Author's Commentary: The Coach Papers

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Problem B: College Coaching Legends

Sports Illustrated, a magazine for sports enthusiasts, is looking for the "best all-time college coach," male or female, for the previous century. Build a mathematical model to choose the best college coach or coaches (past or present) from among either male or female coaches in such sports as college hockey or field hockey, football, baseball or softball, basketball, or soccer. Does it make a difference which time line horizon that you use in your analysis, that is, does coaching in 1913 differ from coaching in 2013? Clearly articulate your metrics for assessment. Discuss how your model can be applied in general across both genders and all possible sports. Present your model's top 5 coaches in each of 3 different sports.

In addition to the MCM format and requirements, prepare a 1–2-page article for *Sports Illustrated* that explains your results and includes a non-technical explanation of your mathematical model that sports fans will understand.

Introduction and Overview

The problem was deliberately written to have a potentially overwhelming amount of data, and to force the student teams to decide what "metrics" they needed to consider to choose the all-time best coach. Good simplifying assumptions could be made so that the problem would be tractable in the

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time allowed yet would still provide useful insights. It was also written so that it could be attempted by students with only lower-division college mathematics.

To recognize the increasing international diversity of the student teams in the MCM, the teams were allowed to choose among all the college sports for either or both male or female athletics. Since the teams participating in the MCM had to analyze a minimum of three college sports, many chose both male and female teams. The most common sports chosen were basketball, football, and baseball. There was some confusion on the part of some international entries, which used professional sports coaches, not college sports coaches. At least one team from the People's Republic of China chose to model college sports in their own country, which was acceptable.

As has been the norm recently, there were required elements in the problem statement. Almost every paper this year included the required nontechnical position paper, although the disparities in the article were remarkable. Any article for a sports magazine that does not contain the *list* of best all-time coaches was considered an extremely poor article!

This commentary will discuss the various elements of the problem, with observations from the judging from the my perspective as the problem's author. I will conclude with a summary.

Readers interested in a discussion of the mechanics of the judging process will find a very good report on the process in [Black 2013].

"Best" College Coach of All Time

Models are constructed to answer questions. Here, we are asked to identify the best all-time college coach. But what did a team mean by "best"? Most teams did not do a very good job of defining what metrics they needed. Most teams dived into the Internet and found lots of data on wins, losses, years coaching, and institutions coached at.

I felt that the number of athletes graduating from the institution with the sports program should be a metric that should be considered—but less than a handful of teams even addressed this point.

The coach's popularity was a variable of interest by many teams. How does one measure popularity over the past 100 years? Again, many teams never stopped to define clearly the purpose of their models, but plunged immediately into chosen models without linking assumptions to the model building process.

The better teams considered carefully what they meant by "best" and included a discussion in their restatement of the problem or elsewhere in the submission.

Models Chosen

Of the 2,871 papers from 606 schools with teams that chose the Coach Problem, well over 90% chose the Analytical Hierarchy Process (AHP) as their model.

AHP is a good tool to rank alternatives based on decision-makers' weights, using pairwise comparison with a consistency ratio less than 0.1. Every one of the papers that used AHP used subjective inputs for obtaining the weights; very few teams did sensitivity analysis on those criterion weights. No teams found the breaking points of the weights that actually altered the ranking of the number-one coach.

Most papers used the AHP or else TOPSIS (Technique of Order Preference by Similarity to Ideal Solution) to incorporate the different elements of the solution into one decision model. Teams used their own judgment to estimate the criterion weights in each case. Since different teams provided different weights and inputs, solutions varied widely even using the same sports and coaches.

The other 10% of the teams used a variety of methods from networks, principal component analysis, genetic algorithms, a grey model [Julong 1989; Giannelli n.d.], linear regression, . . . ; and the list goes on.

Most teams avoided the issue of uncertainty, assuming that the data were accurate but the weights were not and hence needed some analysis. The best teams included an assessment of the sensitivity of their models to changes in their inputs.

Modeling assumptions were very poor across the board by teams. Some teams assumed away the timeline and gender issue, yet these were main parts of the modeling questions:

- **Timeline:** Two issues that were readily apparent over the 100 years were salaries and schedule. Few teams addressed these issues.
- **Gender:** We will say that teams that included female sports automatically considered gender. Those that did not had to do more than just lightly discuss this. One team said that the proportion of differences in coaches were significant but that gender was not an issue.

Sensitivity Analysis and Model Testing

As in previous years, the judging criteria for this problem considered sensitivity analysis as a main component of good analysis for "coaching legends." Many papers neglected to consider these issues and scored lower as a result.

Sensitivity analysis was appropriate for all elements of the models. For AHP or TOPSIS, sensitivity analysis would have involved varying the weights (or pairwise rankings) to explore what conditions would cause the alternative ranking to change.

Model testing took several forms. For prediction models, graphical methods for examining residuals of historical data were often used. Statistical tests of significance were used for regressions. Consistency checks, such as $CR < 0.1$, were used for the AHP. The better papers used these methods and others to convince the reader that the models selected were appropriate.

Communication

Papers were judged on the quality of the writing. Special attention was paid to the abstract and to the nontechnical article.

The quality of writing, in general, is improving from year to year. This is notable in the papers that come from countries where English is not the primary language spoken. About 70% of the Outstanding papers this year were from teams where English was a second language, and that was a record.

The strongest abstracts/articles included a definition of what the team meant by "best," the results of the model, and a simple explanation of how the answer was found. The judges continue to be surprised by the number of papers where the abstract and even the article for *Sports Illustrated* only describes what the team will attempt without describing what they found.

A nontechnical letter or article does not mean that numbers are not included. Rather, it means that it can be read meaningfully by someone without an education in advanced mathematics. Too many of the articles omitted all details of the solution as well as the solution itself!

Papers that labeled figures and tables with informative captions scored higher than those that did not.

The quality of citations was also a discriminator. Papers that cited their sources and provided complete references formatted according to a recognized standard scored higher than those that did not.

Several of the very best papers were a joy to read. The explanations were clear and complete, and the phrasing was almost lyrical. The judges will continue to value outstanding writing.

Summary

The Outstanding teams:

- modeled all the aspects of the problem described in the problem statement,

- included the standard contest discussions (assumptions, sensitivity analysis, strengths and weaknesses, etc.),
- had defensible and useful models,
- explained the modeling choices made, and
- were well written.

Papers that listed model #1 through model #N, without ever reconciling which model was best and which was used in the final analysis, were generally not Outstanding.

The judges were pleased by the teams' submissions. The topic allowed for a wide range of solutions, and the allowed choice of sports provided a diversity of solutions. The growth in the quality and number of submissions is very encouraging to those who work to promote the practice of good mathematical modeling.

References

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About the Author

Dr. William P. Fox is a professor in the Department of Defense Analysis at the Naval Postgraduate School and teaches a three-course sequence in mathematical modeling for decision making. He received his B.S. degree from the United States Military Academy at West Point, New York, his M.S. at the Naval Postgraduate School, and his Ph.D. at Clemson University. Previously he has taught at the United States Military Academy and at Francis Marion University, where he was the Chair of Mathematics for eight years. He has many publications and scholarly activities including books, chapters of books, journal articles, conference presentations, and workshops. He directs several mathematical modeling contests through COMAP: HiMCM and MCM. His interests include applied mathematics, optimization (linear and nonlinear), mathematical modeling, statistical models for medical research, and computer simulations. He is President-Emeritus of the NPS Faculty Council and President of the Military Application Society of INFORMS.