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WIP: Enhancing Task Distribution in Project-Based Learning: A Management Tool for Improved Course Efficiency

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Abstract

This Work in Progress paper presents the development of an AI-powered project management tool designed to support students in project-based engineering courses by enhancing task distribution and management. Project-based learning is a cornerstone of engineering education, fostering essential graduate attributes such as teamwork, communication, and project management, as outlined by the Canadian Engineering Accreditation Board (CEAB). However, engineering students, particularly in upper-year courses, often face challenges in managing tasks due to demanding schedules and uneven workloads within teams.

The proposed tool leverages artificial intelligence to break down complex projects into manageable sub-tasks, optimize task assignments based on team members' skills and availability, and streamline project planning. Developed using Next.js for the frontend and FastAPI for the backend, the tool integrates advanced machine learning models to extract tasks from course syllabi, classify them into categories, and allocate them efficiently among team members. Initial results from surveys conducted with final-year engineering students demonstrate positive impacts on team collaboration, task completion, and stress reduction.

Future iterations of the tool will incorporate user feedback to refine features, such as sub-task generation and personalized scheduling, and assess its effectiveness in real-world course settings. This research contributes to the ongoing discourse on improving student experiences and outcomes in engineering education, emphasizing the role of innovative tools in fostering collaboration and equipping students with the skills needed for modern engineering challenges.

Introduction

Participating in project-based courses is a common experience across many engineering programs from first year design courses to capstone and more. The Canadian Engineering Accreditation Board (CEAB) includes project management as one of the twelve graduate attributes engineering students must develop and demonstrate throughout their degree [1]. Often this attribute is embedded within project-based courses, such as final year capstone courses, and first year and upper year engineering design courses [2]. Many of these projects are team-based, teaching engineering students important attributes, such as, individual and teamwork, communication, professionalism in addition to technical skills related to their disciplines and engineering design [3]. With teamwork, comes the need to understand the strengths and weaknesses of each team member and being able to break down large course deliverables into smaller, more manageable tasks and distributing those within the team [4]. However, with busy engineering schedules, students can often struggle with managing and distributing tasks for such projects, especially in upper years where their schedules might not be as streamlined as some common first year programs [5], [6].

This work in progress study aims to develop a custom project management tool that is powered by Artificial Intelligence (AI) for students participating in project-based courses requiring them to work in teams. The goal of this software is to promote prompt delivery of project components by dividing larger course and project related tasks into manageable sub-tasks and optimizing the availability and technical capabilities of team members to assign those tasks. In doing so, the authors of this paper hope to reduce stress levels and streamline the process of managing the project. Additionally, the authors hope that this tool would allow students to spend less time planning their tasks, and more time completing them.

Research Question

This study aims to answer the following research question:

1. What are the key design and development considerations for creating an AI-powered project management tool to assist students in project-based engineering courses, and how can this tool potentially enhance task distribution and management?

Literature Review

Engineering education has seen longstanding benefits of experiential learning for many years despite the traditional lecture-based approaches to teaching and learning where more attention is allotted to the lecturer, giving students limited opportunities to drive their learning process [7]. Experiential learning methods, such as field trips, laboratory investigations, and project-based learning (PBL), are integrated into engineering curricula to better prepare students for modern industry demands. These methods not only enhance student engagement and performance but also help develop essential skills such as communication, teamwork, flexibility, initiative, analytical thinking, and management. Additionally, project management and teamwork are critical components of engineering education, as they prepare students for real-world challenges by emphasizing planning, organizing, executing tasks efficiently, and collaborating effectively. This literature review explores the integration of PBL in engineering education, its impact on project management and teamwork, and the overall enhancement of the engineering curriculum.

