We explain New_NoE in sec. IV through both theoretical analysis and empirical validation:

We assume the computation time for encoder processing each signal: x ($x>0$)

and computation time for decoder processing each pair: y ($y>0$)

Original NMR-SQA Method

Parameters:

- Number of epochs: NoE
- Each batch contains N degraded signals, each paired with 1 reference

Computational time per pair:

- Encoder cost: $2x$ (one reference + one degraded signal)
- Decoder cost: y
- Total time processing per pair: $2x + y$

Total computational time= $NoE \times N \times (2x + y)$

Proposed Method

Parameters:

- Number of epochs: New_NoE
- Each batch contains:
  - N degraded signals
  - M reference signals
  - Each degraded signal pairs with all M references
  - Total pairs = $N \times M$

Computation efficiency implementation:

- References and degraded signals are computed **once per batch** when passed through the encoder
- Per batch computation:
  - Encoder cost: $(M + N) \times x$
  - Decoder cost: $M \times N \times y$
  - Average time processing per pair: $((M + N) \times x + M \times N \times y) / (M \times N)$

Total computational time= $New\_NoE \times ((M + N) \times x + M \times N \times y)$

Setting equal training time:

$$NoE \times N \times (2x + y) = New\_NoE \times ((M + N) \times x + M \times N \times y)$$

Therefore: $New\_NoE = NoE \times N \times (2x + y) / ((M + N) \times x + M \times N \times y)$

In my model $x \sim y/2$ (*this derived empirically)*

$New\_NoE \sim 2N \times NoE/((M+N)/2 + M \times N)$
Besides, in my setting $M<<N$, $M \times N \sim M \times (N+M)$
$(M+N)/2 + M \times N \sim (M+ 0.5) \times (M+N) \sim M \times (M+N)$
Therefore, we select $New\_NoE \sim 2N/(M \times (M+N)) \times NoE$
We also analyze in general cases:

1. When $x >> y$:
   - $New\_NoE \sim (2N/(N+M)) \times NoE$
2. When $x > y$ but not $x >> y$:
   - $(3N/(N+M)) \times NoE > New\_NoE > (2N/(N+M+M \times N)) \times NoE$
3. When $x << y$:
   - $New\_NoE \sim NoE/M$
4. When $y > x$ but not $y >> x$:
   - $(3/M) \times NoE > New\_NoE > (N/(N+M+M \times N)) \times NoE$
5. When $x = y$:
   - $New\_NoE = (3N/(N+M+M \times N)) \times NoE$