# Mathesis

Volume 48, Issue 4 May 2016

## *President's Message*

By Cecile Carlton

Even though parts of New Hampshire experienced snow in the last week of April, it REALLY is Spring. On March 18, 2016 NHTM held its annual conference – a HUGE THANK YOU to Keene State College for the use of its facility (and especially to Dr. Beverly Ferrucci who negotiated the use of rooms in the Putnam Science Center). It was ideal for the 30 sessions offered to approximately 140 participants, and space for fifteen exhibitors. We also extend our gratitude to the presenters and volunteers who made it come together and to those who were able to participate in the varied sessions. In addition, Dr. Eric Feldborg from the NH Department of Education provided the Keynote address around STEM education. Stephanie Wheeler was the recipient of our Balomenos Service Award and Stefan Fritz was awarded the Prevost Teaching Award. More detailed information can be found at our website www.nhmathteachers.org.

In April, I had the opportunity to attend the NCTM Annual Conference held in San Francisco CA. It is always revitalizing as well as overwhelming. So much to choose from. At the delegate assembly, NHTM was recognized for the number of its members who are also NCTM members. Terri Magnus, our NCTM Representative received on behalf of NHTM the 2016-2019 Leadership Circle Silver Level Member recognition from Diane Briars, NCTM President.

**Inside This Issue**

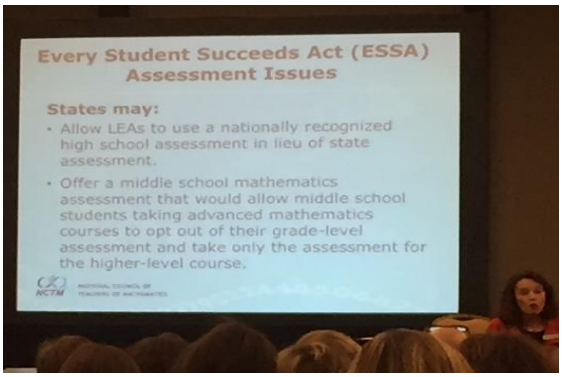
## *President's Message*

(CONTINUED FROM PAGE 1)

By Cecile Carlton

Sessions of interest included messages from NCTM related to advocacy for ALL students (see NCTM Position Papers http://www.nctm.org/Standards-and-Positions/NCTM-Position-Statements/); concerns from the *Every Student Succeeds Act* (ESSA) connected to assessments; NCTM's interest in focusing on systemic improvement in High School Mathematics, including a move to an integrated high school mathematics course; to teacher preparation, where "the status quo is unacceptable". Information about *Common Vision – for Undergraduate Mathematical Sciences Programs in 2025,* was shared. Key components of the report include (1) update curricula; (2) articulate clear pathways for curricula driven by changes from K-12 level and courses students take in college; (3) scale up evidence based pedagogical methods; (4) find ways to remove barriers; (5) connect to STEM. (One can secure a copy of the report from the Mathematical Association of America website or link to a copy here.).

Other sessions of interest included essential knowledge for teachers connected to the teaching of statistics [Policy document for Statistics and Probability – teachers need to know – **SET** *Statistical Education of Teachers*: http://www.amstat.org/education/SET/SET.pdf] and *Guidelines for Assessment and Insruction in Mathematical Modeling Education* (GAIMME), which can be found on-line http://www.siam.org/reports/gaimme-full_color_for_online_viewing.pdf or from http://www.siam.org/reports/gaimme.php]




**Contents include:**

- What is Mathematical Modeling?
- Early Grades (K–8)
- High School (9–12)
- Undergraduate
- Resources

**Also includes:**

- Example problems and solutions
- Levels of sophistication
- Discussion of teacher implementation
- Suggestions for assessment

**Funded by**

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Another session I really enjoyed was given by the San Francisco School District, where they made a bold move and removed leveled mathematics courses through High School. Their session was titled ***Fighting the Good Fight: Standing Up for Equity in Mathematics***. Check out more specific information at this link: http://www.sfusdmath.org/secondary-course-sequence.html.

And for those who are interested in ***"Engaging the Struggling Student***" NCTM announced it is holding an INNOV8 Institute November 16-18, 2016 in St. Louis. More information can be found at http://www.nctm.org/innov8/. Participants

## *President's Message*

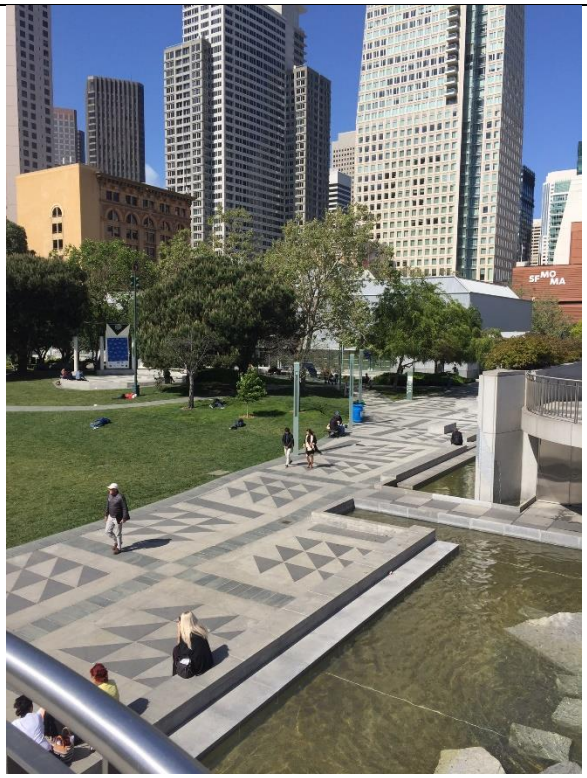
(CONTINUED FROM PAGE 2)

are encouraged to send teams of teachers. We will see if the NHDoE is interested in identifying a team and then work to disseminate the information to teachers in New Hampshire.