Project-Based Learning

Experiential learning is integrated in many different fields of higher education in addition to engineering through field trips, laboratory investigations and project-based learning [8]. While the traditional project-based learning approaches are more geared towards applying concepts learned in earlier courses, more recent project-based courses allow students to learn concepts while working on course projects at the same time. With the rapid technological advancements, engineering students and graduates are required to have adaptable skills, including communication, teamwork, flexibility, initiative, analytical, and management skills [8]. Additionally, traditional teaching assumes uniform learning styles and paces, which is often not the case. Students need engagement, varying learning speeds, and team learning opportunities. Researchers in engineering education have highlighted a need and corresponding benefits of integrating project-based learning in the engineering curricula [9]. Savage et al. highlight that project-based learning can be a method to make learning exciting and relevant, allowing students to explore technical problems from a system-level perspective [10]. Additionally, these courses emphasize self-directed learning, sustainability, global community awareness, and help develop other "soft skills", which are important to develop throughout their engineering education to become well-rounded engineers [10], [11]. Uziak mentions that project-based courses help engineering students develop their problem-solving, time management, and technical communication skills, which are also some of the key graduate attributes listed by the CEAB [1], [8]. Overall, many researchers report several positive outcomes for integrating project-based learning in engineering, including an increase in student engagement and performance, improved teamwork and collaboration skills, an increased focus on students and more [8], [10], [11]. Therefore, it is evident that project-based courses are important aspects of teaching and learning in engineering education.

Project Management in Engineering

Project management and engineering projects are two distinct but interrelated concepts. The CEAB lists economics and project management as one of the graduate attributes for accrediting engineering undergraduate programs, which defines it as an ability to appropriately incorporate economics and business practices including project, risk, and change management into the practice of engineering and to understand their limitations [1]. Project management focuses on planning, organizing, and executing tasks efficiently while managing resources to meet project deadlines. Integrating these attributes to project-based engineering courses helps students practice continuous development, collaboration, risk management, and resource allocation [12]. Wong and Donald investigate a sequence of four interdisciplinary design courses at the University of Guelph, each integrating project management to varying degrees [13]. They argue that while project management is fundamental to engineering careers, there are challenges in teaching it effectively. These challenges include reduced student motivations, as they prioritize graded activities and often treat project management as peripheral, and curriculum overload, as time constraints prevent deeper exploration of project management concepts [13].

Teamwork in Engineering

Teamwork is another crucial skill engineering students ought to develop and is one of the 12 CEAB graduate attributes for Canadian undergraduate universities [1]. It is also listed as one of the graduate attributes for American accreditation process by the Accreditation Board for Engineering and Technology (ABET) [14]. One of the major opportunities for Canadian engineering students to develop their teamwork skills is through project-based courses, such as first and upper-year design courses and final year capstone course. In a study completed by Thompson at the University of Louisville, first-year students report improvements in their teamwork skills after participating in a first-year project-based course integrating teamwork related content [15]. Additionally, the participants report unequal participation and procrastination to be the most significant barriers to effective teamwork [15]. This can often lead to conflicts within the team members, leading to tension within the team. Chase et al. suggest that the engineering stress culture (ESC) is characterized by heavy workloads, high expectations, and competition [16]. This can be characterised by stress, anxiety, and depression, and is more prominent within the traditional engineering programs with high workloads and competition. However, a study conducted by Chase et al. report that project-based learning settings can help reduce ESC, while also enhancing professional identity and inclusion, particularly for non-traditional or underrepresented students [16]. Therefore, while project-based learning can help reduce stress level in engineering students, proper teamwork and team management skills are required in order to optimize collaboration and ensure a smooth, successful process.

In conclusion, the integration of project-based learning (PBL) within engineering education has demonstrated numerous benefits, including increased student engagement, improved performance, and the development of essential skills such as communication, teamwork, and problem-solving. The incorporation of project management principles within PBL courses further enhances students' ability to plan, organize, and execute tasks efficiently, preparing them for real-world engineering challenges. Effective teamwork is another crucial aspect, as it fosters collaboration, reduces the engineering stress culture, and promotes inclusivity, particularly for non-traditional and underrepresented students. As engineering education continues to evolve, the adoption of PBL, along with a strong emphasis on project management and teamwork, will play a crucial role in producing well-rounded, adaptable, and skilled engineers ready to meet the demands of the modern workforce.

Tool Design

The authors of this study have developed a custom AI-Powered project management tool for project-based courses. This tool aims to distribute tasks for project-based engineering courses to streamline the task generation and distribution process of the project. Figure 1 includes a flowchart visualizing the modules within the tool and the flow of data.

