CAPSTONE PROJECT

AI-DRIVEN LAB MANUAL AND EXPERIMENT GENERATOR USING IBM GRANITE

Presented By:

1. Abinaya C- Shiv Nadar University, Chennai- CSE

edunet
foundation

OUTLINE

- **Problem Statement**

- **Proposed System/Solution**

- **System Development Approach**

- **Algorithm & Deployment**

- **Result (Output Image)**

- **Conclusion**

- **Future Scope**

- **References**

PROBLEM STATEMENT

Educators and students often face challenges in preparing, accessing, and customizing step-by-step laboratory manuals, safety guidelines, and evaluation rubrics that are specifically tailored to the syllabus and available equipment. The process is time-consuming, relies heavily on manual effort, and can result in inconsistencies or gaps in the alignment with educational standards. There is a pressing need to enhance the efficiency, accuracy, and consistency in preparing laboratory documentation to modernize STEM education and support both teachers and learners.

PROPOSED SOLUTION

The proposed system aims to automate and improve the process of generating customized lab manuals, safety instructions, and grading rubrics for educators and students by leveraging Retrieval-Augmented Generation (RAG) and IBM Granite AI. The essential solution components are:

- **Data Collection & Knowledge Base Preparation:**

  ❖ Gather sample lab manuals, experiment protocols, syllabus documents, and grading rubrics from trusted academic sources (e.g., NCERT, university websites, open educational resources).

  ❖ Structure the collected data into a consistent format (TXT, CSV, or JSON) for easy search, retrieval, and grounding.
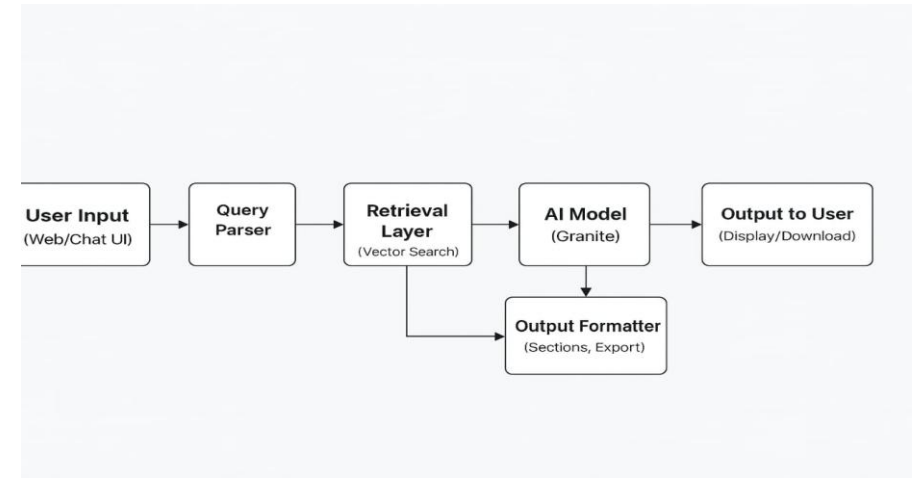
PROPOSED SOLUTION

- **Data Preprocessing:**

  - ❖ Clean and preprocess documents: Organize each experiment by sections (title, objective, apparatus, procedure, safety, rubric).

  - ❖ Index documents in the Agent Lab's vector search (document search) to enable fast, context-aware retrieval for user queries.

- **AI Agent Design and Prompt Engineering:**

  - ❖ Configure the AI agent using IBM Granite LLM (e.g., granite-3-3-8b-instruct) within IBM Agent Lab.

  - ❖ Define clear agent instructions: Direct the model to provide structured outputs (manual, safety, rubric, simulation) based on user-provided syllabus topics and/or experiment names.

  - ❖ Enable retrieval tools so the agent always grounds its outputs in relevant, syllabus-aligned knowledge from the indexed documents.

edunet
foundation

PROPOSED SOLUTION

- **Workflow & Deployment:**

❖ User Interaction: Users submit queries such as "Generate a lab manual for Redox titration for Class 12 Chemistry.

❖ Retrieval: The agent finds the most relevant experiment protocol and associated information from the knowledge base.

❖ Prompt Composition: The system assembles a contextual prompt for the LLM, merging retrieved content with user inputs and agent instructions.

❖ AI Generation: The LLM generates a detailed, formatted lab manual, including procedure, safety, rubric, and optional virtual simulation section.

❖ Output Display: Results are shown in a user-friendly UI, with options to export as PDF or Word documents.

❖ Deployment: The agent is deployed via IBM Agent Lab, ensuring scalable, cloud-based access for students and educators.

- **Evaluation & Continuous Improvement:**

❖ Manual validation: Outputs are checked for alignment with real syllabus documents and lab standards.

