VOLUME 43, NUMBER 3 FALL 2014

California Mathematics Council Community Colleges

CMC³ NEWSLETTER

Fall Conference Coming Soon!

Joe Conrad, Solano Community College

The 42nd annual CMC³ Fall Conference will be held this year on Friday and Saturday, December 5 – 6, 2014. We will be back at the Hyatt Regency Monterey Hotel and Spa which worked very well for us last year. Generally, people were happy with the new location and enjoyed the free in-room wifi and free parking, but the Board heard the concerns about the distance from the downtown area and have negotiated to have a free, continuously running shuttle looping from the Hyatt to downtown Friday starting at 9 p.m. and Saturday starting at 6 p.m. Our group rate remains the same at $140 per night for up to double occupancy. You can make reservations online at https://resweb.passkey.com/go/2014CMC3. (At the website, when selecting your guest type, choose "Attendee" from the dropdown menu. If making reservations by phone, mention "CMC3 Group Rate" when calling Hyatt Passkey Reservations: 888-421-1442.) For more information on the hotel, please see the hotel website at www.monterey.hyatt.com/en/hotel/home.html.

There is an exciting program again this year that will offer a wide range of sessions appealing to many areas of professional development and classroom interests. We are quite excited about our keynote speakers! We return to a Friday night keynote this year with Alon Amit from Origami Logic who will amaze us with his talk about some real-world applications of randomness. Saturday's keynote will be James Stigler from UCLA who has a fascinating talk about the culture of the mathematics classroom in the United States and around the world. Two popular fun events will be held again this year, namely, the Game Night (hosted by Pearson) on Friday night after the keynote and the Estimation Run/Walk bright and early Saturday at 7:30 a.m. The full list of speakers and their titles, and other events, as well as the latest information about the

(see "Fall Conference" on p. 2)

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Fall Conference

(continued from front p. 1)

conference, is available at the conference website: www.cmc3.org/conference/Monterey14/Monterey14.html.

If you have not received it yet, you should be getting the official mini-program and registration form via US mail soon. Please feel free to disseminate the information and copies of the registration form among your colleagues, both full-time and adjuncts. We are excited to see everyone in December!

President's Message

Mark Harbison, Sacramento City College

"The meaning of life, the universe, and everything" is 42. This is true. Not everything in Douglas Adams' *Hitchhiker's Guide*... is equally factual, but this is one statement that is very hard to argue with. To this day, I have yet to see any serious attempt at a rebuttal by anyone.

Coincidentally, our next conference will be the 42nd Annual Fall Conference of the California Mathematics Council, Community Colleges (CMC^3). A group of about 16 of us on the CMC^3 Executive Board and CMC^3 Foundation Board have been busy preparing an excellent program of events. Especially busy has been Joe Conrad, our loyal Program Chair. I am happy to see this office running smoothly in Joe's capable hands. If you are as impressed as I am with the program that he has put together, then please do what you need to do to attend it:

* Visit www.cmc3.org/conference/Monterey14/Monterey14.html and book a hotel room for a night or more at the Hyatt Regency with the "Hotel" link;

* Send in your CMC^3 registration before Nov. 21 to get the discounted price;

* Tell a colleague about it. The experience is even better when shared with a friend.

We are a volunteer-run organization of people *just like you* who enjoy meeting together on occasion to share ideas about improving student success in community college math and statistics classrooms. I am grateful for these colleagues who spend a few Saturdays at our board meetings at various CC locations. (Note that everyone is welcome to attend our next meeting at Diablo Valley College on Jan. 24, 2015. Just ask a board member ahead of time about the room # where we will meet. We'll have free coffee, juice and a.m. snacks!)

But I am even more grateful for the CMC^3 Board members who served in the past.
I have recently read through the Fall Conference programs for all years 1973 to 2013, with just a few exceptions. (I will be super grateful to anyone who can supply me at least a photocopied copy of the program from 1979, 1980, 1981, 2001 or 2007. Please contact me so that I can complete the collection!). There have been literally hundreds of volunteers whose past work with CMC^3 has had a positive impact on what we are doing now and in the future. Many of them have been formally thanked with a "Distinguished Service" or other Award, but I would like to thank them again one more time. Also, I encourage you to say 'thanks' to one of them if you have a chance to do so. Awardees have been listed in each of the last few "full program" links such as www.cmc3.org/conference/Monterey12/Monterey12.html (for example).

So as a tribute to some of our past leaders, I have written the following quiz. It has 7 questions, since 42 is divisible by 7 (and since 42 questions would be too long). The answers are on page 8 of this Newsletter. Good luck.

Thanks to all of you for supporting CMC^3 these last 42 years. I will see you in Monterey on Dec. 5 and 6, 2014.

CMC^3 History Quiz, Part 1

1. Rearrange the letters "yo pal" to form the last name of the 1973 keynote speaker: George _____ .
2. In what year did it switch from a 1-day program to a 2-day program?
3. What was the hotel's name before 2007 when it changed to the Portola Plaza?
4. In what years did the Del Monte Hyatt House host the conference (before changing its name to the Hyatt Regency Monterey)?

