**Rationale for Model Selection**

The objective of this project was to develop a robust classification model to predict whether a customer will subscribe to a bank's term deposit, a critical task for optimizing the bank's marketing strategies. After thorough experimentation and evaluation, we selected an Artificial Neural Network (ANN) as the final model for testing. This decision was influenced by several key factors, including AUC-ROC performance, cross-validation results, the nature of the problem, and the practical implications of the model. Below, we outline the rationale for choosing the ANN model and compare it to an alternative model, Random Forest, to justify our final selection.

**Comparison of Models**

For this task, we compared two models: the Artificial Neural Network (ANN) and the Random Forest Regressor (used as a baseline for feature importance and predictive performance evaluation).

**1. AUC-ROC Performance**

The ANN model achieved a ROC AUC score of 0.7609 on the test set, as shown in the final evaluation (Page 24). This score indicates a strong ability to discriminate between customers who will subscribe (class 1) and those who will not (class 0). The Random Forest model, used for feature importance analysis (Page 10), was not explicitly evaluated for AUC-ROC in the provided document. However, Random Forests typically perform well in classification tasks but may struggle with highly imbalanced datasets like this one, where only a small proportion of customers subscribe (482 positive cases vs. 3636 negative cases, Page 24). The ANN's ability to model complex, non-linear relationships through its layered architecture likely contributed to its competitive AUC-ROC performance, making it a strong candidate for this task.

**2. Cross-Validation Results**

Cross-validation results for the ANN model demonstrated consistent performance across different subsets of the data. The 5-fold cross-validation yielded an average accuracy of 0.8989 with a standard deviation of 0.0027 (Page 21), indicating excellent generalizability and stability. This low variance suggests that the ANN model is robust to variations in the training data, a critical factor for ensuring reliable predictions in real-world applications. While the Random Forest model was not subjected to cross-validation in the document, its feature importance analysis (Page 10) showed that it effectively identified key predictors, but its performance was not evaluated across multiple folds. The ANN's cross-validation results provide stronger evidence of its reliability, supporting its selection as the final model.

**3. Accuracy and Sensitivity**

The ANN model achieved a test accuracy of 0.8932 (Page 24), with a precision of 0.69, recall of 0.16, and F1-score of 0.26 for the positive class (subscribers). While the overall accuracy is high, the low recall for class 1 indicates that the model struggles to identify all potential subscribers, which is a common challenge in imbalanced datasets. The Random Forest model, although not fully evaluated for classification metrics, was used to select top features contributing to 90% of cumulative importance (Page 10). Random Forests are known for balancing accuracy and sensitivity, but they may not capture the complex interactions between features as effectively as ANNs in datasets with many categorical and numerical variables. The ANN's ability to handle such complexity, combined with its high overall accuracy, makes it suitable for the project's goals, though future improvements could focus on boosting recall for class 1.

**4. Model Complexity and Interpretability**

The ANN model, with its architecture of 128, 64, and 32 neurons across hidden layers (Page 12), is computationally intensive and less interpretable than simpler models like Random Forest. The Random Forest model offers better interpretability through feature importance scores (Page 10), which clearly indicate which features (e.g., age, nr.employed, poutcome\_success) drive predictions. However, interpretability was not the primary goal of this project, as the focus was on predictive performance to support marketing decisions. The ANN's ability to model non-linear relationships and interactions between features, such as cyclic encodings for month and ordinal mappings for education(Page 7), aligns with the dataset's complexity, which includes a mix of numerical, categorical, and engineered features.

**5. Alignment with Project Goals and Practical Applications**

The primary goal of the project was to develop a model that accurately identifies potential subscribers to optimize the bank's marketing campaigns. The ANN model's strong AUC-ROC and cross-validation performance demonstrate its ability to generalize across diverse customer profiles, which is crucial for real-world deployment. The model's capacity to handle the dataset's complexity, including one-hot encoded categorical variables and scaled numerical features (Page 6), ensures that it captures nuanced patterns in customer behavior. Additionally, the hyperparameter tuning process (Page 22) identified optimal settings (batch size: 32, learning rate: 0.001, dropout rate: 0.2, optimizer: Adam), further enhancing the ANN's performance. In practical applications, the ANN can be integrated into the bank's customer relationship management system to prioritize high-probability subscribers, improving campaign efficiency and return on investment.

While the Random Forest model offers advantages in interpretability and computational efficiency, its performance was not fully evaluated for classification, and it may not handle the dataset's non-linear relationships as effectively as the ANN. The ANN's superior performance in AUC-ROC and cross-validation, combined with its alignment with the project's predictive goals, makes it the preferred choice.

**Final Choice**

The Artificial Neural Network was selected as the final model due to its strong AUC-ROC performance (0.7609), excellent cross-validation results (average accuracy of 0.8989 ± 0.0027), and ability to model complex, non-linear relationships in the dataset. These factors ensure that the model generalizes well and provides reliable predictions for identifying potential subscribers. Although the model's recall for the positive class is relatively low, this can be addressed in future iterations through techniques like class weighting or oversampling. The ANN's robust performance and alignment with the bank's marketing objectives make it an ideal choice for practical deployment, where predictive accuracy and generalizability are paramount.

This decision reflects a balance between predictive power and the need to handle the dataset's complexity, ensuring that the model meets the project's goals while providing actionable insights for the bank's marketing team.