This is just a sample of the resources and information gleaned. More resources will be added to our NHTM web site resource page. Also, I share greetings from former PSU faculty and current NHTM members Dr. Barbara Boschmans and Dr. Brian Beaudrie who now teach and reside in Arizona. They are co-chairs for NCTM's regional conference that will be held in Phoenix, AZ October 26-28, 2016.

And last but not least, Matt Larson, who will be joining us in Manchester, NH on October 20-21, 2016 for our ATMNE 2016 Conference, had an inspiring session on *A Brief History of Mathematics Education: Lessons for Today*. The key message was the pendulum swings back and forth between procedural and conceptual understanding in mathematics. He talked about the "RESISTANCE CYCLE" and provided some excellent ideas for deeper learning. Perhaps he will be willing to share more of this message with us in October, stay tuned and keep checking the website atmne2016.org.

Thank you for the privilege to serve as your NHTM President for the past two years. It has been a pleasure and it has allowed me to work on my goal of continuous improvement of mathematics education for the students of New Hampshire! My best to all of you!



Math is everywhere! Where NCTM Conference was held in San Francisco, we walked from the Moscone Centers (North, South and West) to the Marriott for various sessions. It put miles on our Fit Bits!

## *Post Secondary Representative*

By Rich Andrusiak

As this is my final column as post-secondary representative, I want to thank the NHTM board and the mathematics teachers of NH for their support. I'm grateful for the time that I've spent on the board serving the NH mathematics community. Congratulations and welcome to Sharon McCrone – our newly elected post-secondary representative!

The landscape of post-secondary education is changing quickly. With tuition rates at levels making it difficult for students to obtain degrees without mortgage-sized debt, students are looking for alternatives and becoming more "mobile" between institutions and thus raising the conversation regarding transferability of credits and course equivalencies. I'm pleased that the Community College System of New Hampshire (CCSNH) and the University System of New Hampshire (USNH) are working together to create course equivalencies in STEM fields. We need to advance to the point where students can take mathematics courses across colleges in both systems and have them transferred as equivalencies. These course equivalencies are a key step in graduating more STEM majors.

Another pressing issue remains the percentage of students requiring developmental mathematics course work when they enter college. The state has finally increased the high school graduation requirement in mathematics. We need to continue to work to create specificity regarding the mathematics required for graduation. The CCSNH is engaged in a project working on a co-requisite model to developmental mathematics education. Far too many students requiring remediation do not complete their gateway mathematics courses or go on to complete college degrees. Early data, from large states, adopting the co-requisite model that CCSNH is exploring, indicate large increases in the percentages of students completing gateway courses and subsequently completing college degrees in comparison to students placed in traditional developmental models. There are lots of interesting questions to explore, including impact on problem-solving and critical thinking skills and habits of the mind, along with maintaining high levels of rigor.

We need to continue to work as a state to address some of these pressing issues. A few years ago, I put a call out to the college community in an attempt to create a post-secondary mathematics education taskforce to discuss challenges and how we can address them as a state. We are all very busy people; however, I still hope that such a taskforce will be created.

It has been a pleasure working with a great group of dedicated, passionate, and committed mathematics educators.

## *NCTM Representative*
## **Mindsets, Modeling, and Muir**

By Terri Magnus

I appreciate the fact that my position requires me to attend the NCTM (National Council of Teachers of Mathematics) Annual Conference, to meet with leaders of NCTM and other NCTM affiliates, and to represent NHTM at the regional caucus and delegate assembly. The regional caucuses enable affiliate representatives the opportunity to network with each other, learn how to improve our own affiliates, and share input on our relationship with NCTM. The delegate assembly meets the next morning to learn about the new initiatives at NCTM, to recognize new affiliates and award winners, and to vote on any resolutions brought forward by an affiliate. This year, there were no resolutions to vote on; instead, Diane Briars, the outgoing NCTM president, after her planned presentation, gave affiliate representatives the opportunity to share our needs and concerns with her and other officers. The animated discussed continued for about an hour and touched on many items. I even had a chance to ask about what NCTM was doing to ensure that ALL teachers of mathematics--not just those active in NCTM and its affiliates--get the mathematical content knowledge needed for effective teaching through credential requirements or continued professional development. Diane Briers assured me that NCTM and AMTE (Association of Mathematics Teacher Educators, another NCTM affiliate) were indeed working on some initiatives in that area. Hopefully, I will be able to report on their progress in the future. In addition, expect to hear more about NCTM's ongoing work on equity in mathematics education.


