# School Math Stretches to New Horizons on Exotic "Bus-Driver Holiday"

**By Harold Don Allen FCCT**

Charles DeBouvelles, early sixteenth century French mathematics aficionado, rode with me, certainly in spirit, as the Lufthansa jumbo jet out of Frankfurt, an Air Canada code-share routing 18 hours and 9 time zones east of Montreal, traversed southeastern Europe and bore south over Turkey, the Iranian coast, and the Arabian Gulf. The 747-400, not a seat vacant, set down close to midnight at one of the busiest of airports, even at that inauspicious hour, Dubai International, air-age gateway to awesome skyscrapers, oil rigs, hustle and bustle, and desert extremes of that most productive enclave of the United Arab Emirates, the city (1.4 million) and emirate of Dubai.

The late autumn sojourn "east of Suez" (in Kipling's phrase) had been, at least ostensibly, to look in on grandchildren and their elders in their new home setting, school, and work environment. Schools, however, can be intriguing places, especially in new contexts. Indeed, forty-three good years of school commitment, the majority in pre-service and in-service teacher preparation, convince me that a school is where one can share and one can ever learn. Visits to my grandchildren's thriving "ex-pat" institution led to a most welcome invitation to meet and interact with secondary math faculty and to share materials and insights with potential for open-ended in-class enrichment and math club or math fair investigation. This investigation submitted DeBouvelles (or de Bouelles), 1470-1533, and his number theoretic endeavours to renewed scrutiny, some four centuries after the fact.

The classic DeBouvelles conjecture, and others like it, can and did prove instructive to reflect upon, giving rise to the more general question, in mathematics or otherwise, how many "successes" are necessary to warrant belief that a result is "always" true?

First, several basic definitions, albeit somewhat arbitrary, that should serve to facilitate comprehension and communication.

By "number," for what follows, understand counting number as 1, 2, 3, and so on—a particularly familiar "sequence without end."

"Multiply?" A number is deemed a multiple of a given number if it is obtainable by multiplying the given number by a counting number, including 1. Thus, 6, 12, 18, ..., are multiples of 6.

"Divisor?" A divisor of a number is a number that exactly divides it (that is, leaves no remainder). Thus 1 is the sole divisor of 1, 1 and 5 are the two divisors of 5, and 1, 2, 3, 6, 7, 14, 21, and 42 are the eight divisors of 42.

"Prime Number?" A prime number we take to be a number that has exactly two divisors. Other numbers are 1, the "unit" with its single divisor and composite numbers, for example 8, 9, and (say) 91, all of which have more than two divisors. The sequence of prime numbers, 2, 3, 5, 7, 11, 13, ..., has intrigued enquiring minds since antiquity. Is the sequence unending? Or is there, alternately, a largest possible prime number? Euclid raised such questions 2300 years ago, and proceeded to provide an answer, his textbook example of indirect proof.

DeBouvelles, in 1509, was to propose a conjecture—an educated guess, one that involved, as it happens, the counting numbers, the "multiple" concept, the prime number sequence, simple whole number operations, and (most importantly) one intriguing mathematical question. Take a multiple of 6 (say 54), subtract 1 (54 – 1 = 53), add 1 (54 + 1 = 55), and consider the resulting number pair (53, 55, in this instance). DeBouvelles conjectured that, in each and every such case, at least one, and very possibly two, of the resulting numbers would be prime.

How many such pairs would you need to examine to demonstrate that DeBouvelles indeed had been right?

All of them, you might argue.

How many to find a counterexample, an instance where the conjecture doesn't hold?

More than DeBouvelles himself checked, you'd be safe in asserting.

Youngsters can be fascinated to discover how inadequately the early mathematician had done his homework prior to sharing his conjecture with the world.