5. Who gave a "Plenary Talk", instead of a "keynote" in 1995?
6. Match these topics to the years when sessions covered them:
   a. "Mathematics Proficiency"
   b. "Sacramento Scene"
   c. "Micro-computer"
   d. "SLO's"

1983-1987
2005-2013
1998-2008
1982-1983

7. How many minutes does each speaker get to present an "Ignite" talk?

(see p. 8 for the answers)

Mark Your Calendar:

42nd Annual CMC³ Conference

December 5 and 6, 2014

Hyatt Regency Monterey Hotel and Spa

The Nineteenth Annual Recreational Mathematics Conference at Lake Tahoe

Larry Green, Lake Tahoe Community College

Mark your calendars for April 17 and 18 in 2015 for the 19th annual Recreational Mathematics Conference. The conference will be held in Lake Tahoe's Montbleu Resort Casino and Spa, which is located near the lake and has all the amenities including a salon and spa, arcade, shopping area, and of course plenty of table games and slots if you are feeling lucky. This conference is unique in that all the talks are recreational in nature focusing on applications and other mysteries of mathematics.

We still have openings in the schedule for session speakers who have some cool application of mathematics to share. Just go to http://www.cmc3.org/conference/callForProposalsTahoe.html to fill out the call for proposals form. Also please encourage your students to start working on a mathematics project so that they can apply to be the 2015 Tahoe student speaker awardee.

For more information, contact your CMC³ campus representative or contact Mark Harbison, Tahoe Conference Speaker Chair at harbism@scc.losrios.edu or Larry Green, Tahoe Conference Co-Chair, at DrLarryGreen@gmail.com. This is a one-of-a-kind conference that brings people back each year to enjoy the wonders of mathematics and the beauty of Lake Tahoe.

What's Happening at Columbia College

Maryl Landess

The Mathematics Department at Columbia College has some significant personnel changes to report. John Leamy, long-time mathematics professor for Yosemite Community College District, has retired. The department appreciates his excellent contributions over the years and looks forward to John joining our ranks of adjunct faculty in the spring. We are very excited to welcome his replacement, Jim Retemeyer. Jim comes most recently from Merced Community College and started teaching for us this summer. His passion and enthusiasm will serve our students well. We also welcome one of our talented adjunct, Katryn Weston, in a one-year full-time position. Together with our other valued adjunct, some returning after a few years hiatus, the department is pleased to have a robust offering of math classes for the fall.

The Columbia College Math Department is also pleased to accept additional financial support granted by our AWE (Academic Wellness Educators) Committee from basic skills funds for the upcoming academic year. These funds will allow us to significantly increase both the hours that our Mathematics Resource Center (Math Lab) is open and the number of student workers we can make available to help students.

(see "Columbia College" on p. 10)

The Pleasures of Problems

Kevin Olwell, San Joaquin Delta Community College

Joe Conrad's energies will now benefit the entire CMC^3 organization rather than just the problem solving addicts among us. In his stead I hope to offer problems that will be as challenging and enjoyable as Joe's offerings have been. (Disclosure: These problems will almost never be my own inventions. Mostly I have saved them over the years from long forgotten sources or taken them from books of problem collections.)

In the transition from Joe's authorship to mine I have not received any of the solutions that were submitted to Joe's final problem, but Joe informs me that Paul Cripe submitted a solution. The solution I present is the one that occurred to me.

Joe's final problem: Prove that if $p(x)$ is a positive polynomial, i.e. $p(x) > 0$ for all x, then the polynomial formed by adding $p(x)$ and all its derivatives is also a positive polynomial.

Let $f(x) = p(x) + p'(x) + \cdots + p^{(n)}(x)$ be the polynomial formed by adding $p(x)$ and all of its derivatives. Two observations: (A) $f(x)$ and $p(x)$ have the same leading term, and (B) $f(x) = p(x) + f'(x)$. (A) implies that $f(x)$ has an absolute minimum at some point x_0. Substitute x_0 into (B): $f(x_0) = p(x_0) + f'(x_0) = p(x_0) > 0$.

Fall 2014 problem: Find all real solutions to the equation

$$\sqrt{x+3-4\sqrt{x-1}} + \sqrt{x+8-6\sqrt{x-1}} = 1.$$

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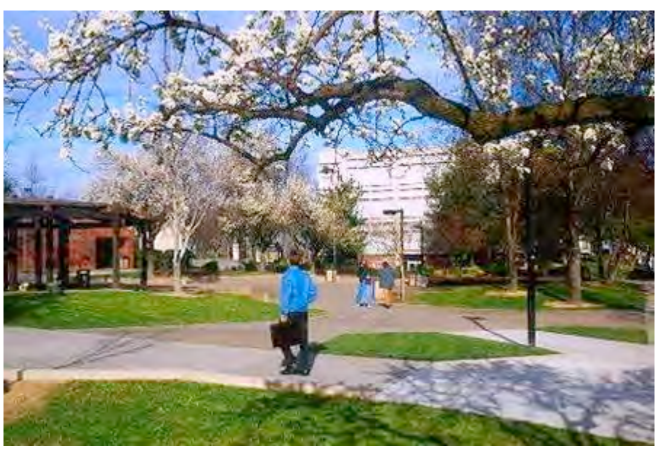
What's Happening at American River College

Ted Ridgway

The ARC math department has been working hard to focus on meeting our students' needs in new and creative ways. We've made good progress in a few different directions.

First, in order to help students get started in the right class, some of our faculty have developed a short-term summer program to help students prepare for their assessment tests. It is advertised to students who have taken the assessment test but disagree with their placements. It is designed to help students remember things that they used to know, more than to teach them from scratch. The students commit to attending for two weeks or more, for several hours a day. There is some lecture, but lots of practice and group work. At the end of the program, they are allowed to retake the assessment test if they would like. On average, students improved their placement by about one



course level, although some students improved more than that. Some students also chose not to retake the assessment, because they realized that their original placement was appropriate.