Of course, the conference is filled with many presentations and workshops designed for the sharing of great ideas for classrooms and current research into mathematics education. One topic, Mindsets, has permeated every mathematics conference I've attended recently and it continued to be a hot topic in San Francisco. Coined by Carol Dweck, a growth mindset is when one believes that abilities can be developed and a fixed mindset is a belief that ability (particularly mathematical ability) is something that you either have or don't have. Children who are praised for their intelligence or talent don't want to work harder, but those who are praised instead for their perseverance, strategies, and processes, grow not only in their mathematical ability but also in their ability to tackle life's challenges. Presenters, including Jo Boaler, Eduardo Briceño, and Uri Treisman, demonstrated the importance of developing growth mindsets and how growth mindsets can be encouraged in the classroom.

It is not just our students' mindsets that need to be challenged in order to promote high quality mathematics teaching. We need to influence our students' parents, our legislators, and other voters and decision makers to recognize good quality

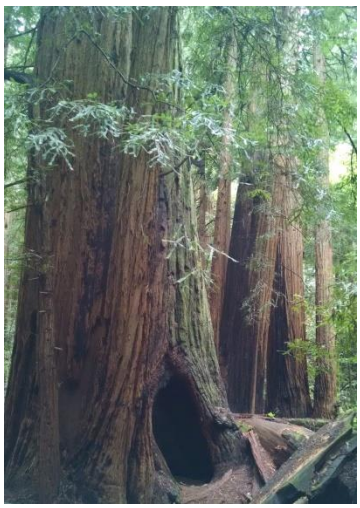
## *NCTM Representative*
## Mindsets, Modeling, and Muir

(CONTINUED FROM PAGE 5)

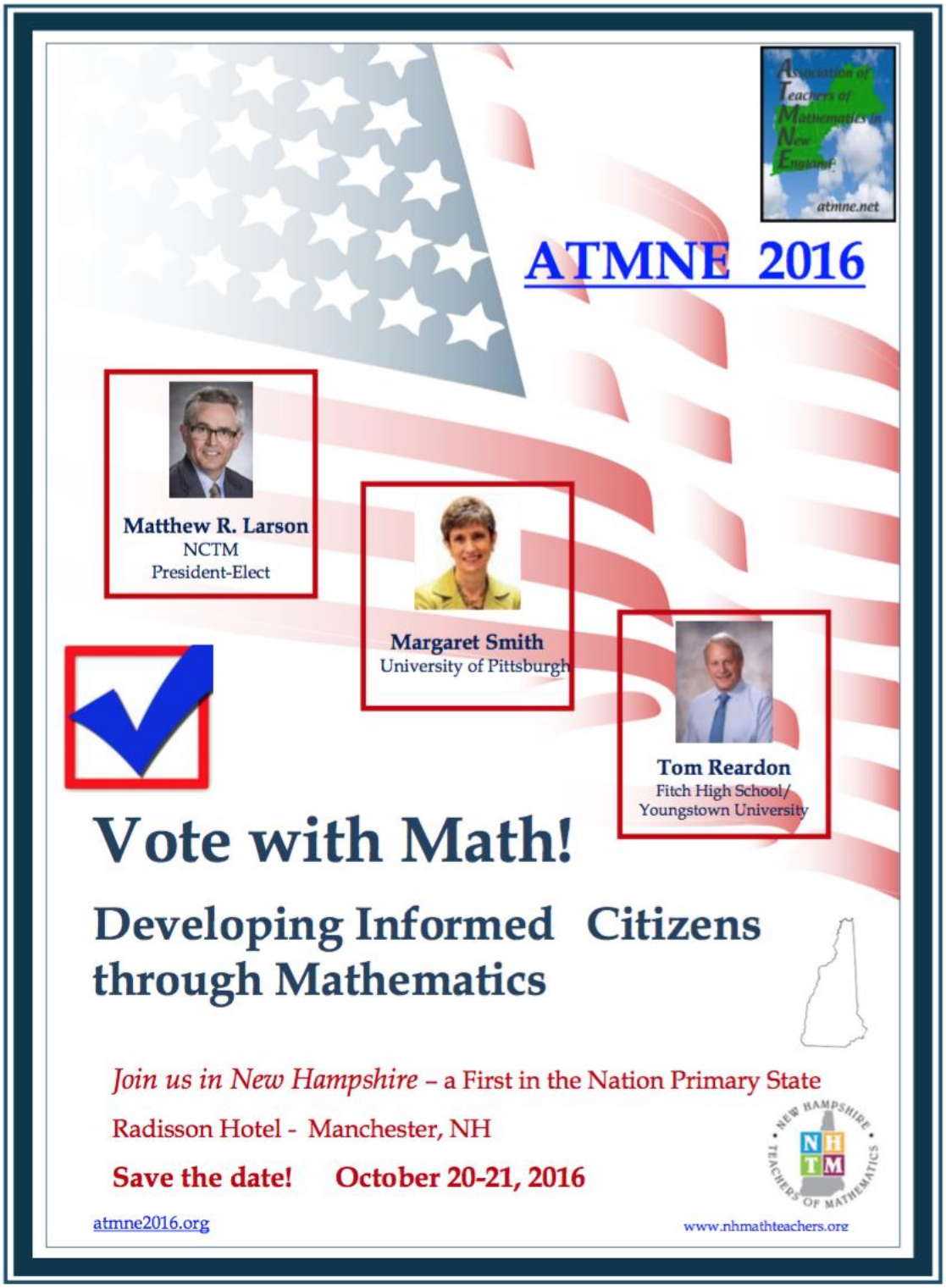
mathematics education. In this election cycle, many a candidate has taken an anti-Common Core or a back-to-basics stance on mathematics education and education in general. The incoming NCTM President, Matt Larson, reminded us that this cycling between mathematics education reform and traditional teaching is not new; it just resurfaces under new names. While the national organizations do their part to advocate for research-proven teaching methods, he suggested that teachers have the most critical role in breaking this cycle. As teachers, we have the opportunity to talk to administrators and to parents about how what we are doing in our math classes helps students not only perform procedures, but also understand the concepts, think critically, and solve real world problems.