A mathematical conjecture, given time and effort, tends to be slotted into one of three categories. The conjecture may be demonstrably true: no prime number ends in 4. The conjecture may be shown to be false, as by counterexample: no prime number greater than 11 is palindromic, that is reads the same from left to right as right to left: false, 181 by testing for divisibility, can be shown to be such a prime. The conjecture may be indeterminate, possibly true, possibly false, although we've not been able to determine which.

Such a conjecture may possess special fascination. A conjecture by Christian Goldbach (1690—17864), its concepts distinctly elementary, is one such assertion that children may encounter (as "enrichment") in a school text. An elegant wording: Every even number (that is, multiple of 2) either is prime (2 is) or else can be written as the sum of two primes, not necessarily different. Thus 22, an even number, gives rise to 19 + 3, 15 + 5, and 11 +11 (plus, if you would, 5 + 17 and 3 + 19).

Such a conjecture as Goldbach's, actually, is but one of many like it, capable of raising good mathematical questions that prove easier to pose than to resolve. Even informal, intuitive investigation can lead less to answers than to new questions and potentially, further insights: Is there an even number with exactly 12 or 15 (say) distinct Goldbach representations? Can we identify a least such even number? A greatest? Can we graphically represent such information in a useful, perhaps novel and revealing manner?

Quite simple number and related activities yield, on occasion, unanticipated and rather intriguing results, promoting appreciation of the sorts of secrets that can be hidden behind a number facade. Some years ago, a helpful elementary teacher shared with me "number bracelets" of which his Grade VI pupils had become especially fond. For this activity, think of numbers as being 0 through 9. Pick two such numbers, not necessarily different. State a rule for combining the two numbers to obtain the next number of a sequence. Add the first and the second—what could be simpler!—with the further provision that you record only the units digit of the sum when the result exceeds 9. Choose, say, 3 and 4 and repeat the combining to obtain your "bracelet", here 3, 4, 7, 1, 8, 9, 7, 6, 3, 9, 2, 1, 3, 4 ..., observing that your sequence has started to repeat. Try 4, 3, ..., actually a longer "bracelet" and q quite different sequence. Try 6, 8, ..., a sequence restricted to evens. Try 0, 1, ..., now that should yield a bracelet that you've seen before. Or change the rule. Try three starting numbers instead of two. Or change the "operation" ... say "three times the first number plus twice the second." Explore! Consider constructing actual bracelets. Ten colours of "pop beads" shouldn't be that hard to find or to produce.

Beyond pop beads? For a senior high math club or math fair, individual or small-group investigation, a base or modulus other than ten could take "number bracelets" instructively further afield. Conjectures of the Goldbach type are sufficiently mainstream that they are likely to receive attention in Mathematics for Liberal Arts textbooks and courses, and in introductory works in the Theory of Numbers, the traditional Higher Arithmetic. Such conjectures, if they remain open questions, may have intrigued and challenged generations of young mathematicians, and well communicate important aspects of conjecture, proof and disproof.

Our next exploration, however, is primarily the stuff of Mathematical Recreations (think mathematicians at play!) and Computer Recreations. "Hailstone numbers," the unlikely entities of the so-called "3n + 1 problem," have entranced some fine minds over the 70 or so years that the problem has been making the rounds. The delightfully named "hailstone conjecture" is accessible to quite young children. Indeed, no topic on my enrichment agenda has been as popular with school-age youngsters (and their parents). As we begin to examine the conjecture, you may begin to grasp why.

Let's, accordingly, spell out the hailstone process, and then state the simple conjecture that provides for the fun.

Take any number, a counting number, from 1 on up.

If the chosen number is 1, then stop right there. Game over.

If the chosen number is not 1, then proceed as follows:
The number, necessarily, will be even (a multiple of 2) or else it will be odd, an odd number greater than 1.

If the chosen number is even, then divide it by 2.

If the chosen number is odd, then first multiply it by 3, and then add 1.

Play on, working at each step with the new number just obtained. Generate a whole sequence of numbers, their values rising and falling according to the oddness or evenness of the preceding result. Stop only if and when you reach 1.

