AI-Driven Planning Tools to Support Capstone Projects in Computer Science Education A Framework for Ethical, Personalized Academic Support

Abstract

Students of all academic levels within higher education struggle with academic planning, time management and resource coordination; particularly during their final years as students when capstone projects are presented. Traditional planning systems often lack, empathy, personalization, transparency or actionable guidelines which contributes to stress, missed deadlines and disengagement. This proposal explores planning with AI-- by combining Large language models, constraint satisfaction programming and agentic software focusing on student needs. This approach can assist students in building conflict-free, personalized project schedules empowering students with brainstorming, time-line generation, risk-free mitigation and team/supervisor coordination specifically tailored to the individual needs, goals and skills require by the large commitment of a capstone project within software development educational systems.

Aiming to design through engagement metrics, schedule efficiency and academic performance, this research and study will invest age the pedagogical and ethical implications of using LLMs to support academic learning while proposing responsible ethical implementations.

1. Problem Statement

The persistent challenge of planning and time management within higher education show that students frequently encounter scheduling conflicts, lack of drive or direction, or poor alignment between academic task and personal commitments. This is particularly evident in final year capstone projects within computer science programs, which usually require high level technical skills, demanding levels of coordinatization and far sight through long term planning.

Many academics and students lack structured guidance when setting goals, selecting technology or tools and while breaking down complex project requirements into achievable manageable milestones. Most existing tools fall short: as they're generic, poorly integrated or not specifically designed for a project based learning approach. Recent studies show that 40% of students report schedule conflicts that hinder academic planning (Ellucian, 2023) and up to 35% take irrelevant or misaligned courses due to unclear planning of future goals. (Zawacki-Richter et al, 2019). This commonly results in increased negative affects on student mental

health, which generally is a leading cause of poor or hindered academic outcomes or unfortunately disengagement entirely.

2. Significance of the Problem

A cornerstone of effective pedagogical intervention is planning for academic success, intuitions and researchers recognize the need for digital tools which support structured, personalized guidance work, yet most tools fail to meet the growing needs of students- particularly for capstone project where sound, ethical, individualized support is needed most.

Impacts

- **Students**: Increased stress, missed deadlines, lower performance.
- **Faculty**: Greater administrative burden, inefficient support systems.
- **Institutions**: Higher dropout rates, lower retention, reduced educational impact.

Poor planning has been shown to directly affect students. A report published by the Higher Education Authority (HEA) found that 40% of Irish universities showed high levels of stress due to academic pressures, exacerbated by insufficient access to counseling services, which are often underfunded and overstretched (source: HEA, Student Mental Health and Wellbeing Report, 2023). While a survey by Union of students in Ireland (USI) reported 1 in 3 of students struggled with deadlines due to poor communication of course requirements and limited access to academic advisors particularly the Larger institutions.(USI, National Student Survey, 2022).

Irish Universities face increasingly more administrative burden due to improper institutional planning, understaffing, outdated legacy system. A 2022 Irish federation of University Teachers report highlighted faculty at larger institutions spend up to 20% of their time on administrative tasks due to inadequate support systems and inefficient digital learning platforms, reducing time for teaching and research (IFUT, Faculty Workload Survey,2022). Among even tertiary education sectors a student ratio of 23:1 can be seen which according to The Education And Training Monitor Report 2023. A figure seen to be one of the highest in Europe and known to increase workload pressures and limit faculty ability to provide proper personal student support. These affects are compounded, an average 15% of first year student (with up to 20%) in STEM courses due to inadequate academic support and poor course planning (HEA, Progression and Retention in Irish Higher Education, 2024).

Ireland's underinvestment in higher education according to a 2019 OECD study directly correlates to sever educational impacts for student and for universities in areas like retention and negatively performing rankings at a global level, This along with delays in modernization of curricula and slow adaptation of interdisciplinary programs impact the systemic shortfalls within Irish Universities.

3. Literature Review

3.1 Planning Challenges in Higher Education

- **Ellucian (2023)**: 40% of students face scheduling conflicts disrupting academic progression.
- **UNESCO (2021)**: Uncoordinated schedules reduce engagement by up to 25%.
- **Zawacki-Richter et al. (2019)**: 35% of students enroll in courses not aligned with their program due to lack of guidance.

