Background on SBLive's "Colley Royalty" formula:
How/why we took inspiration from Colley's Bias-Free Ranking Matrix Method

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1. HISTORY OF THE COLLEY METHOD

SBLive's linear algebra-based ranking algorithm, which has long been tentatively referred to as the "Colley Royalty" Method, was inspired by the Colley Bias-Free Ranking Matrix Method.

Wesley Colley, Ph.D., an astrophysicist at the University of Alabama at Huntsville, devised his algorithm in order to help address the subjectivity and controversy regarding poll-based BCS college football selections in the 1990s and early 2000s.

The method was one of a small handful used by the NCAA from 2001-2014 to rank football teams for bowl games and the national championship. Taking only wins, losses, and strength of schedule into account, Colley's Method used no subjective variables. The NCAA used Colley's Method until 2014, when it instituted the College Football Playoff in which teams and seedings are voted on by a 13-person committee. To this day, Colley Method's remains one of the most accurate and well-known linear algebraic rating systems in the field, and a staple of contemporary sports betting models as well.

2. THE MATH BEHIND COLLEY'S ORIGINAL FORMULA

Colley's Method base equation is derived from Laplace's Rule of Succession, which boils down to the formula:

Every team's **rating = (1 + its number of wins) / (2 + its number of games played)**.

In order to take strength of schedule into account, Colley replaces number of wins in the numerator with **((wins – losses)/2) + sum of opponents' ratings**.

That leaves the final equation, that each team's **rating = (1 + ((number of wins – number of losses)/2) + sum of opponents' ratings) / (2 + number of games played)**.

Using variables as abbreviations, every team's **rating = (1 + ((W – L)/2) + SOR) / (2 + G)**

The ensuing system of equations can be solved directly or iteratively.

3. BENEFITS OF COLLEY'S ORIGINAL METHOD, AND ITS SYNERGIES WITH HIGH SCHOOL SPORTS

Not only does the Colley Method have a slew of advantages over most of its competitors. In fact, the qualities that made it so effective for the NCAA are at least as relevant and desirable in the high school space.

- **"Simple" and transparent**

  While few people would describe linear algebra and matrix math as simple or intuitive, Colley's core formula couldn't be more accessible. The equation for each team's rating consists only of wins, losses, total games played, and the sum of its opponents' ratings in a relatively short equation. The better a team's record and strength of schedule, the better its rating – it's that simple.

- **Schedule-centric**

  Needing precision within an NCAA Division I dataset consisting of hundreds of teams, Colley designed his algorithm with strength of schedule as one of its core components.

  Compared to NCAA Division I football, or most other D-1 sports, the high school realm has exponentially more teams, talent disparity, and variation in strength of schedule. And unless every team in a given data population plays every other team – like in an NBA schedule – winning percentage means little without accounting for strength of schedule.

- **Based on linear algebra**

  As linear algebraic systems took over during the BCS era, most rating systems based on index points and/or adjusted winning percentage quickly became obsolete. The interconnective nature of linear algebraic systems means that teams' on-field (or on-court) performances tell the whole story, regardless of what division, conference, or geographic region they come from.

  Using statistical firepower in place of human subjectivity when comparing the resumés of teams who played no common opponents, Wes Colley – in addition to Ken Massey, Peter Wolfe, David Rothman, and other renowned pioneers of linear algebra – ushered in an era of increased mathematical sophistication throughout the world of sports rankings.

- **User-friendly**

  Individual teams' ratings are easy to track in Colley's Method. Every team starts the year with a 0.5 rating, and 0.5 remains the mean rating across the data set as the season progresses.

- **Already mathematically precise without MOV**

  In professional and college sports, Colley's Method remains one of the most accurate predictive models to this day, and unlike most of its competitors, it does so without involving margin of victory.

  While utilizing MOV increases models' mathematical precision dramatically, margin of victory does constitute an additional data input, and one that is not without complication. The original Colley Method is even used as a playoff criterium by some high school state associations, such as the OSAA.

Clearly, the Colley Method is in many ways an ideal base model for a high school ranking system. But even more mathematical precision is necessitated to work with populations of hundreds or thousands of high school football or basketball teams. Across broad high school data populations, there's much less statistical interconnectivity, and the amount of disparity between the best and worst teams isn't comparable to anything at the college level.

4. SBLIVE'S "COLLEY ROYALTY" METHOD

The only major difference between SBLive's proprietary algorithm and the original Colley Method is the incorporation of margin of victory using our proprietary concept of "royalties".

For every game a team plays, it gets one royalty, which uses linear regression to provide a Colley rating value for how it performed in that game relative to its opponent's rating. For any given game, a team's royalty is calculated by starting with the opponent's rating and going up or down from there based on that game's outcome and MOV.

In a one-game example, if Team A defeats Team B by six points, and Team B's rating was 0.95 coming in, Team A's royalty for that game would be 0.95 + (6 x the linear regression coefficient), which would come out to something between 0.96 and 1.00.

After calculating all teams' royalties, recentering is applied evenly to the whole dataset to fix the average of all royalties to exactly zero, thus avoiding inflation and deflation. As a result, this unique algorithm maintains proportionality to Laplace's Rule of Succession.

Going back to Team A's initial equation, the sum of Team A's recentered royalties times the royalty coefficient is inserted in parentheses into the numerator between "sum of opponents' ratings" and the end parenthesis. The royalty coefficient turns the royalty/MOV component of the algorithm up or down as a coefficient of the recentered royalty sum; a coefficient of zero effectively deletes the royalties, whereas the royalties factor in more as the coefficient gets closer to 1.0.

The final equation for **Team A's rating = (1 + ((Team A's number of wins – Team A's number of losses)/2) + sum of Team A's opponents' ratings + (sum of Team A's recentered royalties x royalty coefficient)) / (2 + number of Team A's games played)**.

Abbreviated, **Team A's rating = (1 + ((W – L)/2) + SOR + (RC x SRR)) / (2 + G).**

Using royalties to incorporate margin of victory – but not to an overwhelming extent – SBLive's algorithm successfully improved on Colley's Method in terms of precision. When tested on 10 years of NFL data, the Colley Royalty Method outperformed Colley's

Method by an average of 1.5-2%, which is a sizable jump given the efficacy of Colley's Method to begin with.

In addition to its improved precision, the Colley Royalty Method has two distinct conceptual benefits in the high school space. By nature, royalties add yet more of an emphasis on strength of schedule to the original Colley Method. Additionally, the concept of royalties opens up the mathematical structure to address the few conceptual drawbacks of using Colley's Method and of incorporating MOV.

We cap margin of victory at a certain threshold so that particularly lopsided blowout results don't help or hurt teams beyond reason. When teams with overwhelming rating differences play, there's a catch in the calculations referred to as "the Margin Adjustment Rule" that ensures that the higher-ranked team won't receive a detrimental royalty despite winning by the maximum margin of victory, and vice versa. (In that instance, each team's royalty for that game would be its own individual rating.) And in any instance, the MOV cap eliminates the incentive to run the score up in a game that's already lopsided.

As a product of the Colley Method, the Colley Royalty Method will always give teams a high baseline of credit for playing elite schedules. But the royalty system works to offset the benefit of playing highly ranked teams if those games aren't competitive, and to diminish the harm highly ranked teams incur for occasionally playing a particularly overmatched opponent.

One last minor tweak is that our method counts draws as half a win and half a loss, whereas Colley's Method shuns draw results entirely.