國立中央大學
National Central University

MIAT

A Knowledge Graph and LLM Based Framework for Personalized Reading Assessment and Management for Children

Supervisor: Prof. CHEN Ching-Han
Prof. Frank GECHTER

Student : WU Hsin-Jou

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Outline

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- Problematic & Research Objectives
- Knowledge Graph and LLM-Based Management System Design
- Experimentation
- Conclusion

Abstract

This study proposes a personalized reading assessment framework for children, combining knowledge graphs and large language models (LLMs) to overcome the limitations of traditional standardized tests. The system integrates OCR, LLM-based semantic parsing, and multi-level knowledge graph construction to track reading activities in real time and model knowledge structures dynamically. Key assessment metrics include Knowledge Quantity, Relationship Density, Cognitive Level Distribution, and Knowledge Association Density, visualized through an interactive dashboard. Evaluated on 2,600+ children's books and a longitudinal case study, the system demonstrates its ability to monitor knowledge growth and diversity, providing a scalable, data-driven approach for personalized education. This framework highlights the potential of AI to enhance learning analytics and child literacy development.

Problematic

- Reading Necessity and Efficiency in the Age of AI
  - **Reading remains fundamental** for children's cognitive and language development in an AI-driven world
  - Reading builds critical skills:
    - Vocabulary growth
    - Comprehension
    - Creativity
    - Lifelong learning ability