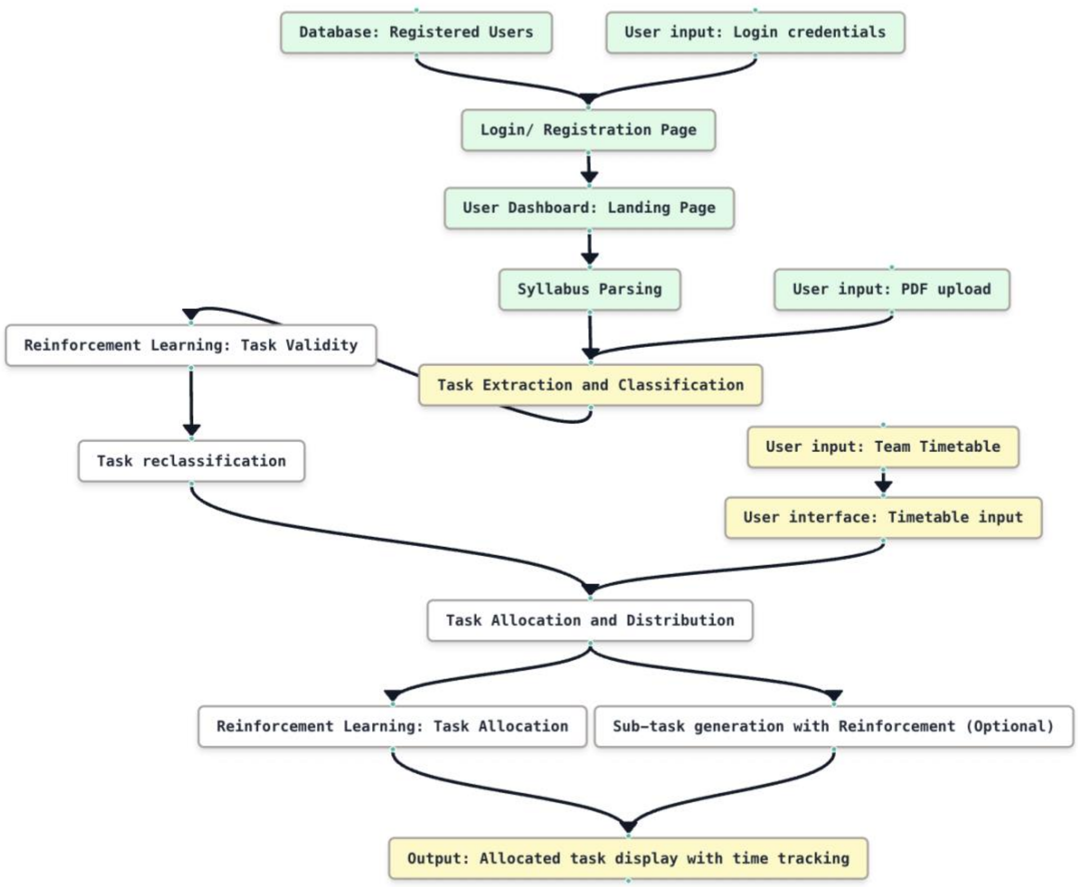

Figure 1: Flow chart of the modules within the project-management tool.

Some of the key features of this tool includes the ability to:

1. parse through course syllabi to extract course tasks related to the project;
2. generate sub tasks based on the extracted tasks to break larger tasks down to smaller, more manageable chunks;
3. classify the extracted tasks into different categories;
4. collect the availability and skillset of students in the team; and,
5. assign tasks to the team members based on their availabilities and expertise.

The tool is available to students as a web application that they can access from any web browsers, and log in using credentials created with the website. The user interface of the web application is developed using NextJS, which is a JavaScript based framework used to build the front end of web and mobile applications that determines the look and feel of the web app, as well as how the user interacts with it. The backend is developed using FastAPI, which is a Python based framework for handling interactions between the user interface and the database, machine learning models and other external API calls.
The system uses a few different machine learning and artificial intelligence models for completing the tasks mentioned above. First, the Optical Character Recognition (OCR) process is carried out on the PDF documents uploaded by students to convert them into text files. This is achieved using PyMuPDF, a Python library used to extract text from the PDFs effectively. Next, the text is sent to a Large Language Model (LLM) developed by Cohere to extract the tasks from the syllabi. Next, the extracted tasks are fed into a custom classifier trained using a Robustly Optimized BERT Pretraining Approach (RoBERTa), using datasets containing tasks related to project-based courses to categorize them into different predefined bins. And lastly, these tasks are assigned to members within the team based on their availabilities and expertise using a resource allocation algorithm. Future versions of this tool will allow the generation of subtasks using a Natural Language Processing (NLP) algorithm, which will help break down larger tasks into smaller, more manageable tasks before classifying and assigning tasks to team members.

