CORRESPONDENCE FROM MATHEMATICIANS

Students began to recognize the tedious trial-and-error process behind mathematical discoveries

When struggling with mathematics problems in today's classroom, students occasionally experience a flash of discovery that is inspired by the past. An example happened in an intermediate algebra class at the end of a lesson on completing the square. In an attempt to pique students' interest and to connect completing the square with other mathematics, one of the authors, Jennifer Horn, challenged the students to complete the square on the standard quadratic equation, $ax^2 + bx + c = 0$. Obviously, she intended for them to "derive" the quadratic formula that they had used in previous lessons.

After several failed attempts, the students became frustrated and asked for help. With her help, the class eventually derived and recognized the familiar formula. Although they needed assistance, those students felt a strong sense of achievement in their results. As it subsided, they began to recognize the tedious trial-and-error process behind many mathematical discoveries. One inquisitive student even blurted out, "What on earth compelled someone to figure that out?" This comment sparked the idea for a project that would help those students learn the origin of some important mathematical concepts.

The three authors meet on a regular basis throughout the school year to discuss issues and questions that arise in our classes. Together, we made the plans that resulted in the project described here.

Jennifer Horn taught the activity first. The following month, she shared her students' letters and talked about what she had learned. From her experiences, we made changes and refined the project. Then Amy Zamierowski tried the revised activity in her classes. The description that follows is a composite of the experiences of those two authors. For simplicity, we decided to use Horn's voice to describe the experience.

BACKGROUND

Spurred by NCTM's Standards, which emphasize reading and writing proficiency, and my district's focus on writing across the curriculum, I designed this mathematics history project to incorporate research skills with discovering the origins of familiar mathematical concepts. The focus of the assignment was a one-page personal letter from a mathematician to an appropriate correspondent about one of her or his mathematical discoveries.

Due: _____ Name: _____

1. Look through the options, and pick a famous mathematician.
   Due: _____ 5 pts. _____
2. Research your person to find out who he or she is.
   Due: _____ 10 pts. _____
3. Determine a suitable person to whom your mathematician could write. It must be a real person with a name.
   Due: _____ 5 pts. _____
4. Determine a topic about which your mathematician would write.
   Due: _____ 5 pts. _____
5. Write a two-page letter (rough draft) that is about three to four paragraphs (double-spaced) long. I will look it over and suggest revisions.
   Due: _____ 10 pts. _____
6. Final letter after revisions (single-spaced).
   Due: _____ 20 pts. _____

(Choices for possible person on back)

55 total

Fig. 1
"Who Am I" project

For this nonroutine assignment, I identified six stages to guide my students through the project. See **figure 1.** Each of the six stages included a description of the task to be performed, a due date, and the maximum number of points. I handed out this rubric at the beginning of the project so that students would be able to track their progress.

"Sharing Teaching Ideas" offers practical tips on teaching topics related to the secondary school mathematics curriculum. We hope to include classroom-tested approaches that offer new slants on familiar subjects for the beginning and the experienced teacher. Of particular interest are alternative forms of classroom assessment. See the masthead page for details on submitting manuscripts for review.

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STAGE 1: CHOOSING A FAMOUS MATHEMATICIAN

I hoped to stimulate interest by using an old set of posters that had been "willed" to me by the previous occupant of my classroom. These eighteen posters were published by J. Weston Walch and were titled, "Who Was I?" See **figure 2** for an example. Each poster included a picture and a brief biography of a mathematician; however, the mathematician's name was purposely omitted.

The students' first challenge was to discover their mathematician's identity. As a motivational tactic, I allowed them to browse through the posters and select one with a story that intrigued and interested them. My classes were fairly small, so every student in the class had a different poster. In larger classes, I would suggest allowing two students to choose a poster but requiring them to work independently. This first step, choosing a poster, took only about ten minutes of class time; the students were eager to begin the research.