Problematic of Children's Reading Management

Standardized Tests

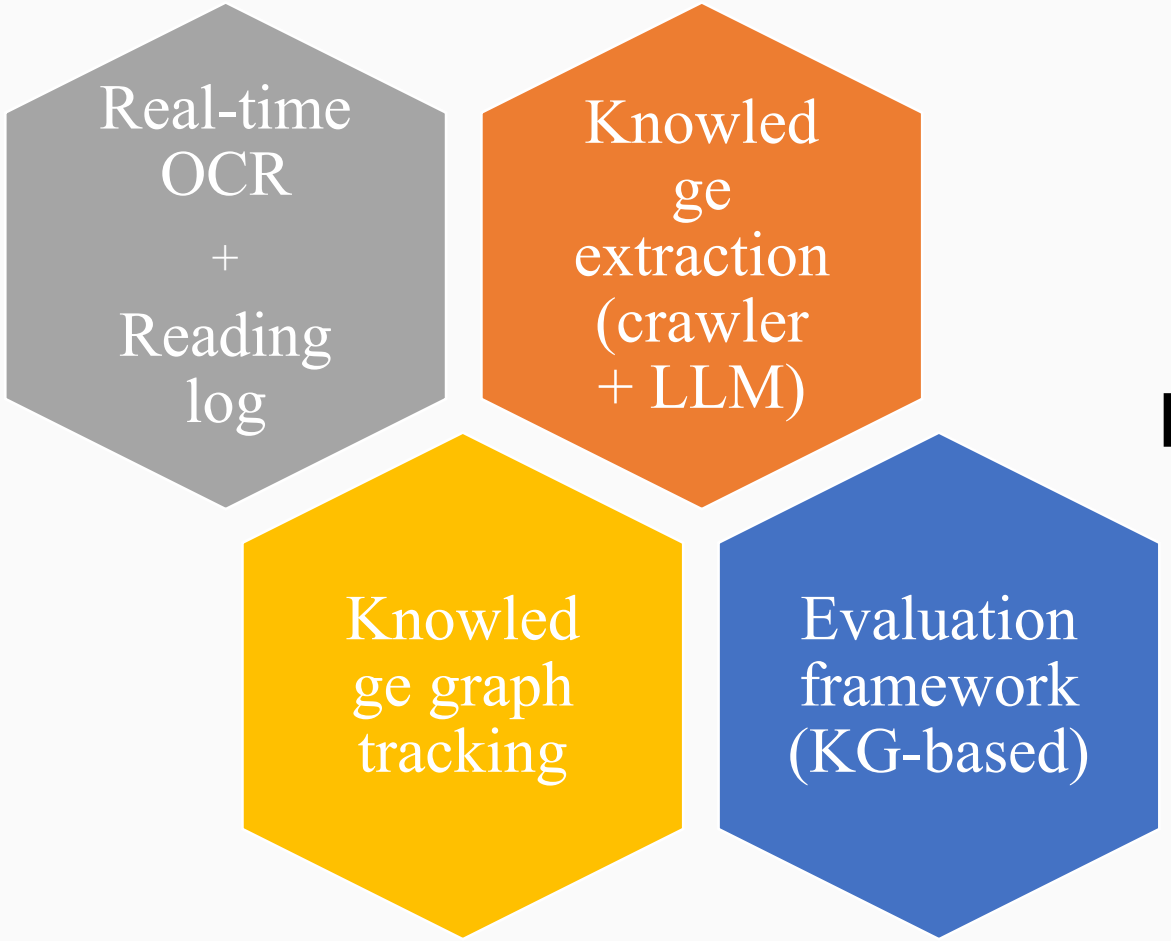
Subjective Judgment

Lack of Objective, Continuous Monitoring

Limited Visualization of Knowledge Structure

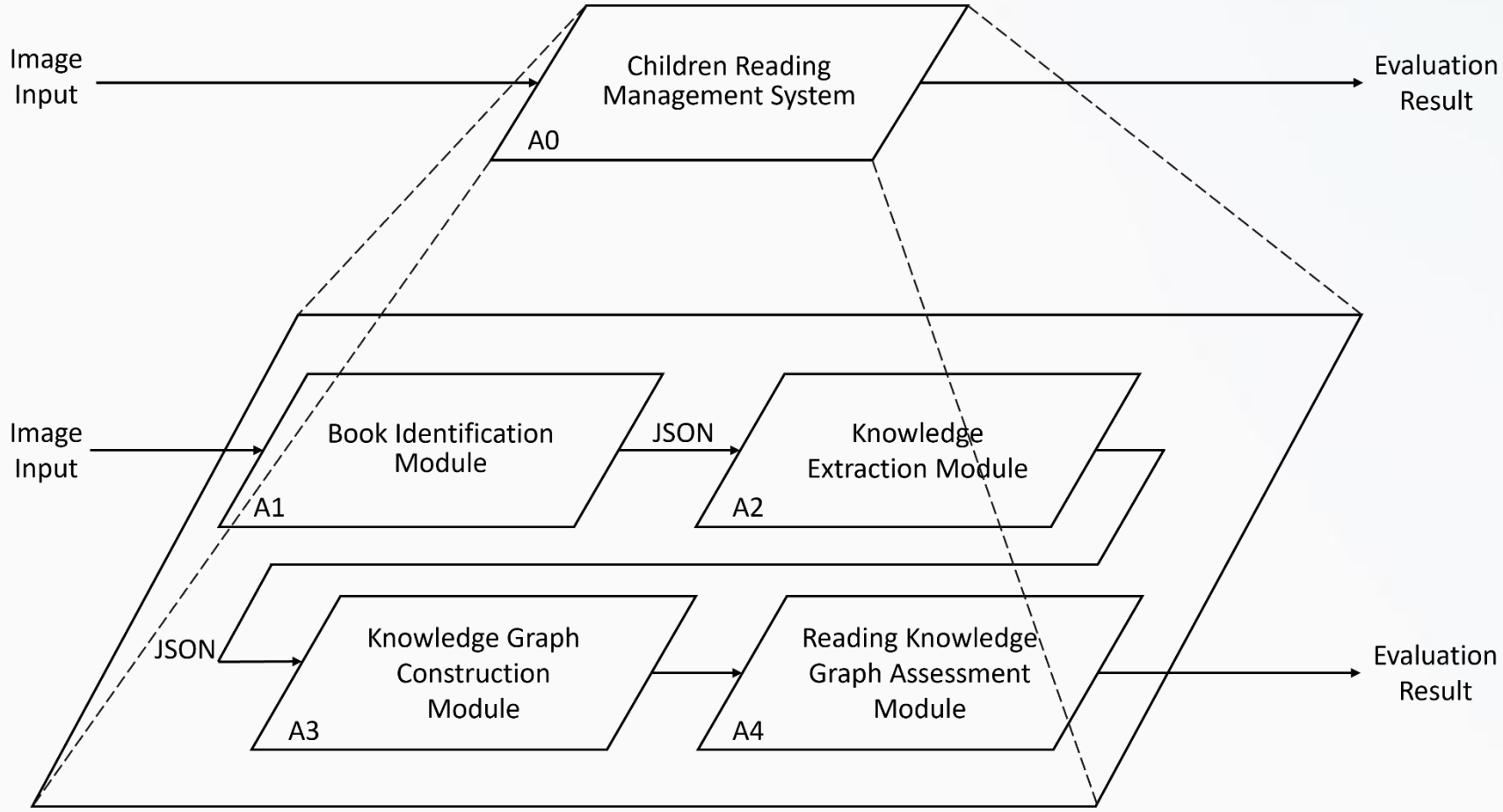
Limited Personalized Guidance

Research Objectives

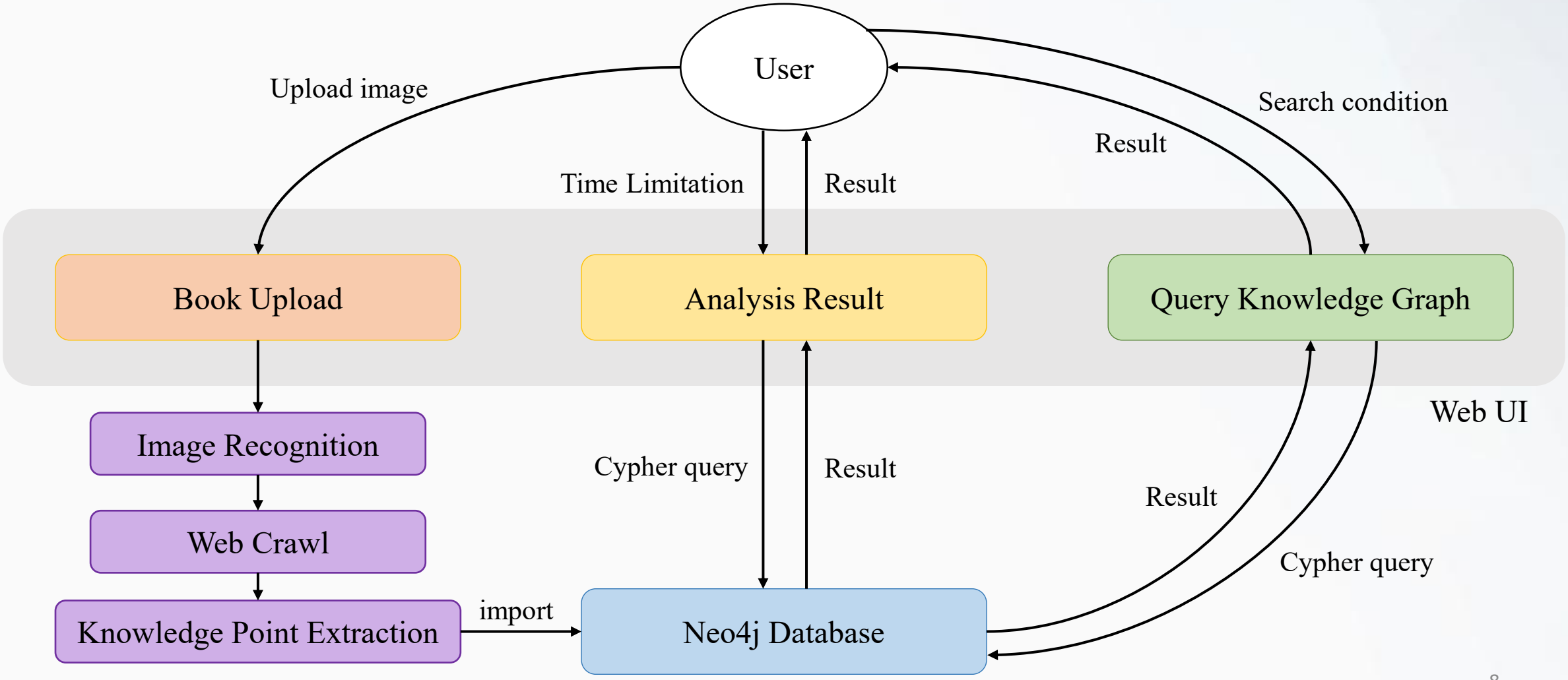