Thus, choosing as starting number (quite arbitrarily) 17, we obtain, successively, 17, 52, 26, 13, 40, 20, 10, 5, 16, 8, 4, 2, 1. Thus, 17 indeed, in 12 steps, leads to 1, reaching a "height" of 52 on the way. The typical ups and downs of the sequence mimic the rises and falls of a hailstone in a thunderhead and prior to its ultimate fall to the ground. Any number whose sequence drops to 1, therefore, is called a hailstone number. The sequence for 27 grabs attention, its length and the height to which it rises, both being extreme, with the repeated ups and downs thought provoking and instructive to plot.

The basic "hailstone" conjecture is still unproven. It is, "All such sequences reach 1. Every number, therefore, is a hailstone number."

Many years ago, I demonstrated the hailstone procedure and told of the conjecture in a Friday afternoon Grade VII math class, arousing some interest. Indeed, one lad approached me and asked whether, over the weekend, he might try 73. Of course! On Monday, he arrived with an impressive stack of hand computation. Using felt pen and many metres of adding machine tape, we mounted his results near ceiling level, covering three walls of the room. Down to 1? You'd better believe it! Years later, the young man turned up with his parents on graduation night, showing them that his efforts still commanded pride of place high on the math room walls.

During a subsequent summer, in another city, I shared hailstones with a one-week enrichment group, well-motivated youngsters assembled on a university campus. One youngster, who had been home-schooled, found the topic and the relevant interaction of distinct interest. That same young man, on graduating in university mathematics, recently presented me with a copy of his honours paper--on hailstones. His formal "search of the literature," North American and overseas, is impressive. And, yes, the conjecture remains unproved, though not for want of computer-age attack.

Children, in my experience, seem to be fascinated by palindromes, words or expressions which read the same left-to-right or right-to-left. Such words as eye, level, and radar are evident palindromes, as are the expressions "Was it a cat I saw?" or "Able was I ere I saw Elba." (attributed to Napoleon) or "A man, a plan, a canal—Panama!" In much the same manner, 77, 454, and 6801086 might be thought of a number (digit) palindromes. The concept is of little real importance, but gives rise to a simple activity with teasingly unpredictable results.

Choose a number of two or more digits. Either the number is a palindrome or it isn't. If it is, stop there. If it is not a palindrome, then write its reversal (the number with the digits in reverse order), and work out the sum of the original and the reversal. (The reversal of 3692 is 2963, clearly. The reversal of 290 is 029, let's agree.)

Choose a number, say 623. Reverse it and add: 623 +326 =949, a palindrome in one step.

Choose 58: Reverse and add: 58 + 85 = 143. Repeat the procedure: 143 + 341 =484, a palindrome in two steps.

Choose 157. Obtain 8888 in three steps.

Check whether 990 reaches a Palindrome in five steps, 79 in six steps, and 395 in seven steps.

My students affirm that 89 gives a palindrome, but that big numbers are reached and surprisingly many steps are required.

Is every number either a palindrome or else a limited number of steps from being one? Great question, that!

"Nested squares," I like to call them, a number activity involving sets of four numbers (counting numbers or 0) entered at corners of an outlined square. "Nested," in the mathematical sense, implies that you'll be looking at squares within squares within squares, which will likely be the case. Children seem to delight in the drawing, the simple arithmetic, and the challenge in foreseeing the outcome.

Proceed as follows:

Draw a large square. (I use flip charts.)

Have four people each choose a number. Write the numbers in the corners of the square.

Place a dot at the midpoint of each side of the square. Join the dots, giving rise to a smaller, tilted square. At each corner of this new square, write the number that represents the difference (large minus small) of the numbers already on the ends of that side of the larger square. (Repeat as required.) Thus, starting with 2, 4, 7, 3, one obtains 2, 3, 4, 1, then 1, 1, 3, 1, then 0, 2, 2, 0, then 2, 0, 2, 0. Finally, with step five, 0, 0, 0, 0. Had I "stacked the deck?" Try four numbers of your choice. In Dubai, four teachers each had provided one number, with an equally interesting outcome.

