Judges' Commentary: The Fusaro Award for the Cellphone Energy Problem

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Introduction

MCM Founding Director Fusaro attributes the competition's popularity in part to the challenge of working on practical problems. "Students generally like a challenge and probably are attracted by the opportunity, for perhaps the first time in their mathematical lives, to work as a team on a realistic applied problem," he says. The most important aspect of the MCM is the impact that it has on its participants, and, as Fusaro puts it, "the confidence that this experience engenders."

The Ben Fusaro Award for the 2009 Cellphone Energy problem went to a team from the Lawrence Technological University in Southfield, MI. This solution paper was among the top Meritorious papers and exemplified some outstanding characteristics:

- It presented a high-quality application of the complete modeling process.
- It demonstrated noteworthy originality and creativity in the modeling effort to solve the problem as given.
- It was well written, in a clear expository style, making it a pleasure to read.

The UMAP Journal 30 (3) (2009) 409–412.

The Problem: Energy Consequences of the Cellphone Revolution

The Cellphone Energy Problem involved many facets of the "energy" consequences of replacing landlines with cellphones and five Requirements were delineated. Teams had to address issues raised in each of the five Requirements. Additionally, the best papers considered both wireless and wired landlines and the infrastructure to support cellphones and landlines.

The Lawrence Technological University Paper

Assumptions

The team began with a page of assumptions, most of which were well-founded and enabled them to determine parameters in their models. However, certain assumptions made were unrealistic and these led to results that did not reflect the real-world situation. In particular, in the eyes of the judges, assuming that all landline phones are cordless was a serious shortcoming that greatly impacted the issue of energy use. Furthermore, while the team did address the issue of infrastructure, the assumption that infrastructure for cellphones is equal to that for landline phones seemed to ignore the need for the large number of additional communication towers if cellphones were to replace landlines.

Requirement 1: Mathematical Formulation for the Transition

In Requirement 1, teams were to consider the energy consequences in terms of electricity utilization of a complete transition from landline phones to cellphones, with the understanding that each member of each household would get a cellphone. The Lawrence Tech team shone in mathematically modeling this transition! For their first model representing the transition from landline to cellphones, the team used the basic logistic differential equation to model the rate of change in the number of cellphones over time. They used the total population as the carrying capacity and determined the intrinsic rate of growth of cellphones from published results. This was very well done, though references for the tables and graphs should have been included. The second model introduced was a predator-prey system of differential equations, and the team is to be commended on their clear statement of rationale for using this model, with cellphones causing the demise of landlines. However, this model quickly became complicated, so they headed "down a different route." And, once again, their rationale for the equations used and parameters arrived at was commendable.

In modeling the energy used by cellphones, the team considered three distinct models of cellphones and did a good job of researching the habits of individuals of different ages regarding talking times. The assumption they made that the average number of calls is directly related to the talk time per call might be questionable, but this was not considered a serious deficiency and it enabled them to estimate needed parameters in their model.

Requirements 2, 3, 4, and 5

Documented sources were used to estimate energy used for charging batteries, and these were translated into barrels of oil used. Energy usage comparisons were demonstrated for landline cordless phones and cellphones. This was taken forward into Requirement 2 and they seemed to conclude that the optimal mix of landline and cellphones would be the state where the same amount of energy was used by cordless landline and cellphones.

For Requirement 3, after gathering data on energy consumption by phone chargers, the team demonstrated an interesting comparison of energy consumed by daily vs. weekly charging and charger left plugged in or not, and from this they estimated the long-term consequences of avoiding wasteful practices in the charging of cellphones. The team introduced a percentage comparison of energy wasted by various charging methods.

Requirement 4 extended the concepts in Requirement 3 and asked teams to estimate the amount of energy wasted by all idle electronic appliances. Since this question was very open-ended, contest papers showed a wide variety of estimates for the energy wasted. The Lawrence Tech team limited themselves to the average hours that computers, televisions, DVD players/VCRs, and game consoles are left plugged in and the resulting annual oil consumption from such wasteful practices. A linear pattern of growth was projected up to 2059. More-comprehensive papers considered many more electronics and, by comparison, showed that the amount of energy wasted by cellphones is relatively small compared to many other electronic devices. Thus, when the team referred to cellphones as the "most energy consuming devices" in the Executive Summary, judges questioned the credibility of the paper.

For Requirement 5, students were to consider the population and economic growth of a Pseudo U.S. for the next 50 years and predict energy needs for providing phone service based on their analysis in the first three Requirements. Predictions were to be interpreted in terms of barrels of oil used. To their credit, the Lawrence Tech team had numerous appendices with data tables (but again without reference).

Recognizing Limitations of the Model

Recognizing the limitations of a model is an important last step in the completion of the modeling process. The students recognized that their model failed to look at technological changes, including advances in battery and cellphone technology. They also acknowledged that assuming that every member of a population has a cellphone puts cellphones into the hands of infants and ignores the fact that some individuals have more than one cellphone.

Conclusion

Although there were some deficiencies in Requirements 2–5, the quality of the mathematical modeling done in Requirement 1, coupled with the excellent use of resources to answer the questions posed throughout, made the Lawrence Technological University paper one that the judges felt was worthy of the Meritorious designation. The team is to be congratulated on their analysis, their clarity, and their use of the mathematics that they knew to create and justify their own model for the cellphone revolution problem.

About the Authors

Marie Vanisko is a Mathematics Professor Emerita from Carroll College in Helena, Montana, where she has taught for more than 30 years. She was also a visiting professor at the U.S. Military Academy at West Point and taught for five years at California State University Stanislaus. While in California, she co-directed MAA Tensor Foundation grants on Preparing Women for Mathematical Modeling, a program encouraging more high school girls to select careers involving mathematics, and was also active in the MAA PMET (Preparing Mathematicians to Educate Teachers) project. Marie serves as a member of the Engineering Advisory Board at Carroll College, is on the advisory board for the Montana Learning Center for mathematics and science education, and is a judge for both the MCM and HiMCM COMAP contests.

Peter Anspach was born and raised in the Chicago area. He graduated from Amherst College, then went on to get a Ph.D. in Mathematics from the University of Chicago. After a post-doc at the University of Oklahoma, he joined the National Security Agency to work as a mathematician.