Speaking of real-world problems, GAIMME (Guidelines for Assessment and Instruction in Mathematical Modeling Education) is a new document designed to help teachers understand the nature of mathematical modeling and how to incorporate it in our curriculum. Here mathematical modeling refers to the application of mathematics to solve real-world problems and goes beyond the standard word problem. The guide, available at http://www.comap.com/Free/GAIMME/index.html, gives recommendations for implementation at all grade levels. As a teacher of Mathematical Problem Solving and Modeling at Rivier University, I found the sessions related to this document to be very interesting and I'm looking forward to presenting on this topic at the ATMNE Conference in October. The table of contents of this document, is given in Cecile Carlton's "From the President" column, also in this *Mathesis*. Her column discusses some of the other initiatives and resources discussed at the conference.

The conference was not all work though. I enjoyed the opportunity to come a day early and explore another part of the country; in this case, checking out the redwoods in Muir Woods and viewing San Francisco both up close and from the other side of the bridges. Hopefully, you will consider joining me in San Antonio next year for NCTM 2017. We might be able to squeeze in some Spanish Mission tours and Mariachi music in addition to the mathematics.



In the meantime, consider some of the other NCTM professional development opportunities. Register now for NCTM's Summer Interactive Institutes: Engaging Students in Learning: Mathematical Practices (grades K-8 July 11-13 and grades 9-12 July 14-16) in Atlanta, Algebra Readiness (grades 6-8) in Denver July 18-20, and Connecting Number and Operations in the Classroom (grades PK-5) in Denver July 21-23. It's also time to start preparing to attend the new Innov8 Conference, "Engaging the Struggling Learner" in St. Louis, Nov. 16-18.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## *Secondary Representative*

By Michelle Fox

It is the end of the year and classes are winding down, and schedules for next year's classes are being processed. Now that four years of mathematics are required of high school students, students have to take a mathematics course each and every year of their high school careers. As a math-lover, I am thrilled that this is a graduation requirement now, and that the number of mathematics courses needed to graduate is equal to the number of English courses.

Students should be as prepared for college and post-secondary careers as possible when they leave high school, and the more exposure that students have to different mathematics courses, the better. This new requirement will force students to take more mathematics courses, and therefore be more likely to touch on subject matter that they will need for their future careers in college or in the work force.

This new graduation requirement will ensure that students are taking a mathematical based class in their senior year. Students who "take a year off" from math their senior year are not being exposed to mathematics before they take their college placement exams and such. It is never a bad idea to make sure that students are using their "mental math muscles" in a mathematics course their senior year…and with mathematics fresh in their minds, hopefully will be able to achieve higher scores as a result.

Schools offer dozens of courses each year to their students. Only a small portion of those courses is required for graduation. Many students will only take the absolute minimum number of courses and are content to just fulfill their graduation requirements vs. pushing him/herself to take a rigorous course load, despite the efforts of great guidance counselors, teachers, and their parents to get them to do otherwise.

In closing, I hope that the students of New Hampshire high schools take as many courses as possible to ready them for their futures. That will now include four full years (credits) of mathematics-based courses. Those that were slow or resistant to taking a fourth course (previously not required of NH students) will now have to take it in order to graduate. I think this will only mean good things for the future of these students, and open doors for them that would have otherwise been closed.

# Results of the 44th annual NHTM - PSU Contest

By Stephen Latvis

Our 44th Annual State Mathematics Contest is history. The coaches loved the larger space for the meeting, thanks to Plymouth State University for being such a gracious host once again. Fifty-four schools registered and competed on March 15th. This was an awesome turnout once again and we want to thank everyone for participating.

We extend our congratulations to our outstanding performers and to our winning teams and advisors in each division. High praise is due to Kellie Gabriel and her Nashua High School **South** team (from the Large School Division) for their performance in achieving a score of 263 points out of a possible 432 points. Rounding out the first place schools by division: Hollis Brookline High School in the Intermediate School Division earned a score of 247 points, Derryfield School in the Small School Division earned a score of 212, and Bishop Brady in the Medium School Division earned a score of 193. Bravo! Five students achieved a near-perfect score of 32 points this year – seniors Eric Osgood (from Belmont High School), Wanchen Jiang (from the Derryfield School), and Anli Zhang (from Bedford High School); junior Nisha Devasia (from Nashua High School SOUTH); and freshman Anusha Murali (from Bishop Brady)

A separate sheet identifying these students, as well as a number of students that achieved a score of 28, is included at the end of this letter. Name plates for all plaques are being engraved as of the writing of this letter. All awards and all name plates will be mailed or delivered to you. Do let me know if I owe you an Outstanding Performance Individual Award (how many and for whom). Please note that only scores of 32 received an individual award this year!