Every imaginable quartet of such numbers "converges" to 0, 0, 0, 0, it would seem. (I might have used nine-digit serial numbers of well-worn 100 dirham notes.) Even more surprising is the rapidity with which the "0, 0, 0, 0" endpoint seems to be reached. I once had Canadian adolescents experiment for two weeks to find numbers that required all of 15 steps.

Of course, variations beckon. Why a square and not a triangle? Why subtracting and not some other arithmetic procedure? I certainly don't have all the answers. But, in this kind of situation, students enjoy and benefit from listening to one another and reflecting upon each other's insights and tentative results.

Trivial? I'd not say so. We conclude this portion of our "number lore" discussion with (recalling DeBouvelles and Goldbach) a remarkable though less know number conjecture, one whose truth or falsehood is established, but which had withstood the test of forty years.

First, some definitions that are specific to this problem.

A "number of the even type," let's agree, will be a number which is the product of an even number of prime factors. Thus, 24 = 2 x 2 x 2 x 3 (four prime factors) is "of the even type," as are 315 = 3 x 3 x 5 x 7, 1994 = 2 x 997, 3599 = 59 x 61, and 14641 = 11 x 11 x11 x 11.

A "number of the odd type," correspondingly, will be a number which is the product of an odd number of prime factors. Thus, 30 = 2 x 3 x 5, 32 = 2 x 2 x 2 x 2 x 2, and 325 = 5 x 5 x 13 are of the odd type. As well, 101, a prime, can be deemed the product of 1 (an odd number) prime factor, and so also is of the odd type.

Then, if you will, starting with 2, list numbers of the even type and numbers of the odd type. Through 25, you should have 11 numbers of the even type and 13 numbers of the odd type, namely:

Numbers of the even type: 4, 6, 9, 10, 14, 15, 16, 21, 22, 24, 25, ...

Numbers of the odd type: 2, 3, 5, 7, 8, 11, 12, 13, 17, 18, 19, 20, 23, ...

Extend the process, continuing through ever-higher number ranges, and a remarkable "race" between even and odd "types" transpires. "Even types" tend to be fewer than "odd types" to begin with, but, one might reasonably ask, do the even types ever "catch up"?

George Polya, a most remarkable all-round mathematician and mathematics educator, Hungarian by birth, American through most of his lengthy and productive career, raised that question back in 1919—the related conjecture, long neither proven nor disproven, being that being that "even types" never do catch up.

Try a million cases, or a hundred million, and I suspect that you'd be inclined to agree.

Polya, whose great fascination was heuristics, the very process of problem solving, lived a distinctly long and active life. A Santa Clara University graduate group I was with was greatly privileged to be taught by Polya, when he had reached 82. At the dawn of the modern computer age, the Polya conjecture had been shown to be false—by counterexample. "Even types" indeed do catch up, although not until 906,180,359. DeBouvelles, who hadn't persevered to reach his nemesis (111, 121, the 20th pair—both prime!), I like to think might have been impressed.

Mathematics travels well, you might observe. Over the millennia, mathematical insights have crossed frontiers, been assimilated and build upon by new cultures, and have persisted and grown as fundamental to human heritage. At Dubai's stupendous Ibn Battuta mall, an indoor "mile" of air-conditioned and leisure shopping, the overall theme of the 14th century Arab scholar and adventurer (and his 120,000 km of international travel over an interval of 30 years) reflects strong pride in the writings and learnings of the Arabian Peninsula's lengthy and historic past.