Teachers who do not have access to a set of posters can create their own posters relatively easily. They just need to find biographies of mathematicians on the Internet or in mathematics history books and excerpt them for the project. I recommend keeping the biographies short—preferably no more than four paragraphs. The biographies should include interesting facts and at least one recognizable "claim to fame." Teachers should be careful to remove the mathematician's name from the write-up. Including pictures is also possible; many are readily accessible on the Internet. Alternatively, if making these biographies seems too time-consuming, the teacher can tell students to select a mathematician's name from a list similar to the one shown in **figure 3.**

STAGE 2: DISCOVERING THE MATHEMATICIAN

After students had selected a poster, the next step for them was to figure out the mathematician's identity. Before this class session, I talked with the school's librarian about the project and scheduled time for my classes to work in the library. The librarian gathered resources from the media center, and I added other books from my personal library so that students could use a variety of books and encyclopedias. In addition, the library contains several computers that students could use for Internet research.

Our school uses a block schedule with ninety-minute periods, so more than an hour remained in the period for students to work in the library to determine the name of their mystery mathematicians and complete stages 2 to 4 of the project. Before taking students to the library, I reviewed my expectations and reminded the students to be pro-

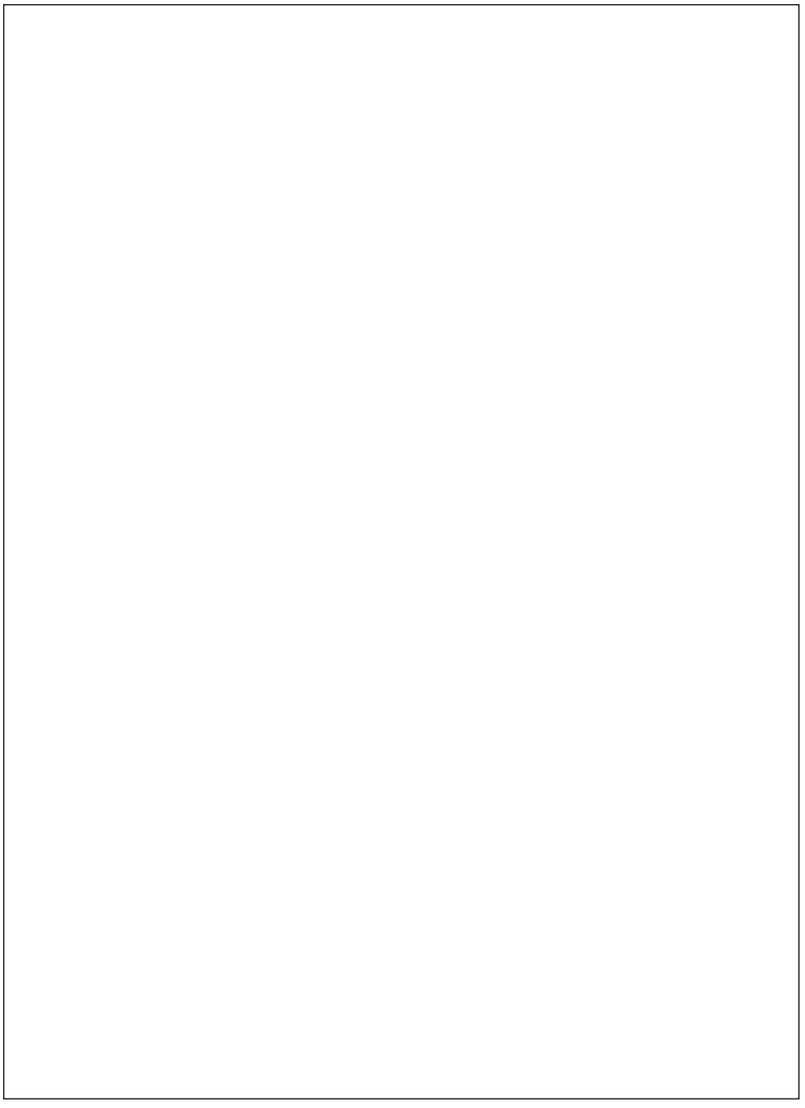

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Fig. 2
Sample poster

1. Leonardo Fibonacci
2. Carl Friedrich Gauss