Our sincere thanks for the contributions all of you made to the contest by performing your duties so well. Many of you did other tasks before, during, and after the contest that assisted in getting the details accomplished. Our special thanks to those who were able to accommodate our needs at the site – Professors Shawn Hackshaw of the PSU Math Department and Karen Weldon, Coordinator of Activities at the Hartman Union Building; to Donna Kelley and her team of question writers; to Jeanine King for heading up registration; to the chairpersons of all the various duties on contest day – Jim Brizard, Ellen Berchtold, Greg Morris, Lorainne Mascioli, Sue Capano and Michelle Morton-Curit; to “team refreshments” for helping me with the food for the coaches; and to any others I may have missed who assisted myself and others attending to the small details on the day itself.

The final stats are still available online at **http://tinyurl.com/44statecontest**; a separate analysis has been done in the past and will be sent at a later date. I am still working with a colleague to have the certificates for perfect scores in specific categories to be sent to you; these will be sent out shortly. **Thank you to those that responded so promptly to my e-mail asking for you to verify the spellings of your students’ names**. Again, our sincere congratulations and thanks to all of you. We hope you are now planning to be present for our 45th contest next spring.

# Results of the 44th annual NHTM - PSU Contest

(CONTINUED FROM PAGE 8)

**SMALL**

| | | |
|---|---|---|
| Derryfield School | 212 | **1** |
| Epping | 82 | 7 |
| Gorham MHS | 94 | 4 |
| GBeCS | 85 | 6 |
| Hopkinton | 155 | **3** |
| Lisbon | 74 | 8 |
| Moultonborough | 87 | 5 |
| Newmarket | 49 | 10 |
| Portsmouth Christian | 175 | **2** |
| Woodsville | 57 | 9 |

**MEDIUM**

| | | |
|---|---|---|
| Belmont | 112 | 8 |
| Bishop Brady | 193 | **1** |
| Bow | 172 | 4 |
| Campbell | 102 | 12 |
| Fall Mountain | 104 | tie-10 |
| Gilford | 107 | 9 |
| Hillsboro-Deering | 80 | 16 |
| Inter-Lakes | 90 | 14 |
| Kearsarge | 136 | 5 |
| Laconia | 127 | 6 |
| Lebanon | 185 | **3** |
| Newfound Regional | 122 | 7 |
| Raymond | 104 | tie-10 |
| Somersworth | 93 | 13 |
| Trinity | 188 | **2** |
| Winnisquam Regional | 88 | 15 |

**INTERMEDIATE**

| | | |
|---|---|---|
| Bishop Guertin | 160 | 9 |
| Coe Brown Northwood | 128 | 13 |
| ConVal | 159 | tie-10 |
| Hanover | 171 | 5 |
| Hollis Brookline | 247 | **1** |
| John Stark | 85 | 16 |
| Kingswood | 81 | 17 |
| Merrimack | 95 | 15 |
| Merrimack Valley | 106 | 14 |
| Milford | 145 | 12 |
| Oyster River | 168 | tie-6 |
| Pembroke | 159 | tie-10 |
| Plymouth | 188 | **3** |
| Portsmouth | 180 | 4 |
| Sanborn Regional | 72 | 18 |
| Souhegan | 167 | 8 |
| Windham | 168 | tie-6 |
| Winnacunnet | 189 | **2** |

**LARGE**

| | | |
|---|---|---|
| Bedford | 166 | 6 |
| Dover | 193 | **3** |
| Exeter | 142 | 9 |
| Keene | 156 | 7 |
| Londonderry | 191 | 4 |
| Nashua NORTH | 188 | 5 |
| Nashua SOUTH | 263 | **1** |
| Pinkerton | 221 | **2** |
| Salem | 151 | 8 |
| Timberlane | 141 | 10 |

*Post Secondary Representative*

# Activity- Mathematics and Voting

By Rich Andrusiak

The following activity introduces students to common voting methods and the flaws encountered.

Voting is fairly straightforward if only two candidates exist. That is, if Candidate A receives more votes than Candidate B, then Candidate A should win the election. However, things become more complicated as soon as three candidates enter the picture. In this activity we will look at some various methods of voting and evaluate them based on “fairness criteria.” We will discover these criteria as we work through the activity.

**Plurality**

Plurality is the voting method that you are probably most familiar with. In this method, the candidate with the most votes wins the election. Furthermore, voters cast a single vote for the one person that they like the most (or hate the least). Consider the following election consisting of three candidates (Alisa, Quinn, and Linda), where each voter voted for the candidate that they like the most. Note that the total number of voters is 66.

**Table 1**

| **Number of Voters** | | | |
|---|---|---|---|
| | 24 | 31 | 11 |
| **First Choice*** | Alisa | Quinn | Linda |

*Note: voters only choose a first choice in the plurality method

1) A candidate receives the majority of the votes if he or she receives greater than 50% of the votes. In the above case, does any one candidate receive the majority of the votes? Explain.

2) Who is declared the winner using the plurality method? Explain.

3) Consider an election consisting of four candidates. What percentage of the votes does a candidate need to win the election using the plurality method?

4) Fill in the table below indicating the percentage of votes needed to win an election consisting of a different number of candidates using the plurality method.