Novel framework integrating AI and KG in EdTech

Reading Management System A0



Reading Management System UI Design



Core Assessment Metrics

Knowledge Point Quantity

Reading breadth

Association Density

Concept integration ability

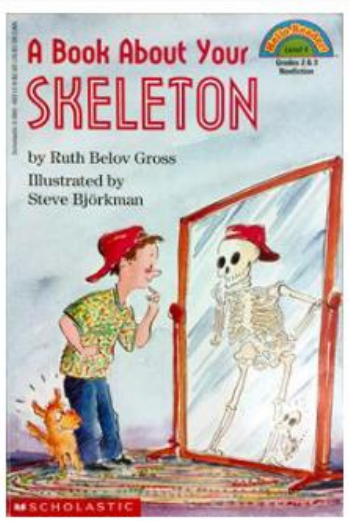
Cognitive Level Distribution

Depth of cognitive engagement

Domain Coverage

Thematic diversity

Dataset Description

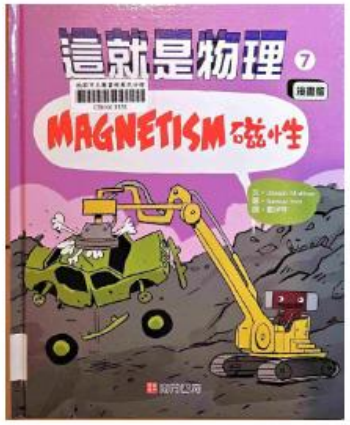


(1) A Book About Your Skeleton

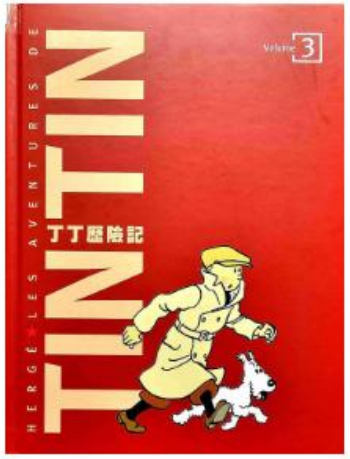
(2) AI: A Visual Guide

(3) Entrepreneurship Begins at Age 10

(4) This is Gaudí



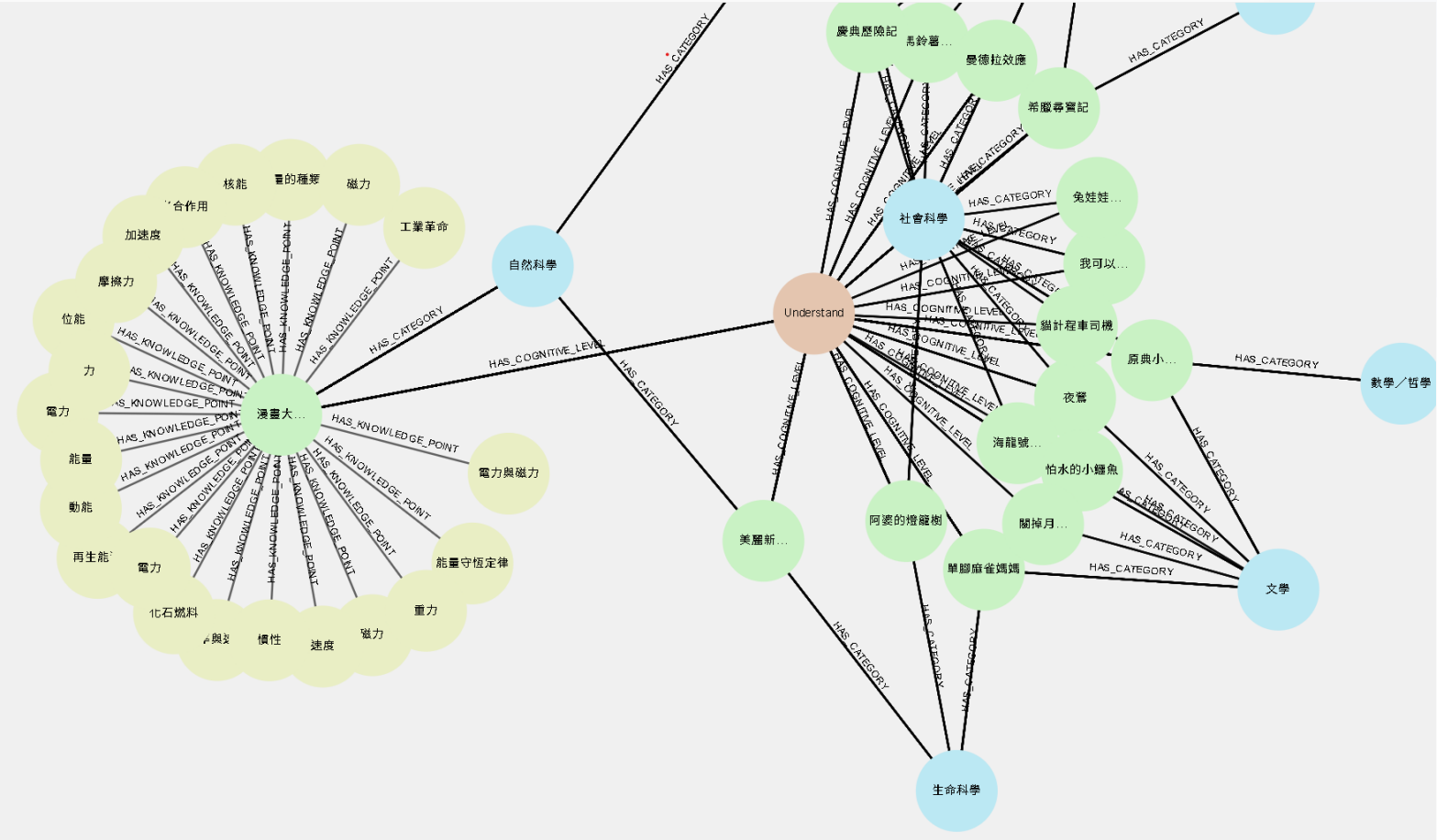
(5) This is Physics: Magnetism



(6) The Adventures of Tintin

- Comprises over 4,000 real children's book images
- Single child's reading history between 2022 and 2024
- Wide range of domains
  - Science
  - Literature
  - Entrepreneurship
  - Art
  - And so on

Visual Evaluation Interface Enables Multi-Dimensional Insights



Color-coded nodes stand for different type of data nodes:

Pink → Cognitive Level

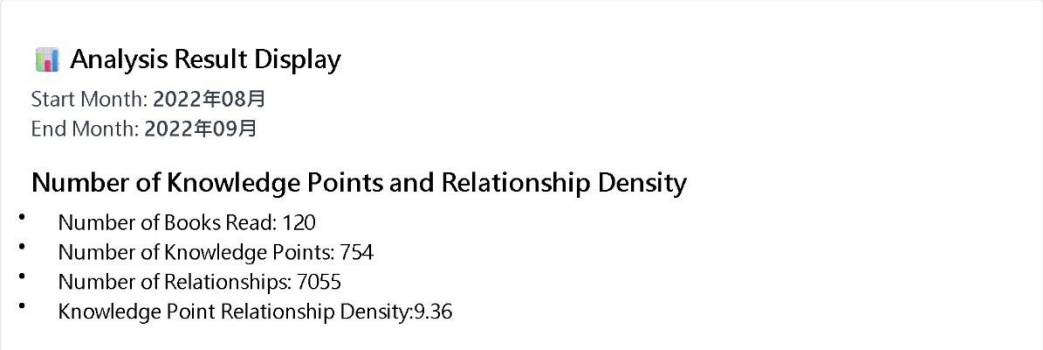
Blue → Category

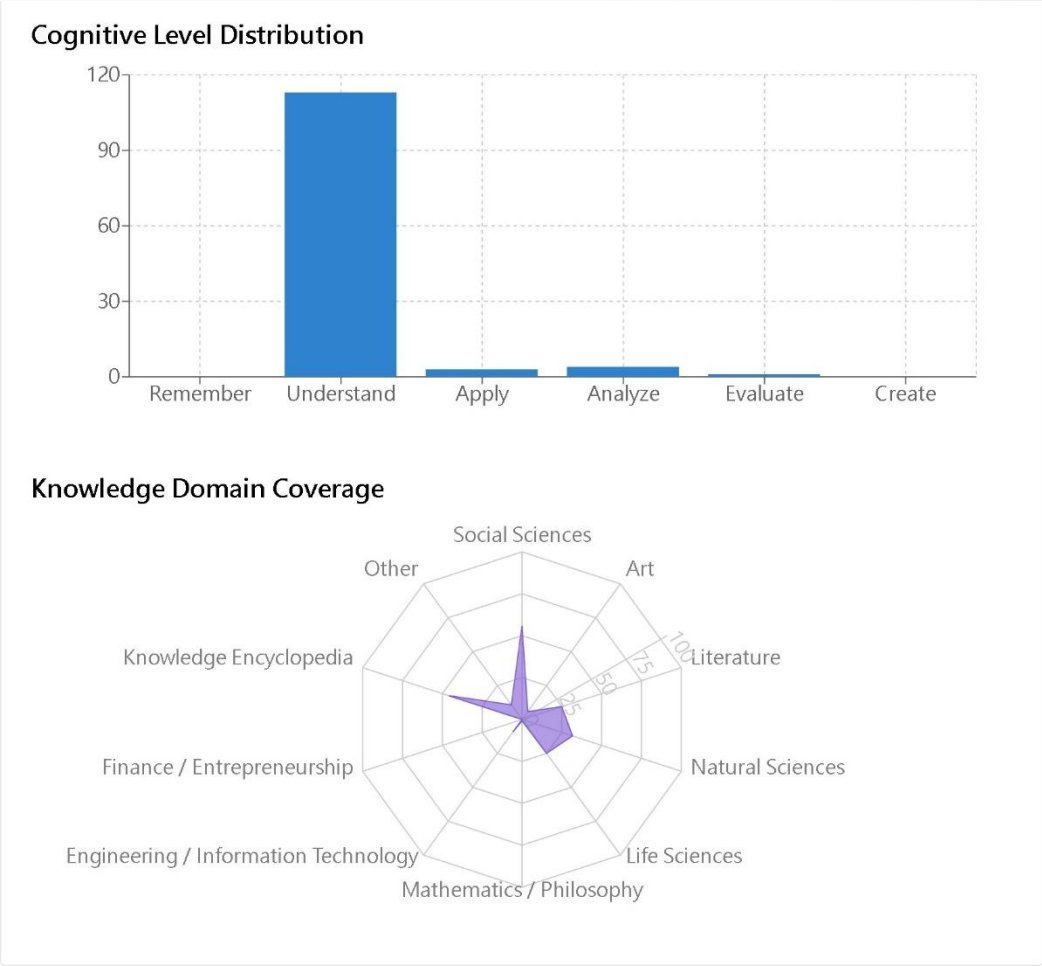
Green → Book

Yellow → Entity (Knowledge)

Color-coded by title, domain, cognitive level → Reflects knowledge structure

Visual Evaluation Interface Enables Multi-Dimensional Insights





Multi-dimensional insights from the visualized evaluation interface, enabling parents and teachers to track a child's reading progress.

Quantitative Growth of Knowledge Acquisition Over Time (Statics)

Time	Jan-Feb 2023	Jan-Apr 2023	Jan-Jun 2023	Jan-Aug 2023	Jan-Oct 2023	Jan-Dec 2023
Number of Books Read	57	287	630	759	827	899
Number of Knowledge Points	378	1541	2818	3333	3519	3784
Number of Relationships	3318	16681	33857	41140	45113	49085
Knowledge Point Relationship Density	8.78	10.82	12.01	12.34	12.82	12.97

Knowledge Accumulation

Conclusion

- Combine **OCR, LLM, and web crawling** to extract and structure knowledge from physical book covers, stored and visualized using **Neo4j**.
- **Multi-Metric Assessment** using four indicators—knowledge count, relation density, cognitive depth, and domain coverage—presented through an interactive dashboard.
- **Longitudinal Insights**: Tracks reading growth over time, enabling dynamic monitoring and personalized learning insights.