Tool Functionality and Output Generation

Our tool is designed to process syllabus documents in PDF format, extracting and categorizing task-related information for further analysis. The workflow begins with the Upload Syllabus page, where users submit a PDF file as shown in Figure 2. Upon submission, backend operations leverage PyMuPDF to convert the PDF into a structured, parsable text format.

Once the document is successfully parsed, the system extracts key information, including:

1. Task Name – Identifies each assignment, project, or evaluation component.
2. Task Percentage – Captures the weightage assigned to each task within the syllabus.
3. Task Description – Provides contextual details about the task requirements.
4. Deadline – Extracts the due date for each task.

While this extracted information is not displayed on the frontend, it serves as the foundation for further processing. After retrieval, the tool employs a task classification algorithm to systematically categorize all extracted task names into predefined task categories as seen in figure 2.

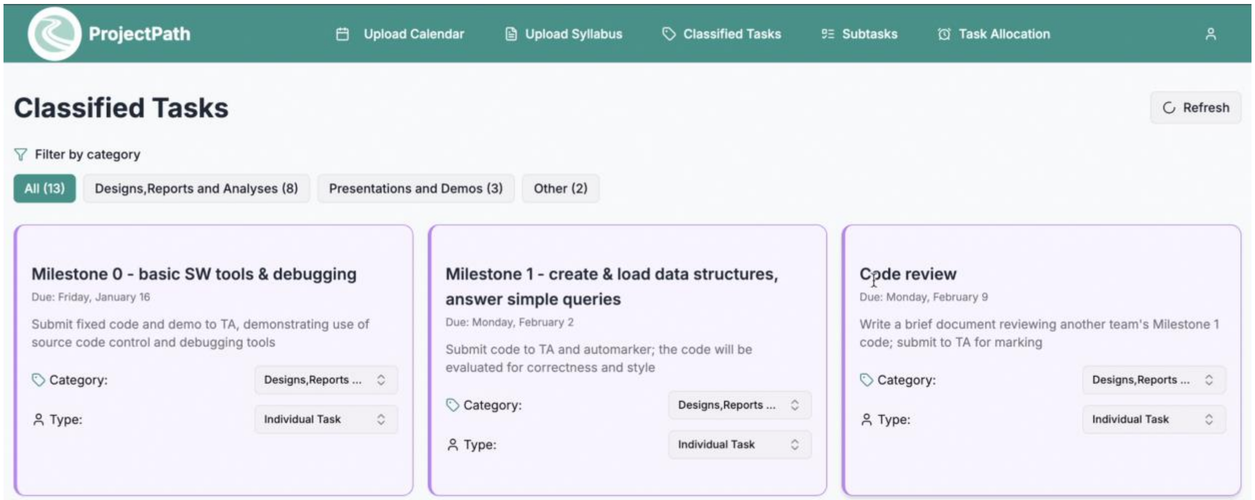

Figure 2: Syllabus Parsing and task classification.

Following classification, the categorized tasks are passed through a backend model that further processes them to generate subtasks as seen in figure 3. This decomposition allows for better workload distribution, ensuring that larger tasks can be broken down into manageable components. By structuring assignments into subtasks, we facilitate efficient workload delegation, making it easier to assign responsibilities among a team of students based on individual availability and expertise. The results of this subtask generation process are illustrated in Figure 3. In addition to generating subtasks, the tool also generates an estimate of the time taken to complete the task. This is done by classifying the subtasks into 3 categories—easy, medium and hard—which are used to estimate the approximate time that the student would take to complete the subtask.