In the interest of improving student success, we have recently redesigned the classes that we offer in our Multimedia Math Learning Center (MMLC). The MMLC offers classes in which students work independently for the most part. They are able to move through the material as quickly as they are able, taking chapter tests along the way. Previously, the program was very flexible regarding attendance. Some students only came to the MMLC for their tests, but

otherwise had no contact with their instructors. Now each student is required to have at least one face-to-face conversation with their instructor per week. It is interesting to note that this amounts to more face-to-face conversation than many students get in traditional lecture classes. The early results have been remarkable. Success rates in our "Algebra Prep" sequence (arithmetic and prealgebra) jumped from 52% to 80%, and in our Algebra sequence (elementary and intermediate) it went from 50% to just over 75%.

We have also had a lot of success with our STATWAY courses, which are part of the nationwide effort led by the Carnegie Foundation to streamline course requirements. It is open to students who have completed (or placed out of) prealgebra. Interested students are required to attend an orientation before they register – those who want to take the course

(see "American River College" on p. 15)

Through the History Glass

J. B. Thoo, Yuba College, `jthoo@yccd.edu`

In the textbook we are currently using [4], as I am sure it is in many of today's textbooks, factoring is taught for primarily two reasons—to solve polynomial equations, and to work with rational expressions. It is interesting to note that this was not always the case.

Consider this: In order even to think of solving a quadratic equation, say, by factoring, one must first have the equation expressed symbolically (for example, $x^2 + 10x = 39$), and then one has to think of setting the expression equal to zero (for example, $x^2 + 10x - 39 = 0$). Neither of these conceptions existed until only a few hundred years ago.

At least until the 16th century, symbolic algebra as we know it today did not exist. In the very beginning, algebra was entirely rhetorical. Even al-Khwārizmī (ca. 780–850)—whose book, *Al-kitāb al-muh̲taṣar fī ḥisāb al-jabr wa'l muqābala* (*The Condensed Book on the Calculation of al-Jabr and al-Muqabala*), the title from which we derived the word "algebra" (*al-jabr*)—expressed his equations rhetorically. For example, he posed the problem [1, p. 543],

> [...] "one square, and ten roots of the same, amount to thirty-nine dirhams"; that is to say, what must be the square which, when increased by ten of its own roots, amounts to thirty-nine?

He did not solve this equation, $x^2 + 10x = 39$, by factoring. Instead, al-Khwārizmī instructed,

> [...] you halve the number of the roots, which in the present instance yields five. This you multiply by itself; the product is twenty-five. Add this to thirty-nine; the sum is sixty-four. Now take the root of this, which is eight, and subtract from it half the number of the roots, which is five; the remainder is three. This is the root of the square which you sought for; for the square itself is nine.

In other words, he solved the quadratic equation by completing the square.

Even Girolamo Cardano (1501–1576), to whom we attribute the cubic formula, although he used a shorthand for expressions (what we call syncopated algebra), provided his solutions rhetorically.

A watershed in the development of algebraic notation was François Viète's (1540–1603) introduction of the use of letters in his seminal work, *In artem analyticem isagoge* (*Introduction to the Analytic Art*). Berlinghoff and Gouvêa [2, p. 98] quote Viète:

> In order that this work be assisted by some art, let the given magnitudes be distinguished from the undetermined unknowns by a constant, everlasting and very clear symbol, as, for instance, by designating the unknown magnitude by means of the letter A or some other vowel...and the given magnitudes by means of the letters B, G, D or other consonants.

Still, Viète did not use symbolic algebra. Thus, he may have expressed $x^2 + 10x = 39$ as, "If to A *squared* should be added ten times A, the sum is thirty-nine *plane*."[1] Nevertheless, this was a great step forward in abstraction.

It was Thomas Harriot (ca. 1560–1621), who studied Viète, who finally gave us symbolic algebra. Harriot studied equations extensively, and he may have expressed $x^2 + 10x = 39$ as $aa + 10a = 39$. (Our present convention of using the latter letters for unknowns and the earlier letters for parameters was introduced by René Descartes (1596–1650) in his work, *La géométrie* [3]. It is also in this work that Descartes introduced our present notation for

[1] The use of the term "plane" is to maintain the homogeneity of the terms, that is, to ensure that all the terms have the same geometric dimension.

exponents.) Moreover, it was Harriot and Descartes who were the first known to have written equations systematically as "something = 0," and they even factored the left-hand side. However, they did this to study the relation between the roots of an equation and the coefficients of the polynomial expression, and not to solve the equation: the factors were formed already knowing the roots, then the expression was expanded. There were already formulas and numerical algorithms for solving equations, and factoring as a method is limited in scope.

Factoring as a first method for solving equations did not really appear in textbooks until well into the 20th century. Even as late as the early 20th century, an algebra textbook may devote three pages to factoring, with a handful of examples. Today, it is common to find an entire chapter on factoring, and I easily find myself spending as many as two weeks in class on factoring.

Jeff Suzuki asked in a talk that he gave at the Fall 2008 Eastern Sectional Meeting of the AMS, "Is factoring taught because it's important, or is it important because it's taught?" What do you think?

Previous columns are on the Web at <http://ms.yccd.edu/history-glass.aspx>.