*Post Secondary Representative*

# Activity- Mathematics and Voting

(CONTINUED FROM PAGE 10)

| Number of candidates | Percentage of votes needed to win using the plurality method |
|---|---|
| 3 | |
| 4 | |
| 5 | |
| 6 | |
| .<br>.<br>. | |
| 10 | |
| .<br>.<br>. | |
| *n* | |

5) Do you think the plurality method of voting is a fair method? Explain. Consider what happens as the number of candidates increases.

6) Explain how it is possible that a “very unpopular” candidate could be elected using the plurality method.

Now, assume that the voters from Table 1 were asked to rank the candidates in order of their preferences rather than just choosing the person they preferred the most. The results of the preference voting from the same group of voters from Table 1 is shown in Table 2. [You may wish to verify that all six possible ways of ranking the candidates is show in the table.]

**Table 2**

| | Number of Voters | | | | | |
|---|---|---|---|---|---|---|
| | 4 | 20 | 18 | 13 | 10 | 1 |
| **First Choice** | Alisa | Alisa | Quinn | Quinn | Linda | Linda |
| **Second Choice** | Quinn | Linda | Alisa | Linda | Alisa | Quinn |
| **Third Choice** | Linda | Quinn | Linda | Alisa | Quinn | Alisa |

7) Which candidate is the third choice of the largest number of voters? Explain.

8) Consider your answer to question 2. Does this impact how you feel about the “fairness” of the plurality method?

*Post Secondary Representative*

# Activity- Mathematics and Voting

(CONTINUED FROM PAGE 11)

**Borda-Count Method**

Jean-Charles Borda was concerned that the plurality method of voting was flawed since it didn't consider how voters would rank candidates. So, he purposed a method based on a point system. In an election with three candidates, each time a candidate is ranked first, he or she receives 2 points; each time a candidate is ranked second, he or she receives 1 point; each time a candidate is ranked third, he or she receives no points. [Note: other point assignments are possible.]

9) How many points would a first choice ranking receive in an election with 10 candidates? Explain.

10) How many points would a first choice ranking receive in an election with *n* candidates? Explain.

11) Referring back to the election shown in Table 2, determine the winner based on the Borda-Count Method. Show your work and fill in the total number of points for each candidate in the table below.

| Candidate | Number of points |
|---|---|
| Alisa | |
| Quinn | |
| Linda | |

12) Compare your results to those of Table 1. Given this situation, which method (Plurality or Borda-count) seems more fair? Explain.

13) Is it possible for a candidate to receive the majority of first place votes (i.e., greater than 50% of the first place votes) and lose the election using the Borda-count method? Explain. If "yes", give an example to support your answer assuming that we still have 66 voters who are voting for Alisa, Quinn, and Linda (you can use the table below for your answer).

| Number of Voters | | | | | | |
|---|---|---|---|---|---|---|
| | | | | | | |
| **First Choice** | Alisa | Alisa | Quinn | Quinn | Linda | Linda |
| **Second Choice** | Quinn | Linda | Alisa | Linda | Alisa | Quinn |
| **Third Choice** | Linda | Quinn | Linda | Alisa | Quinn | Alisa |

*Post Secondary Representative*

# Activity- Mathematics and Voting

(CONTINUED FROM PAGE 12)

For a voting system to be "fair", it is reasonable to assume that whenever a candidate receives the majority of first place votes, he or she should be declared the winner. This is known as the **Majority Criterion.**

14) Does the plurality method satisfy the Majority Criterion? Explain.

**Condorcet's Method* (pairwise majority rule)**
A little more than a decade after Borda's work Marie Jean Antoine Nicolas Caritat, the Marquis de Condorcet, suggested another method of voting. The Condorcet Method considers each pair of candidates in a head-to-head election. If one candidate is found to be the winner over all the others in the pair-to-pair contest, this candidate is considered the Condorcet winner.

15) Fill in the following table for each of the head-to-head matches for the election shown in Table 2.

| Head-to-Head Match | Number of votes for first candidate over second | Number of votes for second candidate over first | Winner of Head-to-Head match |
|---|---|---|---|
| **Alisa vs. Quinn** | | | |
| **Alisa vs. Linda** | | | |
| **Linda vs. Quinn** | | | |

*Any voting system that satisfies the Condorcet Criterion (see below) is considered a Condorcet Method. For our purposes we will consider the pairwise majority rule method but refer to it as the Condorcet Method. Also note that there are many different types of pairwise voting systems.

16) Who is the Condorcet winner? Explain.

17) Compare your result to the winners as determined by the Plurality Method and the Borda-Count Method.

One of the flaws with Condorcet's Method is that it doesn't always produce a winner and results in a cycle.

18) Design the preference schedules for an election consisting of three people where the Condorcet Method does not produce a winner.

*Post Secondary Representative*

# Activity- Mathematics and Voting

(CONTINUED FROM PAGE 13)

A second flaw with the Condorcet Method is that it doesn't always produce the same winner as the Borda-Count Method.

19) Design the preference schedules for an election consisting of three people where the Condorcet Method produces a winner but not the same winner as the Borda-Count Method.

20) In an election of 4 candidates, how many pairwise comparisons does one need to make for the Condorcet Method? How many comparisons with 5 candidates? *n* candidates?

21) What is the maximum number of pairwise wins a candidate can have in an election with a total of *n* candidates?

