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HOT TOPIC: Should we integrate Judaism and a secular subject like math in a day school setting?

JEWISH PI DAY: MAKING A SECULAR SUBJECT MORE JEWISH… AND MORE ENGAGING

by Lawrence Mark Lesser

Introduction

I was blessed with the opportunity to integrate Judaism and mathematics when I took a leave of absence from a university mathematics education position to upgrade my experiential base with full-time pre-collegiate teaching experience – working two years as mathematics department chair and teacher at Emery High, a new pluralistic Jewish community high school in Houston. To make my teaching more meaningful and motivational for my students (and for myself), I sought, compiled, created, and implemented connections to Judaism with a range of students for varied classes and assemblies, and I described those efforts in a 2006 article[1] that appears still to be the most comprehensive overview of areas of Jewish mathematics for classroom use. The current paper is intended to supplement, not supplant, my 2006 paper in the *Journal of Mathematics and Culture*.

Gematria[2] is generally the first or even the only topic that comes to people's minds when considering the intersection of Judaism and mathematics, but I include in my 2006 paper many other examples, including quotations about mathematics from traditional Jewish sources and sages; mathematical "firsts" (first statistical graphic, first fair division problem, etc.); counting (permutations, marking time, etc.); connecting mathematical and Jewish ideas about the infinite; mathematical modeling; use of geometry in Judaism; connections between structures of logic used in mathematics and Judaism; and connections to Jewish text, customs or games (e.g., *dreidel*). Had my time at Emery (which spanned teaching algebra I, geometry, algebra II, pre-calculus, and calculus) included teaching a statistics class, I would have also referenced the excellent Jewish connections to probability and statistics concepts in a 1973 book by N. L. Rabinovitch.[3]

Some of the hands-on explorations I used (not necessarily explicitly connected to Judaism) were deemed interesting enough to be published in Houston's *Jewish Herald-Voice,* such as a photo of my geometry students building polyhedra from marshmallows and pretzel sticks[4] and a photo of my calculus students using sliced fruit to explore the disk method of finding the volume of a solid of revolution.[5]

Pi Day at Jewish Schools

We now consider the particular annual mathematical celebration known as Pi Day. Since 1989, math classes, math clubs, and museums from coast to coast have observed Pi Day each March

14; it is a chance to celebrate the too-often-unsung beauty and connections of math in our world, and, in 2009, House lawmakers enshrined the day as a national holiday across the U.S. We can write March 14 as 3-14, and 3.14 is the beginning of the special number called *pi* (which since 1706 has been represented by the 16th lowercase letter of the Greek alphabet) that you get from dividing the distance around a circle by the greatest distance across that circle. March 14 also happens to be the birthday of one of history's most famous Jewish scientists, Albert Einstein.

In my first spring at Emery High, I conducted that school's first ever Pi Day celebration. I planned a collection of events, including "problems of the day" posted in the hallways, mathematics-related art and writing contests, and explorations connected to a best-selling novel with *pi* in the title[6] that had been required reading for the entire school the previous summer. Details of these activities appear in my 2004 article in *Mathematics Teacher*.[7]

After working for two years at the Jewish high school in Houston, I began a university mathematics education position in El Paso. As an outreach effort to the El Paso Jewish Academy (the city's pluralistic community day school for grades 1-8), I initiated and launched the EPJA's debut Pi Day celebration on March 14, 2008. This time, the format was primarily an hour-long whole-school assembly making interdisciplinary connections to *pi*, supplemented later in the day by activities individual teachers implemented in their classrooms and donated refreshments (pie!) during recess. A half-page article about this event appeared in El Paso's Jewish newspaper.[8]

A challenge with the assembly was not only that the students were younger, but also that there were a larger number of grade levels spanned. As an example of a strategy to bridge the range of students' backgrounds (and to add more interactivity), we defined parts of the circle first with informal language (e.g., "distance across a circle" and "distance all the way around a circle") before introducing the formal terms (i.e., diameter and circumference, respectively). To help students remember the formal terms, we made connections with etymology. For example, to help students remember the meaning of circumference, I asked students to think of other words that began with the "circum" prefix. Some of the examples generated in the room included circumnavigate (e.g., to sail around something – an island, globe, etc.) and circumstances (i.e., the situation around you). An unplanned Jewish connection was made when someone ventured the word "circumcise," which indeed involves circular cutting. While *pi* can be defined as "how many diameters it takes to go around a circle," we incorporated it into an active learning activity by having students use a tape measure to find the distance across the circular object they had been asked to bring to school the day before. The students then observed how many of those lengths it took to go all the way around their circular object, and they all found it was slightly more than three.