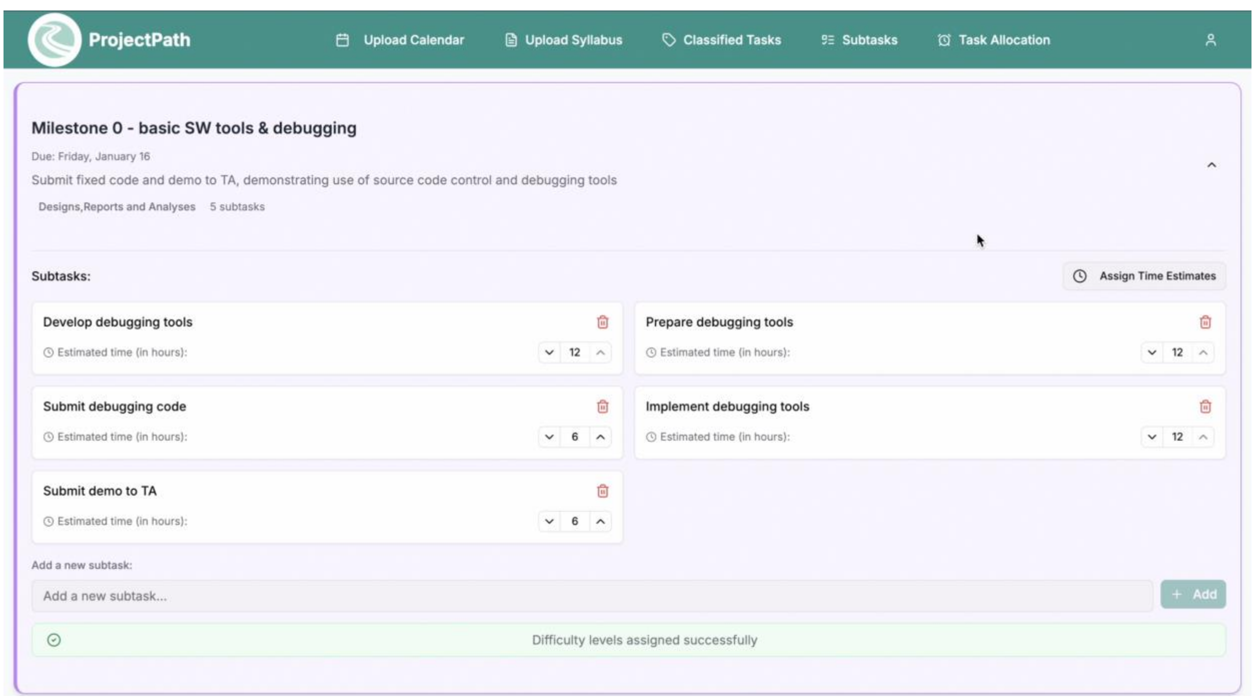

Figure 3: Subtask Generation

However, since these are general estimates, the actual subtasks associated with a task and the time taken to complete each may differ between projects, as well as between team members. To address this, we have added options for the students to add new subtasks, as well as editing the estimated time to complete each task.
Once the tasks and subtasks have been finalized, we can move on to the final stage of the tool: task allocation. The issue we face with the task allocation algorithm is the number of constraints that need to be satisfied to ensure we reach an optimal solution. We need to consider a students' availabilities, the nature of the subtasks being considered, their difficulty level and the different levels of priority they have based on their deadlines.
All these constraints contribute to making this allocation problem NP-Hard, which means that an optimal solution can be only verified in polynomial time. To approach this problem, we decided to make use of dynamic programming principles, which divides the problem into smaller subproblems which can then be solved simultaneously and memoized.
The algorithm takes inputs in the form of the availability of each user, as well as a list of tasks with their deadlines and their difficulty levels. Based on their difficulty level, they are broadly classified as needing 3 hours to complete, 12 hours to complete or 24 hours to complete. We then proceed to allocate these tasks, as seen in Figure 4.

