**Premier League ELO Formula**

Dataset: <https://www.kaggle.com/datasets/evangower/premier-league-matches-19922022>

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| --- | --- | --- | --- | --- | --- | --- | --- |
| **Season\_End\_Year** | **Wk** | **Date** | **Home** | **HomeGoals** | **AwayGoals** | **Away** | **FTR** |
| 1993 | 1 | 15/08/1992 | Coventry City | 2 | 1 | Middlesbrough | H |
| 1993 | 1 | 15/08/1992 | Leeds United | 2 | 1 | Wimbledon | H |
| 1993 | 1 | 15/08/1992 | Sheffield Utd | 2 | 1 | Manchester Utd | H |
| 1993 | 1 | 15/08/1992 | Crystal Palace | 3 | 3 | Blackburn | D |
| 1993 | 1 | 15/08/1992 | Arsenal | 2 | 4 | Norwich City | A |
| … |  |  |  |  |  |  |  |

**Overview of the ELO Rating System**

The ELO rating system, originally developed by Arpad Elo and commonly used in chess, is a method for calculating the relative skill levels of players (or teams, in our case). As explained on the Henry Chess Sets website, the core idea is to adjust ratings based on performance against opponents, with the change depending on the expected outcome and the actual result.

**Key Components in Football ELO Ratings**

1. **Initial Rating (R0R\_0R0​)**:
   * Similar to chess, where players start with an initial rating, football teams also begin with a standardized initial rating. A typical starting point might be 1500, though this can be adjusted based on the historical strength of the teams or the league.
2. **Expected Score (EEE)**:
   * The expected score reflects the probability of a team winning, drawing, or losing against another team. According to the formula used in chess and mentioned on the Henry Chess Sets site, the expected score for Team A when playing against Team B is:

Here, EAE\_AEA​ represents the expected score for Team A, with RAR\_ARA​ and RBR\_BRB​ being the current ratings of Team A and Team B, respectively. This formula ensures that if Team A has a higher rating than Team B, they are expected to win, making their expected score closer to 1. Conversely, if their rating is lower, the expected score approaches 0.

1. **Actual Result (SSS)**:
   * The actual result reflects the match outcome. In football, as in chess, this is quantified as:
     + if Team A wins
     + if the match ends in a draw
     + if Team A loses
2. **Rating Update Formula**:
   * After a match, the team's rating is updated based on the difference between the actual result and the expected result. The Henry Chess Sets site details this formula, which can be directly applied to football:

Here, RA′R\_A'RA′​ is the new rating for Team A, RAR\_ARA​ is the current rating, KKK is a constant (often between 20 and 40 in football), and SAS\_ASA​ and EAE\_AEA​ are the actual and expected scores, respectively. The constant KKK determines how much a single match affects a team’s rating. A higher KKK means more significant changes per match, reflecting more volatility in the rankings.

1. **Home Advantage (Optional)**:
   * The ELO system can be adjusted for home-field advantage in football, a factor not typically accounted for in chess. This adjustment involves adding a fixed number of points to the home team's rating before calculating the expected score. For instance:

Where ***H*** is a constant representing home advantage (e.g., 50 points).

**Example of Application:**

Let’s say Team A has a rating of 1600 and Team B has 1500. According to the ELO system principles:

* The expected score for Team A (assuming no home advantage) is calculated as:
* If Team A wins, their rating is updated as:

This update process mirrors what the Henry Chess Sets site describes for chess but applied to football. If Team A wins, their rating increases; if they lose or draw, the adjustment depends on how unexpected the result was given their and their opponent's ratings.

REF: <https://www.henrychesssets.com/elo-rating-system-definition-and-how-it-works-in-chess/>

**Dynamic K-Factor Formula Based on Match Outcomes and ELO Differences**

To create a dynamic K-factor formula that adjusts based on the ELO difference between the teams and the match result, we can structure the K-factor as follows:

**K-Factor Formula**

Let's define the following:

* ***= 30****: The base K-factor*
* *: The absolute difference in ELO rating between the two teams*
* ***= 1*** *: A constant multiplier for adjustments based on outcomes.*

In this scenario, Team A (with the lower ELO) will gain some points, while Team B (with the higher ELO) will lose some points.

**Example Calculations**

Let's calculate the expected ELO changes for the following scenarios:

**Scenario 1: Both Teams Have Equal ELO Points**

* ***Team A = 1500 ELO***
* ***Team B = 1500 ELO***
* ***= 1***

For equal ELO ratings:

*(Assume that in case of multiplication by 0 is set to 0)*

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Outcome** | **Team A ELO Change** | **Team B ELO Change** |
| Equal ELO | Team A Wins | +30 | -30 |
| Equal ELO | Team B Wins | -30 | +30 |
| Equal ELO | Draw | +0 | -0 |

**Scenario 2: Significant ELO Difference**

* ***Team A = 1500 ELO (underdog)***
* ***Team B = 2000 ELO (favourite)***
* ***= 1***

For significant ELO difference:

* **If Team A Wins**:
* **If Team A Loses**:
* **If Both Teams Draw**:
  + - ***+22.5 for the underdog***
    - ***-22.5 for the favourite***

|  |  |  |  |
| --- | --- | --- | --- |
| **Scenario** | **Outcome** | **Team A ELO Change** | **Team B ELO Change** |
| Equal ELO | Team A Wins | +67.5 | -67.5 |
| Equal ELO | Team B Wins | -22.5 | +22.5 |
| Equal ELO | Draw | +22.5 | -22.5 |

**Summary of Scenario 2 outcomes:**

* ***Underdog Victory: When Team A (lower ELO) wins, the K-factor is significantly higher, leading to a substantial gain for Team A and a corresponding large loss for Team B.***
* ***Expected Loss: When Team A (lower ELO) loses, the K-factor is lower, resulting in a smaller loss for Team A and a smaller gain for Team B.***
* ***Draw: Both teams experience the same, lower K-factor, leading to a modest gain for Team A and a modest loss for Team B, reflecting that the draw was a better result for the lower-rated team.***

NOTE: All variables and constants are subject to change during tweaking and testing the algorithm with the dataset.