The state-mandated high-stakes test provides approximations for the value of *pi* (3.14 and 22/7), and also provides formulas involving *pi*: the circumference and area of a circle and also the surface area and volume of a cylinder, cone, and sphere. While noting the role of *pi* on standardized tests achieved reluctant acknowledgment of its importance, there was a more enthusiastic response when connections were made between the geometric solids and foods commonly eaten at Jewish meals. For example, a chickpea or a *matzah* ball can be considered a sphere and a slice of *kishka* can be considered a cylinder. An explicit connection to the volume formulas can be made[9] (Bodner, 2001) by noting that traditionally a prayer is said after eating food if and only if the volume exceeds one *k'zayis* (roughly half an egg or one large olive). The *Jewish Voice* article[10] depicts other activities in the assembly – estimating *pi* by a formula based on how often toothpicks dropped onto a grid of parallel lines landed on a line (this 18th-century demonstration is included in my 2004 article[11]) and modeling the 22/7 approximation of *pi* by inserting a line of 7 students across a circle of 22 students.

A highlight of the assembly that was perhaps the most unexpected curricular integration was to explore the value of *pi* in *Tanach*. In my 2006 article,[12] I discuss how the implied value of 30/10 = 3 (an error of 4.5%) for *pi* can be obtained from I *Kings* 7:23, which is in the *Haftarah* read by Sephardic congregations for *Parashat Vayakheil*:

> "He made the 'sea' of cast [metal] ten cubits from its one lip to its [other] lip, circular all around, five cubits its height; a thirty-cubit line could encircle it all around."

This *pasuk* became a vehicle for an active learning exploration about standard and nonstandard units of measurement. Each student measured his/her own "cubit" or "*amah*" (i.e., distance from elbow to tip of the longest finger) and found the values to have natural variability. Students also found it interesting to learn that the Talmudic value for a cubit also varied – depending on which of the two Temples was in place or whether the measurement was for particular religious versus secular purposes.

My 2006 article[13] also goes on to discuss how the error in the approximation of *pi* can be brought down to about 1% by taking into account I *Kings* 7:26 and the thickness of the vessel, and dividing 30 by 9 2/3 cubits.[14] Applying a more subtle and technical approach to I *Kings* 7:23,[14] the ratio of gematrias for the two different forms (קוה and קו)of the Hebrew word for "line" is (100 + 6 + 5)/(100 + 6) = 111/106. Multiplying this "correction factor" of 111/106 by the original approximation of 3 yields 333/106, which has an error of only 26 parts per million. Some fascinating "big picture," beyond-the-book discussions about the nature of mathematics, epistemology, and the universe can be generated by introducing quotations from rabbinic debates about topics such as "rounding." In one class, I facilitated discussion of the quote of Maimonides in his 12th-century commentary on the *Mishna* (*Perush Ha-Mishna, Mishna Eruvin* I 5):

> "You need to know that the ratio of the circle's diameter to its circumference is not known as it is never possible to express it precisely. This is not due to a lack in our

> knowledge…but it is in its nature that it is unknown, and there is no way [to know it], but it is known approximately."

Day schools that include *Talmud* study can certainly encounter measurements and calculations involving mathematical figures such as circles (e.g., *Eruvin* 13b, 14a, 76a-b; *Succah* 7b-8b). Consider the statement of *Eruvin* 4:8 about the allowable walking region on *Shabbat*:

> "[one could] travel within 2000 cubits in any direction as [though he was within] a circle [while] the Sages say: As [though he was within] a square, so that he wins the benefit of the corners."