3. Isaac Newton
4. Gottfried Wilhelm von Leibniz
5. Evariste Galois
6. Caroline Herschel
7. Joseph Louis Lagrange
8. Archimedes
9. Eratosthenes
10. Johann Bernoulli
11. John Wallis
12. Blaise Pascal
13. Mary Lucy Cartwright
14. Pythagoras
15. Leonhard Euler
16. Jean Baptiste Fourier
17. Sonya Kovalevsky
18. Pierre de Fermat
19. John Napier
20. Euclid
21. François Viète
22. Nicolai Lobachevsky
23. Hypatia
24. Sir Walter Raleigh
25. René Descartes
26. Marie-Sophie Germain
27. Galileo Galilei

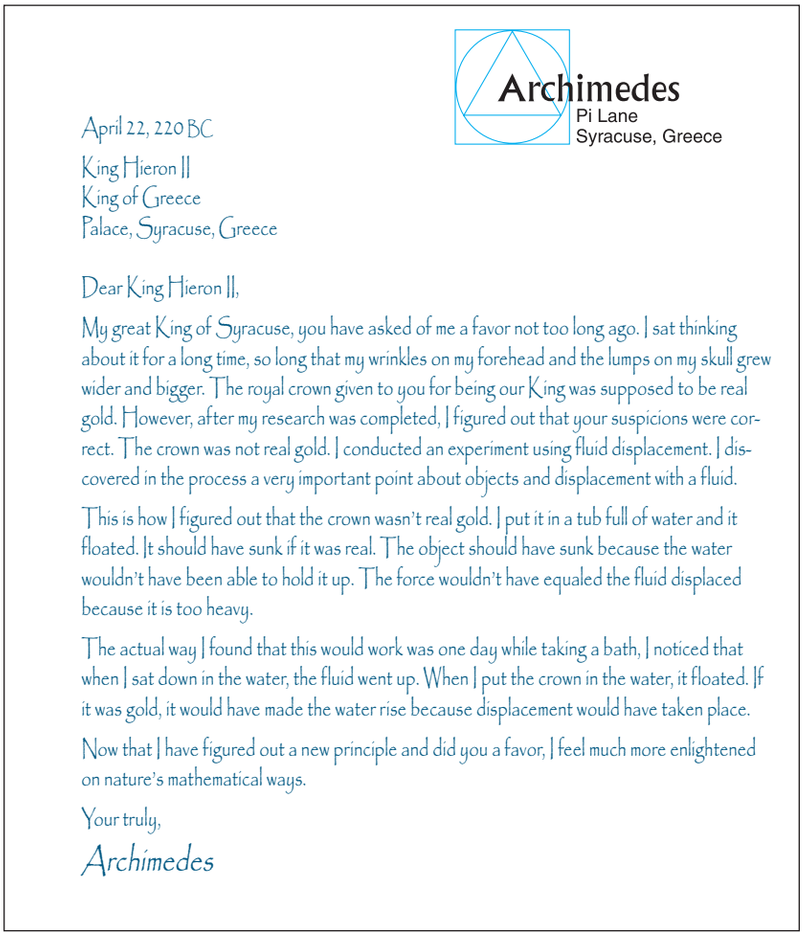
Fig. 3
List of mathematicians

ductive because I had allowed only one day for this portion of the project. I pointed out that whatever they did not accomplish would have to be completed outside of class. Because of these time constraints, I decided to give students a list of names of potential mathematicians. This list, shown in **figure 3,** helped the students narrow their searches.

Students quickly began their research using the Internet

In the library, students quickly began their research using the Internet, encyclopedias, and mathematics history books. Most of them determined the identity of their chosen mathematician in less than half an hour. I was surprised at how easily they found their mathematician's name and credit their familiarity with the Internet for most of their speed and results. This familiarity was an even bigger asset as they continued working on the project.

I suggested that students who had difficulty with this initial research phase of the project should find a historical time line and match it with dates from the biographies. Since nearly all biographies included at least a birth date, this information gave students an easy way to simplify the search and enabled them to be successful. Only a few students from each class needed more assistance.