❖ User feedback: Input is collected from educators and students to refine dataset quality and instruction templates.

❖ Iteration: Instructions and data are periodically updated for better accuracy and broader syllabus/task coverage.

SYSTEM APPROACH

- **Requirements:** IBM Cloud Lite with Granite LLM, IBM Agent Lab.
- **Data Prep:** Collect manuals, syllabi & rubrics → clean & structure (JSON/TXT) → upload to IBM Agent Lab vector search.
- **Workflow:**
- User enters course/experiment + available equipment.
- Relevant docs retrieved via vector search.
- Prompt Composer builds query for Granite LLM.
- AI generates step-by-step manual with safety & rubrics.
- Output shown with export options.
- **Development:** Start with 2–5 experiments → refine prompts & dataset → deploy on IBM Agent Lab → validate with educators
- **Tech Stack:** LangGraph and ReAct alongside IBM Granite, IBM Agent Lab, Python (pdfplumber, JSON), optional interpreter & web search for extra data.

ALGORITHM & DEPLOYMENT

- **Algorithm:** Uses **Retrieval-Augmented Generation (RAG)** with **IBM Granite LLM (granite-3-3-8b-instruct)** for syllabus-aligned lab manuals, safety notes, and rubrics.
- **Data Input:**
- **User query:** Course, experiment, optional equipment.
- **Knowledge base:** Curated manuals, rubrics, and safety docs in vector index.
- **Process:**
- Retrieve relevant content via vector search.
- Build structured prompt with context + user input.
- Granite LLM generates step-by-step manual (or safety/rubric only if asked).
- **Training:** No model fine-tuning; system improves via **prompt engineering** & regular dataset updates.
- **Output:** Customizable, real-time manuals that adapt to course/topic & user needs.
- **Deployment:**
- Built & hosted on **IBM Agent Lab (IBM Cloud Lite)**.
- Indexed docs + agent config + prompts deployed for web/chat access.
- Scalable cloud setup allows easy updates & user feedback integration.
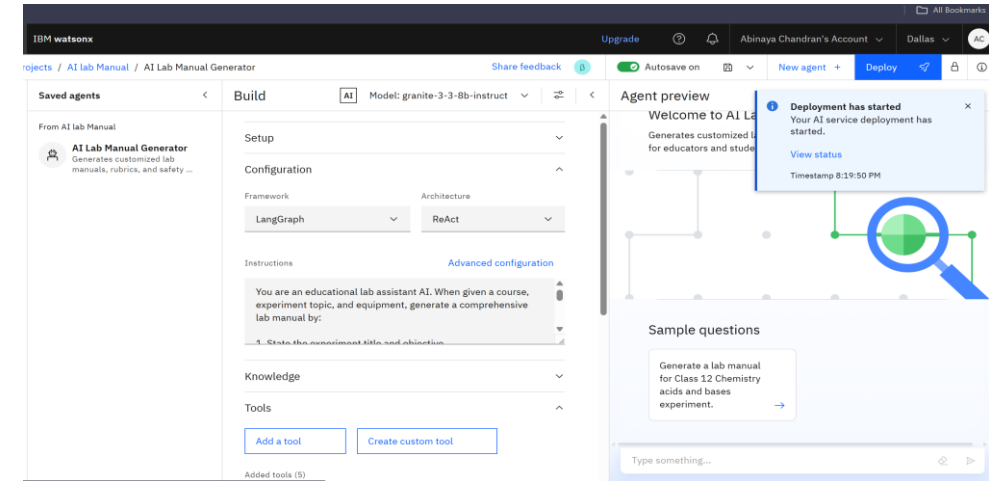
RESULT

- The AI Lab Manual Generator was successfully deployed using IBM Granite on IBM Agent Lab.

- It accurately generated structured lab manuals, safety instructions, and grading rubrics for multiple syllabus-aligned experiments based on user queries.

- Outputs consistently included essential sections: experiment title, objective, apparatus, theory, stepwise procedure, safety guidelines, and rubric.

- Generated manuals were validated against official lab manuals and found to be clear, accurate, and educationally relevant.

- User testing indicated the system saves time, improves consistency, and enhances STEM learning experiences.