**Single Runoff**

In the Single Runoff system one takes the two candidates with the most first place votes and considers a pairwise election of these two candidates (Here, we will consider the preferences to remain the same. That is, looking at the preference schedules determines how many ballots rank one candidate over the other) and the candidate with the majority of the votes wins.

22) Consider the election in Table 2. Find the winner using the Single Runoff method.

23) Design the preference schedules for an election consisting of three people where the winner determined by the Single Runoff Method is not the same as the winner determined by the Condorcet Method.

Kenneth Arrow, a Nobel-prized winning economist, was interested in analyzing elections consisting of three or more candidates where candidates are ranked. He investigated creating a method of voting that would adhere to certain desirable criteria. As a simplification of his work, we will consider four "fairness criteria." Kenneth Arrow showed that it is not possible to have a method of voting, other than a dictatorship, which adheres to all of these criteria.

**Majority Criterion**

If a candidate receives the majority (greater than 50%) of the first-place votes, then that candidate should win the election.

**Condorcet Criterion**

If a candidate is favored over every other candidate in pairwise comparisons, then that candidate should win the election.

*Post Secondary Representative*

# Activity- Mathematics and Voting

(CONTINUED FROM PAGE 14)

**Transitivity**
If a voting system prefers Candidate A over Candidate B and Candidate B over Candidate C, then the system should prefer Candidate A over Candidate C.

**Monotonicity Criterion**
Suppose Candidate A is considered the winner of an election and a second election needs to be held. If some voters rank Candidate A higher in the second election without changing the relative order of the other candidates, then Candidate A should win the second election.

**Independence of Irrelevant Alternatives**
Suppose Candidate A is considered the winner of an election and a second election needs to be held. If no voter changes their preference and one or more of the losing candidate drops out of the election, then Candidate A should win the second election. [When one candidate drops out, that candidate is crossed off of all orderings and the orderings are re-ranked – e.g., if one ordering is Linda, Quinn, Alisa and Linda drops out than Quinn becomes a first place preference and Alisa becomes a second place preference.]

24) Look at each of the above voting methods and decide which of the fairness criteria always hold and which might fail for a given criterion. Fill in the table below. Use a ✓ to indicate that the method never fails the given criterion. Use an × to indicate that the method might fail the given criterion. If a method might fail a given criterion, supply an example to illustrate. You may cite examples from the exercises above (e.g., see Exercise 13). As with previous exercises, it is okay to create preference schedules where a given order does not receive any votes.

| | **Majority Criterion** | **Condorcet Criterion** | **Transitivity** | **Monotonicity Criterion** | **Independence of Irrelevant Alternatives** |
|---|---|---|---|---|---|
| **Plurality** | | | | | |
| **Borda-Count** | | | | | |
| **Cordorcet** | | | | | |
| **Single Runoff** | | | | | |

Reference
Nielson, L.J., de Villiers, M. (1997). Is Democracy Fair? The Mathematics of Voting and Apportionment. Key Curriculum Press, Inc. Emeryville, CA.

*Art's Attic*

# Mary Fairfax Somerville

By Art Johnson

You may have missed this. Scottish mathematician Mary Fairfax Somerville will be pictured on the new Scottish £10 note. She was the top vote getter in a poll organized by the Bank of Scotland. Who was Mary Fairfax Somerville?

**Mary Fairfax Somerville (1780-1872)**

Mary Fairfax Somerville was born to a well off family in Scotland. They were not *Downton Abbey* rich, but her father was a vice admiral in the British navy, so the family was comfortable. As was the custom, the boys in the family were educated in private schools with an eye on a career, while the girls were schooled in domestic arts.

Mary's only formal learning was at Miss Primrose's boarding school for girls, where she did learn to read, but more importantly practiced needlepoint and the social graces. She spent only one year there and when she returned home felt "…like a wild animal escaped out of a cage." Once at home she read everything she could find in the home, but met with family resistance. Only an uncle encouraged her readings.

Her life would have been no different than many other girls in her social circle except for a tea party. The party was at a neighbor's house, organized so the young men and women in the society could meet, mingle, and eventually marry off. As Mary recalls at this tea party, in her mid teens, she was leafing thru a fashion magazine.

> At the end of the magazine I read what appeared to be simply an arithmetical question but on turning the page, I was surprised to see strange looking lines mixed with letters. "What is that?" "Oh," said a friend. "It's a kind of arithmetic; they call it algebra; but I can tell you nothing about it."

The friend was one of the young men at the party, and his comment was along the line of most men's thinking, that Mary could not hope to understand anything so complex as algebra. Was he ever wrong!

Following the party she threw herself into the task of finding out more about this algebra, and found a number of books in the family library, including Euclid's *Elements.* She also sought help from her younger brother's tutor. Consequently, Mary devoted herself to learning more about mathematics, to the point that her father complained to Mary's mother, "Peg, we must put a stop to this or we shall have Mary in a straight-jacket one of these days." The prevailing thought of the day was that 'the strain of abstract thought would injure the tender female frame."

During these years, Mary's life in Edinburgh was a series of parties, visits, balls, teas, concerts, and innocent

*Art's Attic*

# Mary Fairfax Somerville

(CONTINUED FROM PAGE 16)

flirtations. She eventually married in 1804 at age 24. Her husband was a career navy man, and had no interest in her pursuit of mathematics. According to Mary, "He had a very low opinion of the capacity of my sex, and had neither knowledge of, nor interest in, science of any kind." During this time an aunt told Mary that she "should give up her foolish manner of life and make a respectable and useful wife". Her husband died after 3 years of marriage, and Mary returned to Scotland from London.