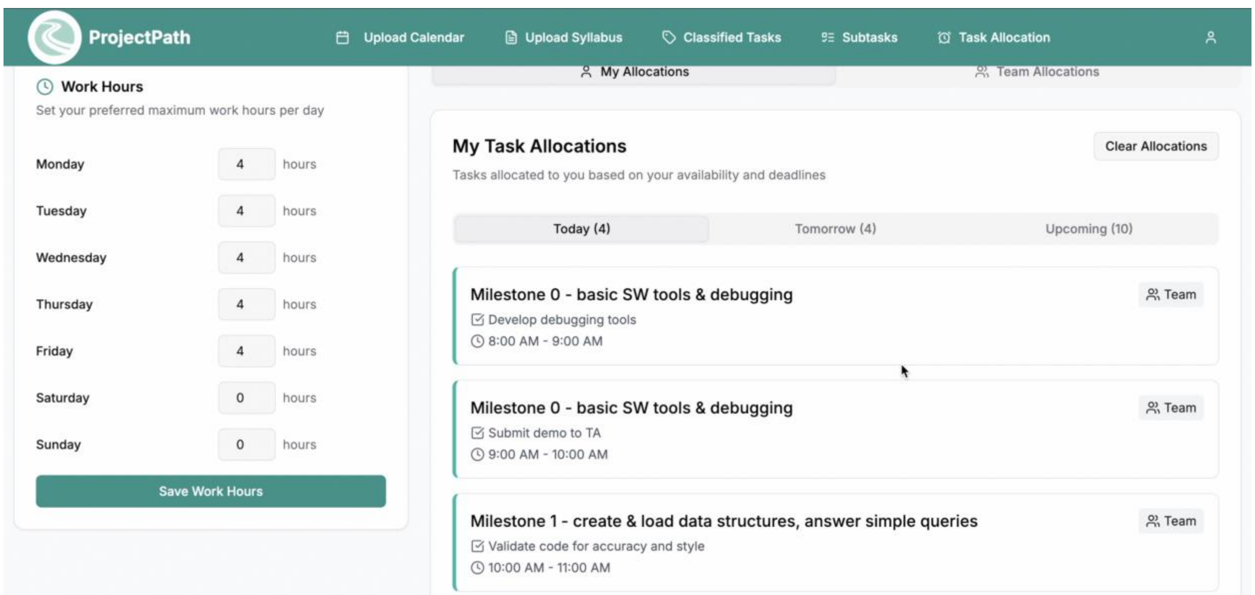

Figure 4: Allocated tasks for an example user following the task allocation module.

Task allocation is one of the most complex components of this tool, not due to the technical development of the algorithm, but rather the reasoning behind the task allocation. A few things to consider during task allocation include:

- whether the tasks should be allocated based on the current skillsets of the users or the skillset they would like to develop (or should develop);
- should there be an equal distribution of tasks among the team members, and if so, what is considered "equal" in terms of workload;

- what happens if the actual time taken to complete a task is much higher—or lower—than the original estimate and the group falls behind? Who takes on the extra work and how is that task allocation conducted.

However, for the scope of this project, we decided to focus on equal distribution of time in terms of the estimated (or edited estimated) time taken to complete the tasks assigned to each member, ensuring each member is working on their tasks for an equal amount of time.
Additional iterations of the tool would include features, such as allowing students to specify their current skillsets, as well as the skills they would like to develop, and integrating that in the task allocation algorithm. Furthermore, the tool's task allocation algorithm can be enhanced by identifying the skills students should develop through the course based on the syllabus and incorporating this in the task allocation process for the tool.

Discussions

Design Decisions

The main motivation behind designing this tool is to help engineering students manage their tasks in a project-based course. Based on our own experiences, project-based courses can often be difficult; there are several different components for students to balance, including finding an equal distribution of work, leveraging the strengths of the team members, and managing the workload of the course with the rest of their courses. Therefore, one of the main goals of this tool is to alleviate the stress of having to distribute the tasks among the team members by leveraging the strengths of team members, while also taking the availabilities of each team member into account. And lastly, we also understand that the availabilities of engineering students may change on a weekly basis due to midterms, projects and other deadlines. As such, we adopted a resource allocation algorithm that considers both the technical expertise and strengths of each team member, as well as their availability on a weekly basis.
This tool utilizes a range of machine learning models, some of which were pre-trained, while others were trained specifically for this project. We decided to train machine learning models to meet the specific needs of the tool in cases where the performance of pre-trained models was not specialized enough to meet the requirements of the project (outlined in Appendix A). For instance, when developing a system to classify tasks extracted from the syllabi, the classifier needed contextual knowledge of tasks that are specific to engineering project-based courses. The existing pre-trained models did not yield good enough results; therefore, we decided to train our own. We extracted sample tasks from 200 syllabi from engineering project-based courses. Some of these are publicly available syllabi, from real engineering courses from different North American Universities, while others are of fictional engineering courses developed by generative LLM tools, such as ChatGPT and Microsoft Copilot based on the formats of the real syllabi. These extracted tasks were then labelled with their corresponding classes, which were used to train a RoBERTa model. This model performed better than the pre-trained models, as it had an F1 score closer to the requirements for the project (outlined in Appendix A). On the other hand, the models used to parse through the syllabi using OCR is done using a pre-trained library. The performance of this model was measured using *word error rate*, the number of words incorrectly identified by the model, and the *character error rate,* the number of characters incorrectly identified by the model. Therefore, this pre-trained model was chosen over training a custom one, as it met the requirements of the project (outlined in Appendix A).

