**Pathfinder**

Personalized Career Path Recommender System for University Students

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Course: CSIS-4495 - Applied Research Project

Section: 050

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# **Introduction**

In today’s competitive job market, university students face increasing challenges when choosing their future career path. The traditional methods of career finding, such as personality tests, career questionnaires, or career advisers often fail to understand individual skills and interests, because they are too broad and fail to understand individual differences in skills, academic background and personality.

These limitations have led to interest in the application of intelligent systems in the field of career counseling and education technology.

To overcome these limitations, personalized career recommendation system has emerged as a solution. These systems collect user-provided information such as gender, academic background, skills, interests, and analyze the data to generate personalized recommendations. Based on this context, this research addresses two key questions:

1. How can machine learning models improve the accuracy and related to these recommendations compared to traditional methods?
2. How can student-provided information be used effectively to generate personalized career recommendations?

These questions are important because wrong career choices can lead to poor experience for students and labor market needs. By developing a data-driven and personalized recommendation system, this research aims to help students make confident decisions about their future careers.

Recent career-recommendation studies range from classical ML pipelines to modern hybrid ensembles. Classical content-based pipelines [1] preprocess user-provided descriptions, vectorize with TF-IDF, segment users via K-Means, reduce dimensions with PCA, and rank careers using cosine similarity; a full-stack reference implementation integrates these components into a web app (e.g., Django). Hybrid stacking ensembles [2], recent work for competency-based education creates a structured student dataset (5 features, 5,000 records) and combines Deep Neural Networks and Random Forest via stacking to recommend STEM tracks, reporting ~90.06% accuracy and 92.07% precision with 5-fold CV. Mobile applications such as CareerX [3] have demonstrated the integration of NLP and machine learning into mobile applications, with user satisfaction rates of around 90%. Other studies have highlighted Hybrid filtering approaches [4], combining collaborative and content-based methods to generate personalized educational roadmaps. Hierarchical multi-tiered systems [5] have also been developed to address sparsity and cold-start problems, achieving over 99% accuracy across diverse career datasets.

Despite these advances, several gaps remain. Classical pipelines often rely on limited or generic features, while hybrid models tend to be tailored to narrow contexts such as STEM education. Feedback mechanisms are rarely integrated in near real-time, leaving evaluations dependent on static, offline metrics. Furthermore, most systems lack generalizability, as results validated in one population may not transfer well to others without adaptation.

Based on these gaps, this research assumes that a machine learning based recommendation system using effectively diverse student-provided information will significantly enhance personalization and accuracy. The expected benefit is to provide students with reliable, data-driven guidance for career choices, while contributing to the development of intelligent systems in education technology.

# **Proposed Research Project**

The proposed Pathfinder project is a data-driven experimental design. The main objective is to build a personalized career recommendation system that uses user provided information, such as educational background, gender, skills and interests, to recommend personalized career pathways.

## **Methodology**

Pathfinder follows a four-step methodology, data collection and preprocessing, model training and recommendation engine design, skill gap analysis and job market trend visualization.

First, training data will be collected from public sources such as Kaggle and through web scraping platforms like LinkedIn and Indeed. Operational data will consist of information provided directly by users via Pathfinder website, including major, GPA, gender, interest, skill, and personality traits. Next, the collected data will be used to train models capable of recommending career paths and personality traits to the suggested career path based on similarity measures such as cosine similarity, KNN, or other machine learning classifiers.

Following recommendation generation, a skill gap analysis will be conducted by comparing the requirements of each recommended career with the user’s current skills. To complement this, job market datasets will be analyzed to highlight trends and demand for recommended careers over the last several years. Finally, the system will be implemented as a functional platform that integrates all these components.

## **Technologies to be used**

This project will integrate several technologies

* Operating System: The system will run on both Windows and mac environments.
* Programming Language/Frameworks: Python will be the primary language, using machine learning libraries such as scikit-learn, TensorFlow, and PyTorch.
* Database: MySQL or H2 database will be used to store cleaned data for model and visualization data since those databases are open source and easy to config.
* Frontend: React or Vue.js will be used to build a responsive and interactive user interface that allows users to input their profiles and view career recommendations, skill gap analysis, and job market trends.
* Backend: FastAPI or Flask will serve as the backend to manage model inference, skill gap analysis, and job trend visualization.
* Visualization Tools: Libraries such as Chart.js, D3.js, or Recharts will be used to display skill gaps and job market trends on the dashboard.
* Collaborative Development: GitHub will be used for version control, source code management, and team collaboration. Team members will work together using branches, pull requests and reviews during development.

## **Expected Results**

The expected outcomes of this research are multifaceted. First, the system is anticipated to provide improved accuracy and personalization compared to traditional career counseling methods. Each user will receive the top three to five most suitable career recommendations, offering clear and actionable pathways. Alongside these recommendations, users will also receive a breakdown of the skills they lack, the importance of these skills, and the estimated effort required to bridge the gap.

Additionally, users will gain insights into job market trends, with visualizations of labor market data over the last five years to highlight demand in various careers. The platform will be designed as a user-friendly and interactive tool that encourages students and job seekers to explore potential career paths and refine their skills continuously

Ultimately, this project will contribute to the advancement of educational technology by developing an intelligent system that supports students in making better-informed career decisions while also aligning educational outcomes with labor market needs.

# **Project Planning and Timeline**

This section presents the planned schedule for completing the personalized Career Path Recommender System. The project is divided into clear phases, each with specific milestones and deliverables, to ensure steady progress and timely completion. The timeline follows the official course deadlines for the proposal, progress reports, midterm and final submissions.