References

[1] J. Lennart Berggren, "Mathematics in medieval Islam," in *The Mathematics of Egypt, Mesopotamia, China, India, and Islam: A Sourcebook*, edited by Victor J. Katz, Princeton Univ. Press, Princeton (2007).

[2] William P. Berlinghoff and Fernando Q. Gouvêa, *Math through the Ages: A Gentle History for Teachers and Others*, Oxton House, Farmington (2002).

[3] René Descartes, *The Geometry of Rene Descartes*, translated by David Eugene Smith and Marcia Latham, Cosimo, Inc., New York (2007).

[4] Elayn Martin-Gay, *Beginning & Intermediate Algebra*, 5th ed., Pearson, Boston (2013).

Answers to Quiz (from p. 4)

1. George Polya gave a talk at 8:15 pm on "Galieleo", though that sounds like a misprint.

2. The program was 1 day in each year 1976 and earlier. Then it has been at least 2 days for each year, starting with Dec. 1 – 2, 1977.

3. The Portola Plaza was formerly known as the Doubletree Hotel.

4. After being at the Asilomar Conference Grounds in 1973 and 1974, the conference used the Del Monte Hyatt House in 1975 and 1977. Other hotels along the way have included the Monterey Plaza Hotel, the Monterey Beach Hotel and the Holiday Inn.

5. Ronald Graham (former AMS President and AT&T Bell Labs researcher) gave a Plenary Talk in 1995 at 8:30 a.m. since there was no room for a lunch time keynote talk. Then he continued to participate in the conference until the closing 3 – 4 p.m. session "An Informal Conversation with Ron Graham".

6a. "Mathematics Proficiency" was discussed in 1982-1983.
Two sample talks were "Mathematics Proficiency, Associate Applicable Courses and Other Recent Events" and "Panel: Satisfying the Mathematics Proficiency Requirement".

6b. There were nine "Sacramento Scene" talks in 1998-2008, usually hosted by Zwi R. and Barbara I.

6c. There were five references to "Micro-Computers" in 1983-1987. For example, "Graphing Three Dimensional Functions on a Micro-Computer" was in 1987.

6d. 2005-2013. Wade E. and others have been talking about Student Learning Outcomes (SLO's) for the last 10 years now, and will continue to keep everybody well-informed in the future.

7. The first "Ignite" talks were in 2013 for 5 minutes per speaker. The Ignite motto is "Enlighten Us, but Make It Quick!". We plan to return to this format again in odd years like 2015 for a fun alternative to the usual Friday keynote.

CMC^3 Foundation Report

Debbie Van Sickle, Foundation President, Sacramento City College

Scholarships and Competitions

Last spring the CMC^3 Foundation awarded a total of $6,000 in scholarships to students attending four of our member colleges. For more information on last year's winners see the summer edition of the CMC3 http://www.cmc3.org/Newsletters/CMC3Summer13Newsletter.pdf. Early in 2015 we will begin sending application materials for our 2014/2015 scholarship competition. Stop by our table at the Monterey Conference in December for more information or go to our website at http://www.cmc3.org/foundation.html.

During the Monterey conference the Foundation sponsors a student poster contest that includes a $100 cash prize for the winner. A highlight of the CMC^3 Spring Conference at Lake Tahoe for the last couple of years has been a talk given by the winner of the Foundation's Student Speaker Competition. Debra Landre, a former CMC^3 President, has sponsored this scholarship for the last several years, allowing us to give the winner a $500 scholarship.

Applications for both competitions are open to any currently enrolled community college student in our region. More information about these competitions will be available on our website at http://www.cmc3.org/foundation.html.

Fundraising

CMC^3 scholarships are only made possible because of the generosity of our members, our vendors and other contributors. Everyone who is a member of CMC^3 is also a member of the Foundation. You can help us in several ways:

- Make a tax-deductible cash contribution*.
- Donate prizes for our raffle. The value of these items is also tax-deductible*. Donations can include (but are not limited to):
- Wine, beer, and other libations
- Candy, cookies and other non-perishable food items
- Gift cards for stores, restaurants, or services
- New items you received as a gift and can "re-gift" to us (stationary, books, t-shirts, electronics etc.)
- New gift baskets (store bought or homemade)
- New items we can add to other gift baskets
- Baskets (need not be new) we can use to make gift baskets
- Help us get cash or raffle prize donations from businesses or individuals. I especially would like help reaching out to publishers and other vendors that you may have an especially good relationship with.
- Purchase lots of tickets for our raffle and encourage your friends to do so as well.
- Purchase our t-shirts and other items for sale at our table during the conferences.
- Suggest new fundraising ideas to any member of our board.

I would like to thank everyone who made generous donations of money and prizes over the last year. Without your support none of our work would have been possible.

Welcome to our two new Foundation Board member

We are happy to announce the appointment of two new members to the Foundation board.

Karl Ting, who joined the Foundation board last spring, taught secondary school mathematics and computer science for twenty years. He earned an MS in computer science and

mathematics from San Jose State in 1987. In 1992 he joined the mathematics faculty at Mission College and began attending CMC^3 conferences soon thereafter. When asked why he wished to take a leadership role with CMC^3, Karl said, "As department chair, I have set a direction to involve more of my colleagues in professional matters outside of the college, so joining [the CMC^3 foundation board] is a start."

We also welcome Danny Tran, now in his fourth year at De Anza College after two years as a part-time instructor at Foothill College. Danny was an undergraduate at UC Berkeley

before earning his master's degree at Harvard. He has attended our fall conference for the past three years. He says of CMC^3, "I believe in its mission and would love to become a part of the council and help support math faculty all over the California community college system."