Technical Limitations of the Tool

This project management tool is a custom tool designed specifically to meet the needs of engineering students in project-based courses in Canadian undergraduate programs. For instance, the tool defines the length of courses to be either one or two semesters in length, with each semester being 4 months long. However, this can be easily overridden, if the deadlines in the course are specified as such. These deadlines are extracted from the syllabus for the course, which is uploaded to the web application by the student. Once the student uploads the syllabus for their project-based course, the tasks outlined in the document are parsed through and extracted, which is used to create the team's timeline for the course. Therefore, one of the limitations of this tool is that if the syllabus does not clearly outline the deadlines of the deliverables of the course. Additionally, the tool uses the time between a deadline and its predecessor to estimate the timeline of that specific deliverable, except for the first deliverable of the course, for which the timeline starts from the beginning of the term. Therefore, certain periods of breaks, such as holidays, wellness week, or other breaks are considered to be work period when developing the schedule unless the teammates specify that they are not available for that time period. Future versions of this tool may be adapted to allow students to indicate breaks and holidays in their schedule or extract this information from the course syllabi as well.

Limitations and Future Work

One of the major limitations of this study is that it is not yet deployed in a real project-based course. Therefore, we were not able to collect real student feedback to measure the effectiveness of this tool in a course setting. However, future revisions of this paper will include student feedback for this tool. Moreover, as this is a work-in-progress study, the authors of this paper are developing this tool in parallel to conducting this study. As a result, some of the features mentioned above, such as the ability to generate sub-tasks based on the original tasks extracted from the course syllabus, are not available to users at the time of writing this paper. However, further research will report findings based on the full product, which will include all the features originally intended by the authors while also integrating some of the feedback received in this study. Additionally, further research may be conducted after deploying the final version of the tool in a project-based engineering course, where all students in the course can use this tool throughout the term. This will allow the researchers to investigate this intervention from a holistic perspective and understand some of the long-term benefits and shortcomings of this project management tool, which can be used to improve the tool.

Ethical Considerations

While this study explores the potential benefits of AI-powered task distribution in project-based learning, it is equally important to acknowledge the ethical concerns and pedagogical challenges associated with automating project management processes. The integration of AI in engineering education, particularly in project management, raises critical questions about skill development, fairness, and long-term impacts on student learning.

One major concern is that automating task breakdown and assignment may reduce students' engagement in fundamental project management skills such as task analysis, workload estimation, and strategic planning. If students become overly reliant on AI to distribute tasks, they may struggle to develop the decision-making abilities required for effective leadership in real-world engineering projects. This could create a skills gap where graduates are proficient in execution but lack the ability to initiate, scope, and manage projects independently. To mitigate this risk, the tool encourages students to review, refine, and modify AI-generated task assignments rather than passively accept them. The motivation behind using this tool as opposed to having students manage their projects from scratch is the finding that adding project management in engineering courses can sometimes result in curriculum overload and cause students to treat project management as optional tasks [13].

Another ethical concern is the tool's approach to assigning tasks based on existing expertise. While this ensures efficiency in project execution, it may inadvertently limit students' exposure to new challenges, reinforcing their current strengths while neglecting areas for growth. This is a recognized pedagogical issue in engineering education, where students often gravitate toward familiar roles instead of developing well-rounded competencies. Without intentional intervention, the tool could exacerbate skill imbalances within teams, ultimately reducing the diversity of learning experiences that project-based courses are designed to provide. A potential solution is integrating an option for students to rotate tasks or express interest in learning new skills, ensuring a balance between efficiency and growth. Furthermore, the tool adapts the RACI approach to project management, where one student is assigned as the person responsible for the task (who is currently the subject matter expert in the area), one student who is accountable, one student who is consulted, and the rest informed [17]. This approach ensures that all members of the team are involved in the task and can be exposed to areas that may not be familiar with, while not being overwhelmed with going too far beyond their comfort zone.