Children can be resilient and, at best, travel well, exhibiting a wholesome sense of adventure when immersed in a new culture, and responding well to new schooling, new subjects, and new friends from among very diverse expatriot classmates. My grandchildren especially delighted in the Ibn Battuta Mall, exploring an authentic Chinese junk, inside and out (Ibn Battuta indeed had reached China) and a huge wall of fun-house mirrors (there evidently for pure fun).

Our grandson also showed distinct interest in the most impressive Mall of the Emirates. Where else but Dunbai can you don skates and play ice hockey (Andrew, in Canadiens colours, was in goal) while outdoor temperatures may range to 35 to 45 degrees Celsius. His younger sister, Olivia's great pleasure was Saturday morning riding lessons, caring for and riding her favourite pony, Leena. As for me, I was intrigued by the cats in the riding stables, feline rodent-control officers, I surmised. Very ordinary short-hair cats, to first appearance, but something in the facial bone-structure differed from housecats back home. Brought to mind were cat likenesses in the British Museum, London—Egyptian cats of millennia past.

**Olivia rides Leena, on Saturday morning..**

"East of Suez."

Mathematical ideas that I carried with me primarily were those in my head—concepts and conjectures that had captured and held the imagination of a generation of Canadian youngsters, including Inuit children that I had been privileged to instruct and befriend over my Eastern Arctic years. Geo-dot configurations, polyomino combinatorics, "sprouts" and "hex" and "sprouts" materials and other hands-on investigations that I might have featured in Canadian enrichment, weren't necessarily accessible, but I'd have been remiss not to refer teachers to the likes of Martin Gardner for such ideas.

Canada's Inuit, whose children, sagely approached, I found lively and enthusiastic learners, and Arabian Peninsula dwellers, half a world away, have one important thing in common, when you think of it. They have lived at extremes that have truly tested human ingenuity and endurance. In Iqaluit, on Baffin Island, my wife and I had walked "home" from work one dark and howling midwinter afternoon. The wind chill had been minus 78 degrees Celsius (Atmospheric Environment Service Canada), and the real challenge had been to keep upright and keep moving. For the early Inuit, the additional challenge had been to live off that land. In the Arab Emirates and the adjoining Sultanate of Oman, months without rain, temperatures to 45 degrees Celsius, even 50 plus, represent an equally formidable set of challenges. The caribou, on one hand, and the camel, on the other, attest to the forms in which life can survive.

Travel books on Dubai (the major tourist destination), the Emirates, and neighbouring states are outstanding, if I can judge by those I acquired before leaving Montreal. Dubai is distinctly complex, with hundreds of thousands of immigrant labourers (skyscrapers don't just happen!), and unequalled investment in infrastructure—hotels, other business and residential accommodation, major highway networks, elevated mass transit (currently being hastened to completion), and wholly new rail links (which should reduce road congestion). Dubai International Airport, scheduled for major expansion, already is one of the busiest in the world.

Dubai! Highrises (the greatest reaching for 160 storeys) and upscale shopping malls dominate the Dubai skyline and the tourist way of life.

Down by Dubai Creek where the stream reaches the Gulf, a bustling area over centuries and millennia, you sense heritage and tradition. The world-leading gold souq (marketing district), textile souq (rugs, wall hangings, even needles and thread), and countless others, merit much more time than travelers budget on an initial visit. Then, there are antiques. The Arabic language, as would be expected, has official status in all Emirates, but great numbers of ex-patriots from Europe, North America (6,000 Canadians, I've been told), the Indian subcontinent (Pakistan is nearby, and, as well, there's India and Bangladesh), the Philippines, Sri Lanka, and other lands, attracted by wages and opportunity, complicate the language picture. When one ex-pat converses with another, English, although perhaps not the first or second language of either, tends to seem the logical choice.

