

IMPLEMENTASI *INTELLIGENT TUTORING SYSTEM* BERBASIS *LARGE LANGUAGE MODEL* DAN VISUALISASI DINAMIS PADA PLATFORM PEMBELAJARAN STRUKTUR DATA

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ABSTRAK

Perkembangan Industri 4.0 menciptakan permintaan besar terhadap talenta digital dengan kompetensi teknis mendalam, namun institusi pendidikan tinggi di Indonesia belum mampu menyelaraskan kurikulum dengan kebutuhan dunia kerja. Kesenjangan ini tampak pada mata kuliah Struktur Data, di mana 76,1% mahasiswa Fakultas Ilmu Komputer UPN Veteran Jakarta merasa materi perkuliahan belum optimal mempersiapkan mereka untuk menghadapi tes teknis seleksi kerja. Penelitian ini bertujuan merancang, mengimplementasikan, dan mengevaluasi platform pembelajaran struktur data berbasis web yang mengintegrasikan *Intelligent Tutoring System* (ITS) dengan *Large Language Model* (LLM) dan *Retrieval Augmented Generation* (RAG), dilengkapi visualisasi dinamis, gamifikasi, dan *storytelling*. Metode yang digunakan adalah *Rapid Application Development* (RAD) melalui tahapan *Requirements Planning*, *User Design*, *Construction*, dan *Cutover*, dengan pengumpulan data awal dari kuesioner kepada 46 mahasiswa. Pengujian mencakup *Black Box Testing*, *User Acceptance Testing* (UAT) dengan instrumen PSSUQ, evaluasi kinerja RAG menggunakan Ragas, serta pengujian performa *real-time*. Hasil menunjukkan seluruh 15 skenario fungsional berjalan tanpa galat, skor *Overall* PSSUQ sebesar 1,769 dari skala 7,0 (semakin rendah semakin baik), dan *Context Precision* RAG sebesar 0,911. Mengingat ketidakcocokan metrik Ragas standar untuk sistem *tutoring Socratic*, dikembangkan tiga metrik khusus yang menghasilkan *Socratic Score* 0,867, *Analogy Score* 0,733, dan *Alignment Score* 1,000, membuktikan keberhasilan Oracle menjalankan peran *tutor Socratic*.

Kata Kunci : Gamifikasi, *Intelligent Tutoring System*, *Large Language Model*, *Retrieval Augmented Generation*, Struktur Data, Visualisasi Dinamis

IMPLEMENTATION OF AN INTELLIGENT TUTORING SYSTEM BASED ON LARGE LANGUAGE MODELS AND DYNAMIC VISUALIZATION ON A DATA STRUCTURES LEARNING PLATFORM

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ABSTRACT

The development of Industry 4.0 has increased demand for digital talent with strong technical competencies, yet higher education institutions in Indonesia still struggle to align their curricula with industry needs. This gap is evident in the Data Structures course, where 76,1% of students at the Faculty of Computer Science, UPN Veteran Jakarta, felt inadequately prepared for technical job selection tests. This study aims to design, implement, and evaluate a web-based data structures learning platform integrating an Intelligent Tutoring System (ITS) with a Large Language Model (LLM) and Retrieval Augmented Generation (RAG), supported by dynamic visualization, gamification, and storytelling. The Rapid Application Development (RAD) method was applied through Requirements Planning, User Design, Construction, and Cutover stages, with initial data collected via questionnaire from 46 students. Evaluation covered Black Box Testing, User Acceptance Testing (UAT) using the PSSUQ instrument, RAG performance assessment via the Ragas framework, and real-time performance testing. Results showed all 15 functional scenarios ran without errors, an Overall PSSUQ score of 1,769 out of 7,0 (lower is better), and a RAG Context Precision of 0,911. As standard Ragas metrics are incompatible with Socratic tutoring systems, three custom metrics were developed, yielding a Socratic Score of 0,867, Analogy Score of 0,733, and Alignment Score of 1,000, confirming Oracle's effectiveness as a Socratic tutor.

Keywords: *Data Structures, Dynamic Visualization, Gamification, Intelligent Tutoring System, Large Language Model, Retrieval Augmented Generation*