UNDERGRADUATE THESIS

COGNITIVE TRAINER: IMPLEMENTATION OF DYNAMIC DIFFICULTY ADJUSTMENT TO WEB-BASED BRAIN-TRAINING GAMES

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APPROVAL SHEET

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ABSTRACT

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Most brain training apps available today use static difficulty levels so they are unable to adapt the challenge to the user's individual abilities in *real-time,* which can potentially lead to frustration and boredom and ultimately reduce the effectiveness of cognitive training. This study aims to design and implement a *rule-based Dynamic Difficulty Adjustment* (DDA) *mechanism in a web-based* brain training *game application* entitled **"Cognitive Trainer",** implement the *Dynamic Difficulty Adjustment* (DDA) method into the game system, evaluate technical functionality through *Black Box Testing,* and evaluate the user experience through *a Likert-scale* USE Questionnaire. The application was developed using React.js and Tailwind CSS which integrates five cognitive exercises, namely *Sustained Attention, Interference Control, Attention Switching, Visual Tracking,* and *Focus Meditation,* all of which are equipped with an adaptive *Dynamic Difficulty Adjustment* (DDA) mechanism except *for Focus Meditation.* The system development method uses *the Waterfall model.* Functional testing was carried out using *the Black Box Testing* method with *Equivalence Partitioning* and *Boundary Value Analysis* techniques for 20 test cases, while user experience evaluation was carried out through a seven-item questionnaire to 20 respondents selected by *purposive sampling technique.* The results of *the Black Box Testing* test showed a success rate of [X]%, indicating that all system functionality including the *Dynamic Difficulty Adjustment* (DDA) mechanism was running according to the specifications designed. The results of the user experience evaluation obtained an average score of [X] out of a scale of 5, which was categorized as [Good/Excellent], reflecting the positive acceptance of the user's acceptance of the suitability of the level of difficulty, engagement, and satisfaction of using the application. This study concludes that *the rule-based* Dynamic Difficulty Adjustment *(DDA) mechanism has* been successfully implemented and validated on React.js web platform, and is well accepted by users as an adaptive and interactive cognitive training system.

Keywords: dynamic difficulty adjustment, brain training, react.js, black box testing, user experience

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Surabaya, July 17, 2026

Author

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$F_0(x)$	: Initial prediction of the model before the boosting
$F_{0,k}(x)$	: Initialization log-odds value for class k before boosting iteration
γ	: Optimal constant or weight value in the boosting process
$\arg\min_{\gamma}$	: Values that minimize the loss function γ
$L(y_i, \gamma)$	: Loss function between actual and predicted values
y_i	: Actual target value / label on the data to-i
$\sum$	: Summing up all training data
r_{im}	: Pseudo-residual (negative gradient) in the data to be iterated to-
r_{ik}	: Pseudo-residual for class k in the ith data
k	: Class indexes in multiclass classification
K	: The total number of classes in a multiclass classification
$F(x)$	: Model prediction function
$F_{m-1}(x_i)$	: Model predictions in previous iterations
$F_m(x)$	: Cumulative model on the m iteration
$F_k(x)$	: Log-odds value of the model for class k
m	: Boosting iteration index
i	: Training data index
$h_m(x)$	: Weak learner or decision tree in the second iteration m