Continuing on the board are treasurer Rebecca Fouquette and CMC^3 past-president Susanna Gunther.

CMC^3 Foundation is a nonprofit charitable organization under section 501(c)3 of the Internal Revenue Code. Contributions are tax deductible to the extent allowable under federal law (as long as no goods or services are provided in exchange for the donation). Our Tax Identification Number is 94-3227552. Cash donations can be made in three ways:

- At the time you register for either conference (There is a box to check on the registration form. Please use a separate check, but mail it in the same envelope as your registration form.)
- In person at one of our conferences, either by check, cash, or credit card.
- By mailing a check to our treasurer Rebecca Fouquette, 595 Gettysburg Drive, San Jose CA, 95123

Columbia College

(continued from front p. 5)

As construction from a recent bond wraps up, the department is looking forward to moving to a newly remodeled building next summer. The facility is located near the science building and will have smart classrooms with doors connecting to the Math Lab in the center of the building. The new Math Lab will be significantly larger than our current space and will include an office for our Instructional Support Specialist, an office for our adjunct faculty, a quiet testing room and two group study rooms as well as several computers, lots of whiteboards and a teaching station for workshops. Beautiful new faculty offices will also be collocated.

Finally, this academic year the department will be focusing on curriculum development to support AA and AS transfer degrees consistent with the TMC's for science and math.

Statistics is *not* mathematics

Ken Bull, College of San Mateo

If you attend conferences on teaching statistics such as USCOTS you will encounter the idea that statistics is *not* mathematics. Is this true, and if so, in what sense is it true? Is it a useful idea? More specifically, does the idea have implications for teaching introductory statistics?

When I mentioned the idea to a colleague whose higher degree is in statistics, the first response was largely negative: "Of course statistics is mathematics!" The negative response arose probably because there was a time when some community college mathematics departments were reluctant to hire someone with a masters degree in statistics on the grounds that they (like engineers) were not real mathematicians, and thus could not be trusted to impart the core values of mathematical thinking. My colleague could easily have backed up the argument that statistics *is* mathematics by referring to the pages of any one of the major statistics journals, or to the CVs of statisticians at major research universities. Statistics as it is done at this level *is* heavily mathematical. Moreover the advanced degree training of statisticians continues to be heavily mathematical, although there is trend to emphasize more computer science.

However mathematical the discipline of statistics is in practice, this paper will argue that the slogan "statistics is not mathematics" does have important implications for the teaching of introductory statistics. It will argue that statistics cannot be taught in the same way that algebra or calculus is taught if we want to get across statistical thinking and the goal of statistical analysis.

To start off, suppose we describe statistics as applied mathematics; then we must consider the nature of that applied mathematics. Along these lines, another of my colleagues (this one a mathematician) suggested: "Statistics seems to be applied mathematics with just one question: 'What do the data mean?'" Almost but not quite; the situation is a bit more nuanced. Statistical practice is driven by specific questions to be answered by data. We can generalize quite a bit since there are similarities across contexts, but in practice, the specific statistical question is always important. Whereas for mathematics, context is often seen as a distraction, with statistics, context drives the data used, the analysis used, and the interpretations made. So, specific statistical questions influence three things, each of which is "covered" in an introductory statistics course; the three are: the data that are used, the techniques for the analysis of those data, and the interpretation of the data. Our introductory statistics courses typically emphasize the second of these, even though increasing emphasis is given to the first and the third. In the paragraphs that follow, we will consider the three aspects — interpretation, data production and techniques for analysis — in that order to show the ways that statistics instruction differs from mathematics instruction.

First off, interpretation — saying what the results mean — cannot be ignored: getting a numerical result is not sufficient. A numerical result generally does not by itself answer the statistical question. Moreover, interpretation must be taught; it does not come naturally, as is often assumed. There are conceptual mistakes that students make even at the most elementary level. For example, many students confuse the interpretation of measures of center/location with the interpretation of measures of variability. In addition, students need to be taught to be sufficiently specific to avoid writing nonsense: "The houses/females/roller coasters/fees are right skewed" or even worse: "*It* is right skewed." And when we get to the interpretation of confidence intervals or p-values, the problems intensify, as is well-known. Instructors who confront these interpretation issues are in a battle for clear thinking using language, and will often think that they have at least partly become teachers of English rather than of mathematics. Or as the students sometimes say: "The math (that is, the computation) is straightforward; how to put it in English is not." Some students come to appreciate the precision of the mathematical formulation compared with the potential ambiguity of language, and at the same time see the importance of being as careful in language as the mathematics is. (A simple example is: $P(\text{Liberal} \mid \text{Female})$ has a clear meaning; "the probability of liberal female " is ambiguous.) This emphasis on expressing the results of what we do with mathematics in clear language is largely though not entirely missing from mathematics teaching outside statistics.

The answers to statistical questions depend upon having good data, or at least adequate data. Data production — sampling and experimental design — is covered in textbooks increasingly more thoroughly, but most of the "general" treatment of data production has to do with learning terminology. The terminology used is helpful as a crude road map, but the road map is only somewhat useful in navigating the complicated by-ways by which data are actually produced in reality. At least the terminology given distinguishes between really bad data production from ideal data production; the reality that lies between these extremes is dealt with not so well, and it may be that for a first course, this is all that can be expected. So, the presentation of types of samples and the bit of experimental design is not "mathematical" in itself. There are definitely mathematical aspects to data production, as in sample size calculations for margins of error and power; for these one has to watch that the calculations themselves do not overshadow the more general lessons that more data is a good thing but that more data is a costly thing.

