Prob that Sue wins on her nth turn: $PSn(n) := \left(\frac{5}{6}\right)^{n-1} \cdot \left(\frac{5}{6}\right)^{n-1} \cdot \frac{1}{6}$

Prob that Bob wins on his nth turn: $PBn(n) := \left(\frac{5}{6}\right)^{n} \cdot \left(\frac{5}{6}\right)^{n-1} \cdot \frac{1}{6}$ $\quad PBn(2) \to \frac{125}{1296}$

Prob that Sue wins: $PS := \sum_{n=1}^{\infty} PSn(n) \to \frac{6}{11}$

Prob that Bob wins: $PB := \sum_{n=1}^{\infty} PBn(n) \to \frac{5}{11}$

Prob that Bob wins on second turn *given* that he is the winner is:

$$P(B=2 \mid B) = \frac{P(B = 2, B)}{P(B)} = \frac{P(B = 2)}{P(B)} = \frac{PBn(2)}{P(B)} = \frac{\left(\frac{125}{1296}\right)}{\left(\frac{5}{11}\right)} = \frac{275}{1296}$$