3.2 Limitations of Current EdTech

- Many EdTech tools lack **transparency** and **personalization** (Prinsloo & Slade, 2017).
- Low adoption rates stem from unclear recommendations and generic design.

3.3 Promise of AI Planning Tools

- **TRACE-cs (Washington University, 2025)**: Combines LLMs and CSP for explainable, conflict-free course planning. Achieved 100% correctness in explanation vs 45–50% for LLM-only tools.
- **Luckin et al. (2016)**: AI in education reduces logistical burden, increasing engagement by up to 30%.
- **Ghallab et al. (2004)**: Technical foundation for AI planning via goal-based search and CSP models.

3.4 Capstone Project Planning

- Capstones bridge theory and real-world practice but require exceptional time, resource, and task management.
- **Müller et al. (2024)** and **ISTE** show AI supports capstone development through intelligent task delegation, feedback, and resource recommendation.
- Tools like **Connected Papers**, **Consensus**, and **Elicit** support literature reviews and idea generation, streamlining research phases.
- **Mainstay** and **IBM Watson–based agents** have shown success in resolving over 90% of student queries (Georgia Tech, 2024), boosting project success rates.
- **Mercer University**'s MBA program showed improved strategic thinking using GPT-based simulations (AACSB, 2024).

3.5 Risks of AI Integration

- **Igbokwe (2023)** identifies concerns: ethical bias, privacy, overreliance, and job displacement.

- BERA (2024) and ISTE emphasize the importance of **responsible AI** use in maintaining academic integrity and equitable access.

3.6 Extended Literature Review

- **Higher Education Authority (HEA), 2023. "Student Mental Health and Wellbeing Report."**
  - Referenced for: 40% of Irish university students reporting high stress levels due to academic pressures and insufficient counseling services.
  - Source details: Published by the HEA, Ireland, 2023. Available through HEA's official publications on student wellbeing in Irish higher education.
- **Union of Students in Ireland (USI), 2022. "National Student Survey."**
  - Referenced for: 30% of students struggling with deadlines due to poor communication of course requirements and limited access to academic advisors.
  - Source details: USI, 2022. Conducted annually, covering student experiences in Irish universities. Accessible via USI's website or reports archive.
- **Irish Times, 2021. "Hybrid Learning Challenges in Irish Universities."**
  - Referenced for: Inconsistent hybrid learning infrastructure during the pandemic leading to disengagement and lower academic performance.
  - Source details: Published in *The Irish Times*, 2021. Available in the education section of the newspaper's online archive.
- **Irish Federation of University Teachers (IFUT), 2022. "Faculty Workload Survey."**
  - Referenced for: Faculty spending up to 20% of their time on administrative tasks due to inadequate support staff and inefficient digital platforms.
  - Source details: IFUT, 2022. Survey conducted among faculty in Irish universities, available through IFUT's official reports.
- **Education and Training Monitor, 2023.**
  - Referenced for: Ireland's high student-teacher ratio (23:1) in tertiary education increasing faculty workload and limiting student support.
  - Source details: Published by the European Commission, 2023. Ireland-specific data available in the annual *Education and Training Monitor* report.
- **Times Higher Education, 2020. "Funding Crisis in Irish Higher Education."**
  - Referenced for: Real-term funding decline of 10% per student since 2008, forcing faculty to take on additional roles like student welfare management.
  - Source details: Published in *Times Higher Education*, 2020. Available in the international education news archive.
- **Higher Education Authority (HEA), 2024. "Progression and Retention in Irish Higher Education."**
  - Referenced for: Non-progression rates averaging 15% for first-year students, with up to 20% in STEM courses due to inadequate academic support.