That the general lessons can easily be obscured by calculation is a danger in what is arguably the most "mathematical" part of the three aspects of teaching laid out above. What has traditionally been emphasized in statistics courses has been the working out of the techniques for analysis, the second of the three aspects of statistical practice.

Often, for both students and teachers, the expectation for a statistics course is: given some raw data, carry out a specific complete analysis (say, a two sample *t*-test) perhaps using a calculator or perhaps with the aid of some kind of software, but traditionally "showing all work" as in any other mathematics course. That this legacy is the expectation is partly because these kinds of tasks were appropriate when software was not available. However, I would argue that the expectation also stems from the "algebraic manipulation" tradition in mathematics teaching, from secondary level algebra and through calculus. At the levels we teach, doing mathematics typically means an exposition that is mostly a sequence of correct algebraic manipulations, hopefully nicely laid out, and logical. That is what we expect from "show your work." Even in solving identities in trigonometry and "show that" exercises in calculus, both of which have as one of their goals a preparation for proving things, the idea is to show a sequence of manipulations that leads the reader to the conclusion. In statistics, with some exceptions, this tradition of algebraic manipulation results mostly in pushing numbers through formulas. Some critical thinking may be introduced if the student has to choose which technique to use, but the "show your work" tradition usually means that the data set has to be small, and therefore probably unrealistic, if not fake.

At this point the reader may be surprised to learn that this paper is *not* against all such algebraic manipulation — even the pushing of numbers through formulas. One major reason for *not* being against this tradition is precisely because it is tradition: this is the way students have done their mathematics courses, and some of them (what proportion?) will say that they will only "understand" something mathematical when they have done a paper and pencil example. Fair enough; they are right to want to get some kind of hands-on experience, and this is what they have done in the past. They should be given the opportunity to do just that. However, they should not be allowed to think that the hand calculation is the goal. Rather it is just the first step.

A second reason for *not* being against hand calculation is that something must be done so that software is not a black box that magically produces results; no, some idea of what is going on is essential, and doing some things by hand is one but not the only way to achieve this goal. One interesting option to pure paper and pencil calculation is to use Excel or a graphing calculator to "step through" the parts of a formula, so that the process is seen without getting tangled up with computational errors. Of course, generally students have to be taught how to use formulas in Excel, or on a graphing calculator. The connection between calculations and a graphical representation can also help as well if this is not simply seen as something more to learn. For these reasons the formulas used for this hand calculation should generally not be the "calculating" formulas devised for "ease of calculation" in the time before software. Very often, these calculating formulas actually obscure what is happening; think especially of all of the places where deviations from the mean are used, and how this is hidden in the calculating formulas.

An entirely similar argument can be made for the graphical presentations that are a part of statistical analysis. Handwork such as making a dot plot may be appropriate to give an idea of what goes into a graphic (perhaps especially the tedium), but the important things have to do with the connections between the graphical presentation and the numerical summaries, and what they tell you in the context of statistical questions. Software can make far better graphs than most of us can by hand, however artistic we are. Moreover, statistics as it is practiced today continually jumps back and forth between graphical and numerical analysis.

The argument up to this point has been that the traditional "algebraic manipulation" focus of much mathematics teaching does not do justice to statistics because what needs to be taught does not (or should not) involve algebraic manipulation. Secondly, the parts of the course that do involve computation can be done much more effectively by software, with bigger and more realistic data sets, and with authentic statistical questions posed. We next consider a kind of "case study" to illustrate these points; the case study has to do with the teaching of the binomial distribution. The binomial distribution is chosen intentionally, as it may be argued that the topic is one of the most "mathematical" parts of what goes into introductory statistics: the binomial distribution is fairly abstract, it can be derived nicely from the conditions for its use, it has interesting links with other parts of mathematics, and at least traditionally it has involved lots of calculation.

An instructor who considers how to present the binomial distribution will be tempted to see that students learn to build a distribution given n and p, using the formula, and then perhaps graph the results. That instructor may also wish students to understand the connection between the conditions ("assumptions") and the working out of the formula, including the connection with the multiplicative rule for the probability of the intersection of independent events. If students can accomplish some or all of that, especially in a testing situation, the instructor will be very pleased. However, this accomplishment, though interesting and worthwhile will largely miss the point for the place of the binomial distribution within introductory statistics.

Why is the binomial distribution important for data analysis? Since the binomial distribution is a model for the distribution of the number of successes for independent trials with a given probability, and a fixed number of trials, it can be thought of as a sampling distribution for the number of successes for a random sample of size n. Now, sampling distributions are one of the most important ideas and one of the hardest ideas of the course. So, the binomial distribution has an important connection with inference, and inference needs to be at the center of our teaching. That inference be at the center is partly because the ideas of inference are so commonly abused in practice, and partly because a good foundation in inference will serve those students well who are bound for any profession using statistics.