Several other connections between *Talmud* and mathematics are discussed or cited in my 2006 article.[15]

I found that curriculum integration was easiest to create (and to justify to any skeptical stakeholders) when my examples closely paralleled the mathematical content and structure of scenarios already in standard textbooks. In an example discussed in my 2006 paper,[16] one of my high school assessments took my students' geometry textbook's vignette of an archaeologist estimating the size of an ancient plate by finding the circumcenter of a surviving outer fragment of the plate, and changed the context so that the plate fragment came from a Jewish couple's engagement ritual (*tana'im*) where their mothers break a plate. The example was additionally effective and immediate because the students had recently studied Jewish wedding rituals in their Judaics class and had learned that plate fragments are sometimes offered by the bride to unmarried relatives for good luck.

In addition to their intrinsic interest and value, these enhancements connected to school culture and activities and appeared to help motivate additional students towards a broader view of and deeper engagement with mathematics, and possibly with Judaism as well. (There were times that I gave an example of Jewish mathematics for which the Jewish component was not totally familiar to some of the students, and I always took the time to "catch them up" as I would with any context that happened to be unfamiliar to some students.)

It is hoped that this article will inspire other educators to create, compile, and share additional examples so as to facilitate further students' conceptualization and experience of both mathematics and Judaism as realms that are not disconnected collections of facts, but are, in fact, intimately connected with each other and with other realms of knowledge and real-life experience.

Endnotes

1. Lesser, Lawrence Mark. "Book of Numbers: Exploring Jewish Mathematics and Culture at a Jewish High School" in *Journal of Mathematics and Culture*, *1*(1), May 2006, pp. 8-31. http://nasgem.rpi.edu/files/1466
2. Gematria is a system of assigning numerical value to a word or phrase, in the belief that words or phrases with identical numerical values bear some relation to each other, or bear some relation to the number itself.
3. Rabinovitch, N. L. *Probability and Statistical Inference in Ancient and Medieval Jewish Literature*. Toronto: University of Toronto Press, 1973.
4. *Jewish Herald-Voice,* Houston, TX. February 13, 2003, p. 31.
5. *Jewish Herald-Voice,* Houston, TX. June 3, 2004, p. 23.
6. Martel, Yann. *Life of Pi*. New York: Harcourt, 2001.
7. Lesser, Lawrence Mark. "Slices of Pi: Rounding Up Ideas for Celebrating Pi Day" in *Texas Mathematics Teacher*, 2004. *51*(2), pp. 6-11. http://tctmonline.org/downloads/TMT_Journal/TMT_Fall_04.pdf
8. "El Paso Jewish Academy Celebrates its First Pi Day" in the *Jewish Voice*, El Paso, TX. April 2008, p. 19. http://elpaso.ujcfedweb.org/local_includes/downloads/25079.pdf
9. Bodner, Y. P. *Halachos of k'zayis*. New York: Feldheim, 2001.
10. *Jewish Voice*, Op. Cit.
11. Lesser, Lawrence Mark. "Slices of Pi: Rounding Up Ideas for Celebrating Pi Day." Op. Cit.
12. Lesser, Lawrence Mark. "Book of Numbers: Exploring Jewish Mathematics and Culture at a Jewish High School." Op. Cit.
13. Ibid.
14. Posamentier, A. S. & Lehmann, I. *Pi: A Biography of the World's Most Mysterious Number.* Amherst, NY: Prometheus Books, 2004.
    Posamentier, A. S. & Gordan, N. "An Astounding Revelation on the History of Pi" in *Mathematics Teacher*, 1984, *77*(1), pp. 52-53.
    Tsaban, B. & Garber, D. "On the Rabbinical Approximation of Pi" in *Historia Mathematica*, 1998, *25*(1), pp. 75-84.
15. Lesser, Lawrence Mark. "Book of Numbers: Exploring Jewish Mathematics and Culture at a Jewish High School." Op. Cit.
16. Ibid.

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