Table 1: Proposed project schedule

|  |  |  |  |
| --- | --- | --- | --- |
| Phase | Duration/  Deadline | Milestones | Deliverables |
| Phase 1:  Literature Review & Project Initialization | 2025/09/04 – 2025/09/11 | Collect references on career recommendation systems | Project Proposal |
| Phase 2:  Data Collection & Preprocessing | 2025/09/08 – 2025/09/25 | * Identify data sources * Implement scraping & preprocessing | Cleaned dataset |
| Phase 3:  System Design | 2025/09/12 – 2025/09/25 | * Define system architecture (frontend, backend) * Design recommendation logic | * System architecture diagram * Progress Report 1 |
| Phase 4:  Recommendation Model Development | 2025/09/17 – 2025/10/16 | * Implement recommendation model * Train/test with sample student data | * Working recommendation engine * Progress Report 2 |
| Phase 5:  Frontend & User Interaction | 2025/10/08 – 2025/11/05 | * Build React UI for student input * Connect frontend to backend API | * Functional prototype * Midterm Report * Progress Report 3 |
| Phase 6:  Testing & Refinement | 2025/11/03 – 2025/11/18 | * Test system with multiple profiles * Debug & bug fixing | * Progress Report 4 * Midterm Video Report |
| Phase 7:  Documentation & Final Report | 2025/11/12 – 2025/11/27 | * Prepare final report and presentation | * Progress Report 5 * Final Report & Implementation * Project Defense |

## **Responsibilities**

Leshan Chathuranga Kuruppuarachchi

* Overall project management and coordination
* Data scraping design and implementation
* Model design and implementation
* Frontend development
* Testing and bug fixing

Hyunhee Kim

* Data collection and preprocessing
* Model design and implementation
* Backend API development
* Data visualization implementation
* Testing and bug fixing
* Documentation

## **Project Timeline Gantt Chart**

Figure 1: Proposed project Gantt chart

# **Project Contract**

**Agreement**

This contract confirms agreement between the team members on the scope of work and timeline as outlined in the proposal.

* The members agree to carry out the project in accordance with the defined phases, milestones, and deliverables.
* All tasks, including data collection, model development, system design, testing, documentation, and presentation, will be completed by the members.
* Project progress will be communicated through official progress reports and consultation sessions.
* The members commit to submitting all deliverables on or before the deadlines specified in the proposal.
* Meetings will be held daily/weekly with prior notice and members should provide progress updates.
* Members should communicate promptly about any challenges or delays.
* Any modifications to scope, schedule, or deliverables will be discussed in advance and inform the instructor.
* Members should maintain professional standards of work and collaboration



Name & Signature: \_Leshan Chathuranga Kuruppuarachchi\_\_\_\_

Date: \_\_2025/09/24\_\_\_\_\_

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Name & Signature: \_\_Hyunhee Kim\_\_\_\_

Date: \_\_2025/09/24\_\_\_\_\_

# **Work Date/Hours logs**

Student Name: Leshan Chathuranga Kuruppuarachchi

Table 2: Work log - Leshan Kuruppuarachchi

|  |  |  |
| --- | --- | --- |
| Date | Number of Hours | Description of work done |
| 2025-09-05 | 3 | Initial research on the topic. Refer previous research papers. |
| 2025-09-07 | 4 | Refer previous research papers.  Research for existing web scraping resources |
| 2025-09-08 | 3 | Research for existing web scraping resources |
| 2025-09-09 | 3 | Work on project proposal |
| 2025-09-10 | 2 | Work on project proposal  Set up git repo |
| 2025-09-11 | 3 | Finalizing project proposal |
| 2025-09-15 | 2 | Work on web scraping code |
| 2025-09-16 | 3 | Work on web scraping code |
| 2025-09-20 | 4 | Work on web scraping code |
| 2025-09-23 | 1.5 | Finalizing project proposal with feedback |
| 2025-09-24 | 3 | Work on progress report 1 |

Student Name: Hyunhee Kim

Table 3: Work log Hyunhee

|  |  |  |
| --- | --- | --- |
| Date | Number of Hours | Description of work done |
| 2025-09-06 | 4 | Initial research on topic and existing systems |
| 2025-09-07 | 3 | Research on existing systems  Search for datasets in kaggle |
| 2025-09-08 | 3 | Work on project proposal document |
| 2025-09-09 | 4 | Research on existing systems  Work on project proposal document |
| 2025-09-10 | 3 | Work on project proposal document |
| 2025-09-11 | 2 | Finalizing project proposal |
| 2025-09-15 | 2.5 | Study collected dataset |
| 2025-09-16 | 1.5 | Searched more dataset in kaggle |
| 2025-09-18 | 2 | Modify proposal report |
| 2025-09-23 | 2 | Work on progress report 1 |
| 2025-09-24 | 1 | Work on progress report 1 |

# **References**

|  |  |
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| [3] | Y. Gupt, "CareerX: AI-Powered Career Path Recommender System for College Students," *ResearchGate,* 2025. |
| [4] | H. Kumar, U. P. Pandey and P. Kumar, "AI-Based Career Path Recommendation System," [Online]. Available: https://amity.edu/UserFiles/aijem/293Harsh1.0%20(AJCS).pdf. |
| [5] | M. QAMHIEH, H. SAMMANEH and M. N. DEMAIDI, "PCRS: Personalized Career-Path Recommender," *IEEEAccess,* 2020. |