AI models used in task distribution may unintentionally introduce biases, favoring certain skill sets or work styles while marginalizing others. If the model's training data reflects existing biases in engineering education—such as the underrepresentation of certain groups in leadership roles—it may reinforce rather than challenge these disparities. Additionally, the AI may struggle to fairly distribute tasks among students with varying levels of prior experience, potentially leading to unequal learning opportunities. To address these concerns, transparency in AI decision-making is crucial, and students should have control over final task assignments to ensure fair and equitable participation.

By introducing AI-driven task allocation into project-based learning, we must consider the broader implications for engineering education. If AI tools become widely adopted, there is a risk that students may disengage from critical project management activities, reducing their preparedness for professional engineering roles. This study does not advocate for the replacement of human decision-making but rather explores AI as a tool to assist students in managing workload distribution more effectively. Moving forward, the tool should be evaluated not only on efficiency gains but also on its impact on students' development of essential project management skills.

AI-powered tools have the potential to enhance project-based learning, but their integration must be approached with caution to avoid unintended ethical and pedagogical consequences. Future iterations of this tool will incorporate safeguards to ensure that students remain actively involved in task analysis and project planning students remain actively involved in task analysis and project planning while promoting equitable and well-rounded skill development. By fostering transparency, adaptability, and student agency in AI-driven project management, we aim to support—not replace—the essential learning processes that engineering education seeks to cultivate.

Summary

The integration of project management and teamwork into project-based learning is crucial for developing essential graduate attributes as outlined by the Canadian Engineering Accreditation Board (CEAB). However, challenges such as uneven workloads, scheduling conflicts, and lack of team collaboration often hinder the effectiveness of these courses. This tool addresses these issues by offering a scalable and student-friendly solution tailored to the unique demands of engineering education.

While the current study provides valuable insights into the tool's design and implementation, it remains limited by the lack of deployment in a real-world course setting. Future work will involve piloting the tool in project-based courses, collecting user feedback, and refining its features to enhance its utility and effectiveness. By exploring the long-term impacts of this intervention, the researchers aim to contribute to the broader discourse on engineering education, advancing tools and practices that prepare students for the complexities of modern engineering projects. Ultimately, this study reinforces the importance of integrating innovative tools like the one presented here to support student success, foster collaboration, and enhance learning outcomes in project-based learning environments. Future revisions of the paper will aim to include student feedback for this tool.

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Appendix A: Requirements for the Project-Management Tool

The table below lists the project requirements of the project management tool, along with the methods used to verify whether a solution meets that requirement.

Table 1: Project requirements and their verification methods for the project-management tool.

ID	Project Requirement	Verification Method
1	PDF Parsing accuracy: > 95%	**TEST:** Parse multiple course information documents and compare the parsed content with the actual syllabus. Calculate the word error rate by analyzing the percentage of correctly recognized words. Repeat with different documents to ensure consistent accuracy.
2	Task Extraction Accuracy: > 90%	**MEASURE:** Collect ground truth data from approximately 200 course syllabus files. Compare the extracted deliverables to this ground truth data and calculate the extraction accuracy by measuring the ratio of correctly identified items to the total items in the ground truth dataset.
3	Task classification algorithm F1 score > 70%	**MEASURE:** Use a set of tasks with known categories as a test dataset. Run the classification algorithm and compare the predicted categories with actual categories. Measure performance using both F1 score and accuracy, calculating the F1 score to balance precision and recall, and accuracy to determine the percentage of correctly classified tasks.
4	Acceptance rate by user: > 60%	**MEASURE:** Conduct user feedback sessions where users interact with the tool's suggested subtasks. Record acceptance rates based on user responses and calculate the percentage of accepted subtasks out of the total suggested.
5	Resource allocation is an NP hard problem: The solution is verifiable	**MEASURE:** Use user feedback to evaluate resource allocation accuracy. Calculate the ratio of instances where users needed to correct the algorithm's assignments compared to the total allocations. This ratio will indicate the effectiveness and reliability of the resource allocation algorithm. **Success Criteria:** The algorithm achieves 90% or higher accuracy in resource allocations, with minimal user corrections needed.