' overall backgrounds, to form groups spontaneously, to vote on the best day to schedule a test or review session, to offer feedback on the difficulty of an assignment, to offer feedback on whether the teacher is going at the right speed on that day's lesson (choices: "too fast", "just right", "too slow").

EFFECTIVENESS

While I thought it was clear that this was one of the most effective bang-for-the-buck strategies I have incorporated into my teaching, I wanted more than my anecdotal gut impression. On November 17, 2010 (about three months into the intervention), the students in my two introductory statistics sections were given an anonymous written survey by a third party -- the director of my university's teaching center -- while I stepped out of the room.

The questionnaire asked students for their levels of agreement/disagreement towards statements that the use of ABCD cards in the author's class: (1) "helps me feel more engaged during class", (2) "gives me helpful feedback about whether I am understanding ideas correctly when they are presented during class", and (3) "allows Dr. Lesser to more effectively prioritize which topics, examples, and activities to choose during class to better meet the students' needs."

The three statements each used this Lickert scale: 1 = strongly disagree, 2 = disagree, 3 = somewhat disagree, 4 = somewhat agree, 5 = agree, and 6 = strongly agree. All students present (N = 49) completed the survey (with no student leaving any items blank) and here is the distribution of responses:

Survey Statement	#1 (students feel engaged)	#2 (feedback for student)	#3 (feedback for professor)
1's	0	0	0
2's	0	0	0
3's	0	0	0
4's	1	4	3
5's	18	15	15
6's	30	30	31
mode	6	6	6
median	6	6	6
mean	5.6	5.5	5.6
standard deviation	0.5	0.6	0.6

All three items yielded fairly similar distributions of ratings, with a mode of 6, median of 6, mean of at least 5.5, and standard deviation of about 0.6. Of the 49 x 3 = 147 total ratings for the three questions combined, 62% were 'strongly agree', 33% were 'agree', 5% were 'somewhat agree', and none of the 147 ratings involved any of the three levels of disagreement. This degree of positive response was striking, especially considering that I had learned about the innovation less than a week before this course began.

The survey also gave students the option to write comments, and 30 of the 49 students (61%) surveyed did. All comments were positive, and had these themes (in descending order of frequency) about card use:

1) Makes class lively, dynamic, interesting
2) Inexpensive (especially compared to electronic clickers)
3) Gives feedback
4) Students plan to use it in their future teaching
5) Useful, practical, convenient, efficient
6) Removes peer pressure or embarrassment from wrong answers
7) Gives everyone an equal chance to participate

That semester's anonymous end-of-course university student evaluations offered further reinforcement, not only in the overall rating of the instructor, but also in the specific question most related to classroom voting, namely "varied use of questions".

	Q#9 (varied use of questions, etc.)	Q#11 (overall rating of instructor)
Very Poor	0	0
Poor	0	0
Satisfactory	2	2
Very Good	7	2
Excellent	50	54

DISCUSSION

While the benefits seem consistent with the findings of Prather and Brissenden (2008), and the teacher and students certainly uniformly perceived it as useful, it might be interesting to conduct an experiment to measure learning outcomes for voting and non-voting classes. The limitations of this, of course, are that instructors do not generally have the luxury to assign students randomly to courses, it is hard for instructors to otherwise teach identically to both sections, and it could even be arguably unethical (in the sense of Holcomb, 2002) to deprive one section of this promising, easily-implemented technique.

After the semester was over, I discovered a number of sources of clicker questions for statistics on the internet, such as:

<www.derekbruff.com/resources/crs_stats_questions_2008.pdf>

<www.ou.edu/statsclickers/clickerQuestions.htm>

Lesser and Winsor (2009) discuss the balance of not overestimating what English Language Learners know (since some may periodically feign understanding by nodding to avoid unwanted attention to themselves) and not underestimating what ELLs know (since some may come across as hesitant and uncertain simply because of intonation or cultural patterns). The participation and privacy allowed by the cards may be a great way to avoid both of these pitfalls because each student is forced to participate, but in a way that does not make any one student stand out from the others.

Perez et al. (2010) bring up an interesting point about the value of anonymity of ABCD cards. They found in an experiment that if students the class response to the question were displayed (as a bar graph), students were 30% more likely to change their answer to the modal response if they had not already selected it.

In closing, we note that the most important thing is that there is real-time assessment of student learning, and teachers may have different reasons for preferring different technologies. Some teachers have found that websites like www. Polleverywhere.com (free for classes no bigger than 30) allow students to text responses using their cell phones and the results show up on the browser you project in the classroom. In some schools, however, this may violate a blanket ban on the use of cell phones.

Posner (2011) lists a number of factors that we can consider when deciding whether to use texting, clickers, or ABCD cards: cost, hardware, Internet, reception, access, vulnerability to cheating, recording results, anonymity, capacity for improvisation, flexibility in format of questions/answers, how/whether answers are displayed/recorded or embeddable in a course management system, etc.

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