By this time she had a circle of friends who strongly encouraged her interest in mathematics and science. She married again in 1812, this time to Williams Somerville, who enthusiastically encouraged her study of mathematics and joined in her widening circle of mathematicians and scientists. In 1816 William was elected to the Royal Society and they moved back to London, where Mary met William Hershel, Charles Babbage, and French mathematicians Poisson, Laplace, and Poinsot.

In 1826 Mary published her first paper on the solar light spectrum. In 1827 she was asked to translate Laplace's *Mecanique Celeste*. She did more than translate it; she smoothed over some of his mathematics and explained difficult concepts that were unfamiliar to most British readers. The book, *The Mechanism of the Heavens*, appeared in 1831 and was an immediate success. A new book published in 1834 suggested another planet beyond Uranus and was instrumental in the eventual discovery of Neptune. Honors and widespread recognition of her talents now flowed freely. It was during this time that she encouraged Ada Lovelace in her study of mathematics and served as her patron.

Her later life with her husband was spent in Europe, mostly Italy, where she continued to publish books and articles, and to support women's education and suffrage movements. When John Stuart Mill organized a massive petition to Parliament for the right of women to vote, he asked Mary to be the first to sign. Eventually, she outlived her husband and all her children, but continued to press for women's rights and to advance mathematics. She died in Naples in 1872.

What if the magazine that day at the tea party had been a different magazine, one with no X's and Y's? Would Mary have become a leading mathematician? The answer is difficult to be sure but based on this last quote from her, Mary Fairfax Somerville was destined to do great things in mathematics. "Sometimes I find [mathematics problems] difficult, but my old obstinacy remains. If I do not succeed today, I attack them on the morrow."

# Summer Conference Opportunity

Won't you consider joining AMTNYS, along with the Association of Mathematics Teachers of New Jersey (AMTNJ) and the Association of Teachers of Mathematics in New England (ATMNE), for a refreshing, relaxing, and inspiring conference this summer? For the first time ever, all 3 organizations are working together to present a professional development opportunity that is not to be missed - "The First New Cubed Math Conference: Coming Together for Learning, Teaching, and Students".


**Where:** Iona College
**When:** June 27-29, 2016

WHY should you go??? Besides the obvious answer...why not?...there are so many other reasons...

- sessions with narrow, focused grade level strands presented by some of our region's most outstanding educators. Presenters will give you ideas and inspiration for your classroom that really applies to YOU at the level you teach during in-depth, multi-part workshops.
- you will have a chance to meet with other teachers from all over our little part of the Northeast in an informal setting
- since the conference is in the summer, you don't have to worry about leaving your class with a sub
- Iona is located close to NYC, allowing for a possible evening excursion to a Broadway show, a baseball game, or a tour of the harbor (register for the conference soon as signing up for these opportunities is time sensitive)
- If you have children in grades K-8 you have an opportunity to sign them up for a very affordable STEM math camp right on campus while you are there - no babysitter needed

Register here:http://www.amtnys.org/Sub%20Pages/Conferences/Summer%20Conference.html

Any questions? Contact Jim Matthews at matthews@siena.edu

This is such an exciting and affordable opportunity. Please join us - hope to see you there!

#NewCubed2016 @amtnys

# October 20-21, 2016 – Manchester NH

# Vote with Math!

# Developing Informed Citizens through Mathematics

ATMNE 2016

Did you know that your membership in NHTM automatically makes you a member of ATMNE?


**R2D2 checks out the NCTM materials at the Keene NHTM conference.**

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**http://www.nhmathteachers.org/page-1715832**

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# Professional Development & Conferences

| | | |
|---|---|---|
| National | | |
| NCTM Summer Interactive Institutes- K-8 | Atlanta, GA | July 11-13, 2016<br>July 14-16, 2016 |
| NCTM Summer Interactive Institutes- 9-12 | Atlanta, GA | |
| NCTM Summer Interactive Institutes- 6-8 | Denver, CO | July 18-20, 2016 |
| NCTM Summer Interactive Institutes- PK-5 | Denver, CO | July 21-23, 2016 |
| MAA MathFest | Columbus, OH | August 3-6, 2016 |
| NCTM Annual Meeting & Exposition | San Antonio, TX | April 5-8, 2017 |
| Regional | | |
| The First New$^3$ Math Conference | New Rochelle, NY | June 27-29, 2016 |
| ATMNE Fall Conference | Manchester, NH | October 20-21, 2016 |
| NCTM Regional Conference | Phoenix, AZ | October 26-28, 2016 |
| NCTM Regional Conference | Philadelphia, PA | October 31- November 2, 2016 |
| Innov8 Conference | St. Louis, MO | November 16-18, 2016 |

*Mathesis* is the newsletter of the New Hampshire Teachers of Mathematics. It is published four times a year: August, November, February, and May. The mission of the New Hampshire Teachers of Mathematics shall be to provide vision and leadership in improving the teaching and learning of mathematics so that each student is ensured quality mathematics education and each teacher of mathematics is ensured the opportunity to grow professionally.