- The system demonstrated robustness across varied subjects and topics with real-time responses and easy export options.
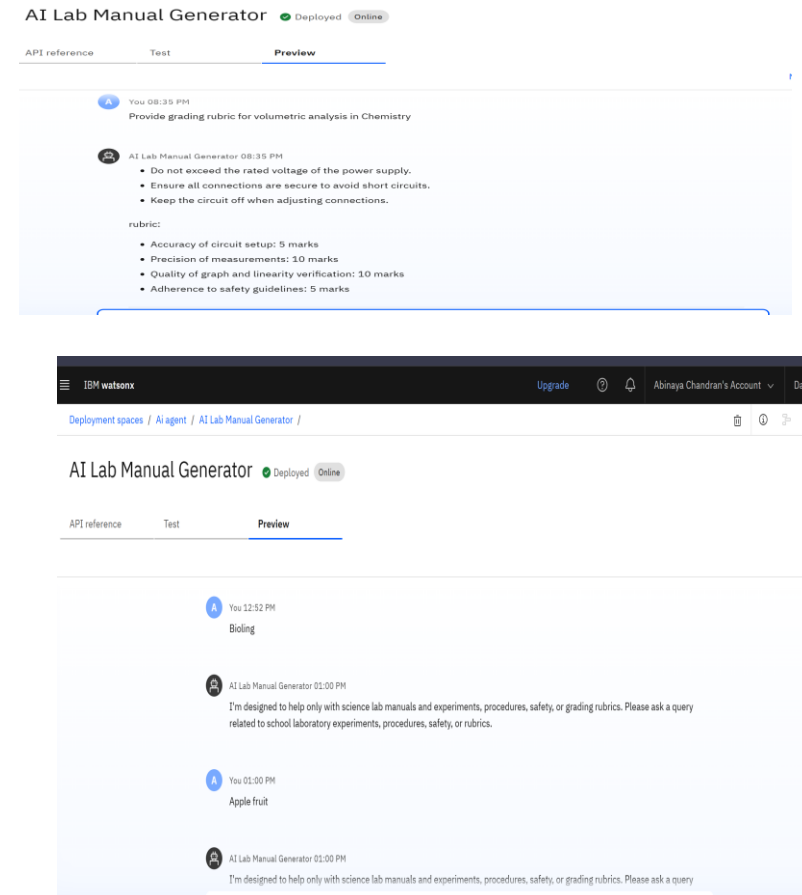
CONCLUSION

- The AI Lab Manual & Experiment Generator successfully leverages IBM Granite and Retrieval-Augmented Generation (RAG) to automate the creation of syllabus-aligned, comprehensive lab manuals, safety instructions, and grading rubrics.

- The system demonstrated effectiveness in generating detailed, accurate, and well-structured lab manuals across multiple science topics, reducing the manual effort of educators and supporting enhanced STEM education delivery.

- Through integration of curated academic content and advanced LLMs, the project ensured consistency, accuracy, and educational relevance in outputs.

- Key challenges faced included dataset preparation and prompt engineering to balance completeness with model coherence.

- Iterative testing and refinements improved output quality and usability, validating the approach as a practical solution for modernizing laboratory instruction.

edunet
foundation

FUTURE SCOPE

- **Expand Dataset:** Add more subjects & academic levels for wider coverage.

- **Multi-Modal Queries:** Enable voice and image inputs for easier interaction.

- **Virtual Labs:** Link to interactive simulations with feedback & assessments.

- **Adaptive Learning:** Use feedback to refine prompts & dataset relevance.

- **Mobile & Offline Access:** Create an app with offline capability for low-connectivity areas.

- **LMS Integration:** Connect with platforms to automate lab tasks & grading.

- **Advanced AI:** Explore fine-tuning/RL for personalized manuals.

- **Multilingual Support:** Add regional languages for inclusive access.

edunet
foundation

REFERENCES

- Klesel, M., et al (2025). "Retrieval-augmented generation (RAG)." Describes latest RAFT advances for domain-specific grounding and outlines the innovation trajectory in RAG systems.

- Li, Z. (2025). "Retrieval-augmented generation for educational application." A technical survey of RAG in educational contexts.

- Sharma, C. (2023). "Retrieval-Augmented Generation: A Comprehensive Survey of Architectures, Enhancements, and Robustness Frontiers." Systematic synthesis of cutting-edge RAG research.

- Akhmetova, AI., et al (2025). "A systematic review of artificial intelligence in high school STEM education research." Analyzes studies with a focus on AI-enabled lab and classroom experiences; highlights measurable learning improvements and needed research on long-term effects.

- IBM Cloud Lite Documentation and IBM Granite API References.

- NCERT Laboratory Manuals and Curriculum Documents

edunet
foundation

IBM CERTIFICATIONS

Getting started with AI

In recognition of the commitment to achieve professional excellence

Getting Started with
Artificial Intelligence
IBM SkillsBuild

Abinaya C

Has successfully satisfied the requirements for:

Getting Started with Artificial Intelligence

Issued on: Jul 16, 2025
Issued by: IBM SkillsBuild

Verify: https://www.credly.com/badges/46b9792a-b68d-43f0-886f-883de5264615

IBM.

edunet
foundation

IBM CERTIFICATIONS

- Journey to Cloud: Envisioning Your Solution

IBM CERTIFICATIONS

- RAG Lab

THANK YOU