So, how can the Binomial Distribution be used to strengthen the core inferential ideas of the course, rather than being an exercise in correctly using a complicated formula, or even understanding the mathematical connections in its development? Here are a couple of ideas. One of the ideas is an example that has been used by Allen Rossman and Beth Chance and some of their colleagues to introduce inference towards the beginning of the introductory course. (See www.math.hope.edu/isi/presentations/new_orleans.pps *for a good exposition of this idea as well as their general approach.)* Students are presented with side-by-side pictures of the faces of two white men; they are told that one of them is named Tim and the other Bob, and that their task is to assign the names to the faces. The statistical question is: do people associate one of the faces more with "Tim" and the other with "Bob" or, as one might logically expect, will the names get roughly equal face association? The obvious null hypothesis is that the one on the right (say) being named Bob is $p = 0.50$. Here is an obvious binomial situation associated with a statistical question, if the class size is taken as n. As it happens, there is typically a strong tendency for people to associate one of the faces with the name Tim and the other Bob, at least with the faces used. The binomial model with $p = 0.5$ is shown to be untenable, and so one of the keys to the logic of inference as used by statisticians is introduced very early on in what is thought to be a memorable class exercise. (As an aside: one is tempted to think of extensions of the idea to test whether the position of the faces on the page has an effect, or whether the order of the names mentioned has an effect, or whether one would get similar results with different names, or faces that were not white men – perhaps with different names.)

A similar but slightly harder idea would be to collect data on the day of the week that students were born; we would want to test the idea that weekend births occur with the probability $p = 2/7 = 0.2857$. (The Excel function WEEKDAY gives the day of the week for a given date, so students do not have to know the day of their birth.) In North America and probably Europe as well the proportion of weekend births is lower than one would expect if births were distributed equally to each day of the week. That this is so probably stems from the scheduling of induced labor births and Caesarian section births away from the weekend. The results from collecting data on birthdays will not be clear-cut as the Bob/Tim experiment, but it does have the advantage of being able to be connected to a likely explanation, and also uses the binomial distribution with a p not equal to 0.5. The examples (either Bob/Tim or Born-on-Weekend) are sufficiently rich to bring out the connection between what we can calculate using the binomial model with a statistical question, as well as the way such a question is handled by statisticians. If one has birth data, one can follow up the class exercise with a much larger data set. (Even better would be to have birth data from a place where one does not expect the "weekend effect".)

For this and other exercises involving the binomial distribution, a distribution calculator that incorporates a graph of the distribution is very useful. Statistical software packages for teaching should have one (e.g. StatCrunch has one) but an excellent choice is part of GeoGebra, because it is free and gives the complete distribution as well as a histogram showing the distribution and probability calculators for intervals. (In contrast, some on-line calculators that simply shoot back a specific calculation are not as useful for teaching.) Using such resources, one should be able to convincingly show that the binomial distribution approaches normality under sufficiently large n and can also show the usefulness of the rule for using the Normal distribution as the sampling distribution for inference for single proportions. The lesson plan for this trajectory will likely *not* involve only repeated calculations of the binomial distribution formula. It will involve questions about whether births are equally likely to happen on any day of the week, or whether there is an association between appearance and names. Should the instructor think that more calculation is important, it is always possible to assign exercises connected with the context that say something to the effect: "Show how the software calculated $P(X = 24)$" carefully chosen so that the binomial coefficient can be fairly readily calculated "by hand".

The important point is that the material presented, and the way it is presented should be tied to the overall goal of statistics. That is, something like the binomial distribution should be tied to statistical questions using data, including the very important caveat that the question may not be answerable with the data we have. At this point we confront another important difference between statistics and mathematics. An important part of statistical reasoning is a proper respect for handling uncertainty; that is, handling the essential fuzziness of our sight. With mathematics, the goal is to be certain; with statistics, the goal is to recognize and respect the extent of uncertainty in answering questions about the world "outside". But that is another topic.

American River College

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have to sign a contract stating the expectations of the program. After that, they are able to enroll in a two-semester sequence of six-unit classes that combine algebra and statistics. The second course articulates with transfer-level statistics. Most notably, the STATWAY program shortens a three-semester sequence (elementary algebra, Intermediate algebra, and statistics) to just two semesters.

In a similar vein, we have created a one-semester, nine-unit "Extreme Algebra" course, which takes students who have completed (or placed out of) prealgebra, and provides Elementary and intermediate algebra in one semester. Once again, students are warned that the course isn't for everyone. But those who take it are more successful than average. And once again, they get to shorten their path to graduation or transfer.

Finally, many members of our department are also trying to popularize and improve upon the low-cost, alternative course materials that are becoming more common. Several of our prealgebra instructors are using a text that was developed (and is still developing) in our department. Others are using MyOpenMath.com in place of the publisher-created websites, including one instructor who is using release time to develop a MyOpenMath course that pairs with the prealgebra text mentioned before. We are hopeful that in the future we'll be able to teach courses using materials that are as convenient and polished as what currently costs each student \$150 for a semester, but at a cost of \$30 or less.

Math Nerd Musings

Jay Lehmann, College of San Mateo

Last I heard, about 45 states had adopted the Common Core. As you are likely aware, California just adopted it this fall. Many of us will likely attend Larry Green's talk on the Common Core at our conference this December, in hopes of getting a better sense of what the Common Core is all about.

One of the goals of the Common Core is to have students attack unfamiliar problems. This strikes me as a vitally important goal. All too often our students mimic without much understanding of the underlying concepts. This is painfully obvious when we help students during office hours or tutor students at our math centers.

The beauty of unfamiliar problems is that they strip away any opportunity of mimicking, which is precisely why students have such a tough time solving them.

The million-dollar question is whether we can teach students how to solve such problems. I believe the answer is yes and no.