Are there other incentives to work long hours in desert heat? (Those construction jobs are 12 hour shifts. "24/7," the high steel lighted all night.) The Emirates levy no sales tax, no individual income tax, and money can go a bit further. You begin to sense the idea. The national currency, the U.A.E. dirham, for some years has been "pegged" to the U.S. dollar, an arrangement which, it would seem, has worked, at least until the recent slide in the dollar. The acute problem now involves ex-pat workers who seek to send funds home to families, and who now get significantly less for their dirhams. The central bank governor makes front-page headlines when he speaks of a future "pegging" to "a basket of [world] currencies."


**Don Allen FCCT with Gulf News about pegging the Dirham to a basket of world currencies.**

The future, prospects for the longer time interval? In Dubai, in Abu Dhabi (the Emirati capital), in neighbouring Al Ain (the desert oasis community on the Omani frontier), I sense wealth (money at work), industry, grandiose planning, oil money, investment money, and immense developments progressing on schedule. Oil, it is recognized, cannot be forever, though proven reserves should suffice for the decades ahead. Alternate sources of income, big business, world-class tourism, and sustainable industries, are being supported and vigorously developed. Leadership has been strong, and the results certainly are to be seen.

All in all, you may sense, travel can be enlightening, mathematical ideas have significant universality, and a life-long teacher is likely to be well received (my Dubai "bus driver's holiday"!) wherever teaching and learning are going on.

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Mu Alpha Theta, school mathematics honour society and secondary school and junior college mathematics club federation, founded prior to 1960 by Richard and Josephine Andree, can be reached through University of Oklahoma mathematics department, 601 Elm Ave., Norman, OK 73019.

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**Acknowledgement**

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## University of Manitoba. Faculty of Education. Graduate Student Research Symposium 2008

**By Gerald R. Brown**

Each year the U of M Graduate Studies (under the leadership of Dr. Zana Lutfiyya) organizes a symposium to present the current research papers in the Faculty of Education. On March 07, 2008, ten papers were presented. They covered a wide range of topics and interests. All showed considerable preparation, and many were very ably delivered. The conclusions in each case carried implications for current applications directly in schools.

**The first session "Broadening our Perspectives"** began with "A Feminist Analysis of Conflict Management" by Kristine Beauchamp-Friesen which was a spirited review of the leadership literature, and ended with strategies on ways women can be more successful through political, education or negotiation processes as modern leaders.

Jo-Anne Weir did historic research and produced narratives on the 'Contributions of Icelandic Pioneer Women to Adult Education in Manitoba from 1875-1914." It was an excellent statement, soon to be published.

Lisa Tucker then took the participants on a tour of "Spirituality in Teacher Education: Honouring the inner lives of students and teachers" in which she challenged modern educators to seek ways use integrative and holistic approaches in their teaching. She appealed for approaches that will address some of the deep rooted problems currently facing modern society.

**Session 2** addressed **"Living in a Culture Not Fully Your Own: Issues of Assimilation and Inclusion"**. Tian Jin presented a case study of a Tibetan Boarding Class in Inland China from a Tibetan learner's perspective. She generalized many of the similarities and differences in the goals and pedagogies used in China and Tibet.

"Training Culturally Diverse Health Care Workers" by Kishwar Mirza focused on the needs for changes in the current methods of recruiting, training and retaining students from the diverse minorities in Manitoba. She emphasized transformation learning for both the instructors and the English as Additional Language students. She posed many important questions for all levels of education for minority students.

"Transition Services for High School Students with Disabilities: Perspectives of Special Education Teachers" was the topic presented by Youn-Young Park. Specific examples, drawn from investigations with teachers in various Winnipeg School Divisions, were presented for holistic and comprehensive support and services that are needed to prepare students with disabilities to move successfully into adulthood – employment, social relationships, leisure and independent living.

**Session 3** reviewed papers under **"Life Long Literacy"**. Barbara Cahoon examined: "Literacy Across the Curriculum: Teachers Teaching Teachers about Content Area Reading Strategies and their Perceptions of the Effectiveness of these Strategies." The successful implementation of using CAR was reported, and merits attention for future work in helping students become independent learners.