Archimedes
Pi Lane
Syracuse, Greece

April 22, 220 BC

King Hieron II
King of Greece
Palace, Syracuse, Greece

Dear King Hieron II,

My great King of Syracuse, you have asked of me a favor not too long ago. I sat thinking about it for a long time, so long that my wrinkles on my forehead and the lumps on my skull grew wider and bigger. The royal crown given to you for being our King was supposed to be real gold. However, after my research was completed, I figured out that your suspicions were correct. The crown was not real gold. I conducted an experiment using fluid displacement. I discovered in the process a very important point about objects and displacement with a fluid.

This is how I figured out that the crown wasn't real gold. I put it in a tub full of water and it floated. It should have sunk if it was real. The object should have sunk because the water wouldn't have been able to hold it up. The force wouldn't have equaled the fluid displaced because it is too heavy.

The actual way I found that this would work was one day while taking a bath, I noticed that when I sat down in the water, the fluid went up. When I put the crown in the water, it floated. If it was gold, it would have made the water rise because displacement would have taken place.

Now that I have figured out a new principle and did you a favor, I feel much more enlightened on nature's mathematical ways.

Your truly,

Archimedes

Fig. 4
Letter for "Who Am I" project

STAGE 3: SELECTING A CORRESPONDENT

For the third phase of the project, students decided on a suitable person to whom the mathematician could write. The only restriction was that the mathematician had to write to a real person in his or her time period. For example, Archimedes could write to King Hieron II. See **figure 4.** Most students chose a correspondent on the basis of a name included in the original poster biographies. However, some used their initial library research to select a different, but reasonable, correspondent. In some instances, the original poster failed to name any contemporaries. In this situation, the additional research was essential.

STAGE 4: SELECTING A TOPIC

The students also had to find one additional source of information, beyond what they used to identify the mathematician, to use when choosing a topic for their letters. I required the students to turn in a printout or copy of this additional source; I used the copies to verify the reasonableness and accuracy of the letters' contents.

The last step for the first day of the project was to determine the topic of the mathematician's letter. I was flexible about the topic as long as it was relevant to the mathematician's work on the origin of some mathematical concept. Students could choose topics mentioned in the original poster or topics that they found on the Internet and in books.

As I graded the final projects, I discovered a way to improve the activity. Many students included the mathematical concept and its importance in the letter that they wrote, and this addition improved the project. Therefore, the next time that I assign the project, I plan to ask students to include the mathematical concept and its importance in the letter.

STAGE 5: WRITING A ROUGH DRAFT

The next step was for students to write a rough draft of their fictional letter. I gave them a week to complete this part of the assignment, but I did not devote any class time to the activity. However, I did start each class with a short question-and-answer session to address problems that the students might have encountered. I encouraged the students to ask an English teacher or the writing lab for help in developing their rough drafts; several took advantage of these opportunities.

After the students turned in their drafts, I checked for appropriateness of the correspondent and for originality of the topic. I also checked to see that the letters met the two-page length requirement; and I corrected grammar, spelling, and punctuation. To maintain the students' interest and enthusiasm, I returned the letters with my com-

ments and corrections at the beginning of the next class period.

STAGE 6: FINALIZING THE LETTER

Students were allowed one additional week to type and revise their final version of the letter. **Figure 4** shows the work of a sophomore girl in my intermediate algebra class.

In addition to the final copy, students had to turn in their corrected rough draft, a printout or copy of their research from the first day, and the grading rubric. The corrected rough draft allowed me to see whether they had made the necessary changes in their final product.

Overall, students seemed to enjoy the project and to welcome the change from our daily classroom routine. Indeed, several students who were normally a challenge for me to motivate began the project eagerly. Although I would like to report that all of them completed the project in exemplary fashion, that outcome did not occur. However, many of the letters that the students created were informative, interesting, and well written. Their creators were proud of their accomplishments and eager to try a similar project in the future.

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