George Polya's book *How to Solve It* includes excellent suggestions, but they will only take a student so far. The rest of the way must come by students attempting to solve lots of unfamiliar problems. But where does an instructor fit into this? We can certainly discuss Polya's suggestions with our students, but perhaps an even more critical role is to determine an ideal progression of problems.

For students who have never attacked unfamiliar problems before, it's helpful to first assign problems that address concepts students have a firm grasp of. This will ensure that most students will solve most problems, which will build their confidence, a necessary ingredient to attacking harder problems.

Having students work in groups can be effective, although I believe students should sometimes work alone; otherwise some passive students may then mimic their teammate's solving strategies.

But how can any of this be included in our standard courses? Well, some courses lend themselves to it more easily than others. I believe a prime candidate is geometry. It's less important that students learn a long list of topics than in other courses. In fact, there are directed-discovery geometry textbooks on the market.

In other courses, we can certainly carve out time for few collaborative activities and assign some unfamiliar problems as homework. For the more daring, there are directed-discovering textbooks for courses other than geometry.

The beauty of unfamiliar problems is that they strip away any opportunity of mimicking, which is precisely why students have such a tough time solving them.

Several newsletter issues ago, I shared how I've included at least one challenging problem on each calculus test. This semester, I've decided to make these problems worth extra credit, mostly so I could make the problems as hard as I like, without even the slightest tinge of guilt. And, of course, most students love their inclusion. Extra-credit problems have this magic quality in students' eyes. I forgot to include one on my last quiz, and students begged me to put one on the board. Imagine. Students begging to solve yet another problem on a quiz!

I can just see your furrowed brow as you ponder the risk of grade inflation. But keep in mind that these problems are hard. Usually only one or two students make enough progress to earn extra points, and these students would likely get As, anyway.

I realize I'm breaking one of my own guidelines by making the problems so hard, but this is a work in progress. But what I'm enjoying is that significantly more students are working on the problems as the semester progresses. And I don't know if it will prove to be an outlier or a growing trend, but six students made enough progress on the most recent extra-credit problem to earn points.

What was the problem on the quiz? To find the derivative of the function $y = \ln x$. Up until that point, we had discussed how to differentiate implicitly, but we had not discussed anything calculus-related about $\ln x$. I *did* give a hint on the quiz: "Use implicit differentiation."

Even with the hint, I was surprised that 6 of 38 students would make such good progress (most of those 6 students did the complete proof but left their result in terms of y, which they'd been conditioned to do from practicing implicit differentiation). This made me realize that I'm probably selling my stronger students short. It makes we wonder how much more they are capable of. I will likely find out from future extra-credit problems!

After the quiz, we moved on to the section about differentiating logarithms, and the first thing I did was demonstrate how to differentiate $\log_b x$, which is essentially the same proof as differentiating $\ln x$. Imagine the buzz of pride in those six students who had already proved the result. My hope is that they would start to wonder how much of the rest of calculus they could discover themselves.

Another benefit of the extra-credit problems is that all students are kept busy for the full time and, more importantly, they are challenged. For example, one of my two strongest students finished our most recent test well ahead of time, but spent the rest of the hour attacking the extra-credit problem.

For all quizzes and tests, I hand out solution keys when I give back the graded work, but I include neither solutions nor answers to the extra-credit problems, encouraging my students to continue to work on them.

It's wild to consider the type of students we might inherit from the Common Core. On the one hand, my son is a junior in high school and I see no evidence in his homework assignments that he's working on unfamiliar problems; this makes me wonder how many teachers will embrace the true spirit of the Common Core. On the other hand, it is early and if teachers eventually take to the Common Core, imagine the impact of students attempting to solve such problems from kindergarten through high school!

To see the full impact will take 13 years, and I might retire before then, but just in case the impact is evident well before then, I plan to continue playing with my extra-credit problems so I can be ready for them.

Calendar

November 13-16, 2014: 40th Annual AMATYC Conference, Nashville, TN. Contact: AMATYC Office, amatyc@amatyc.org.

December 5-6, 2014: **42nd Annual CMC³ Fall Conference**, Hyatt Regency Monterey Hotel and Spa, Monterey, CA . Contact: Joe Conrad (707) 864-7000 x4372, JosephConrad@solano.edu

March 6, 2015: **AlaMATYC 2015 Annual Conference - "Mathematics: Learning to Infinity"**, Faulkner State Community College, Fairhope, AL. Contact: Michael Green. Website: http://alamatyc.wix.com/alamatyc

March 14, 2015: **CMC³-South "Super Pi Day" Conference**, Anaheim, CA. Contact: Art Nitta and Maribel Lopez. Website: www.cmc3s.org

April 9-11, 2015: **40th Annual IMACC Conference**, Allerton Park, Monticello, IL. Contact: Connie McLean. Website: www.imacc.org

April 10, 2015: **NEBMATYC 2015**, Metro Community College, Omaha, NE. Contact: Steven Reller. Website: www.northeast.edu/Organizations/NEBMATYC

April 17-18, **2015 Annual CMC3 Recreational Mathematics Conference**, MontBleu Hotel, S. Lake Tahoe, Contact: Mark Harbinson harbism@scc.losrios.edu, www.cmc3.org.

April 17-19, 2015: **48th NYSMATYC Annual Conference**, Rochester, NY. Contact: Larry Danforth. Website: www.nysmatyc.org

December 11-12, 2015: **43rd Annual CMC³ Fall Conference**, Hyatt Regency Monterey Hotel and Spa, Monterey, CA . Contact: Joe Conrad (707) 864-7000 x4372, JosephConrad@solano.edu

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