- Source details: HEA, 2024. Published as part of annual retention and progression statistics for Irish higher education.
- **Social Justice Ireland, 2023. "Education and Social Inequality Report."**
  - Referenced for: Retention challenges in regional universities, with 44% third-level completion in West and Border regions vs. 61% in Dublin.
  - Source details: Published by Social Justice Ireland, 2023. Available in their annual socioeconomic reports.
- **OECD, 2019. "Education at a Glance."**
  - Referenced for: Ireland's underinvestment in higher education (3.3% of GDP vs. 4.4% EU average) limiting retention strategies and educational impact.
  - Source details: OECD, 2019. Annual report on global education metrics, accessible via OECD's education publications.
- **Irish Universities Association, 2022. "Curriculum Modernization in Irish Higher Education."**
  - Referenced for: Slow adoption of interdisciplinary programs as a planning failure reducing educational impact.
  - Source details: Published by the Irish Universities Association, 2022. Available through their policy and advocacy reports.
- **Higher Education Authority (HEA), 2023. "Financial Sustainability in Irish Higher Education."**
  - Referenced for: €307 million funding deficit in Irish universities.
  - Source details: HEA, 2023. Part of financial health reports for Irish higher education institutions.

4. Research Objective

The objective of this research is to design, develop, and evaluate the effectiveness of AI planning agents focusing on computer science and the management of capstone/final year projects.

An overall goal of providing open-source, transparent, privacy conscious software that assist in personalized timeline generation and milestones, using LLMs to identify skill-gap and recommend resources to assist students allowing them to identify risks and dynamically plan and coordinate their projects (Alone or with a group).

5. Proposed Interventions

Planning tools for CS students combining the Agentic programming, constraint satisfaction programming (CSP) and large language models (LLMs) allowing these tools to generate conflict free timelines for Final Year Projects which will include timelines, milestones, resource suggestion and risk identification. This along with the ability to adjust personal commitments and availability to properly provide explainable preferable recommendations that enhance

transparency, trust, and overall academic performance by allowing students to hit the ground running, these tools are recommended for final year student. But similar interventions can be modified for specific use cases such as:

5.1 Applications of AI Planning

AI can recommend courses and build conflict-free schedules tailored to each student's goals and constraints. For example, "intelligent course recommendation" engines use machine learning to suggest courses that a student will likely succeed in, keeping them on track for graduation. Scheduling tools analyze course offerings, prerequisites, and student commitments (jobs, labs, etc.) to propose optimal timetables. A recent tool, **TRACE-cs** (from Washington University), combines symbolic planning with LLMs to generate student course schedules and **explain** its choices. TRACE-cs can answer questions like *"Why was course X selected over course Y?"* based on encoded constraints. In testing, TRACE-cs achieved 100% correctness in its scheduling explanations (versus ~45–50% for LLM-only methods) by integrating user input and LLM refinement. Most if not all computer science students must complete a final year project or capstone project.

5.2 Final Year Project Initial Planning

Brainstorming

AI tools can play a major role in assisting advisors and students with structuring their FYP/Capstone project. These early planning stages are crucial for fully understanding your deadlines and requirements correctly so the project does fail. Using LLMs or specific agentic tools dedicated to planning allows students to brainstorm ideas and effetely evaluate project feasibility timelines and complexity by defining the tools and problems/objectives that need to be accomplished.

Timeline Generation

Consider and example, a student can define deliverables, set milestones and preemptively generate sources, fitting their specific requirements. The tools can break each project into phases and plan each estimated time, and output Gantt-style schedules or weekly breakdowns of plans.

Risk Identification and Replanning

One of the most important reasons for using a tool such as this is the ability to identify risk, bottlenecks and specific ways you may be limited when developing. In this case these tools generally offer contingency plans or replan when a student has fallen behind.

5.3 Group Project Planning

Role and Task Assignment

Each software student usually has a group project, which for new developers and engineers can be an extremely daunting task, as with improper management, and unclear team structure, software development methodologies (Like agile development or waterfall method) can be over looked which can negatively affect the team and lead to potential difficulties as the project progresses.

Milestone Planning and Synchronization

Some of these issues, could be solved with the implementation of a tool which assists teams, by planning their scrums, assigning roles, and dividing work optimally, so each members skills and strengths are taken advantage of and nobody is left behind. Rather than team members unsure on who does what, These tools allow students to actively focus on what is deliverable, rather than what is not.

Progress Monitoring and Alerting

Although some tools may offer this as a MS Planner plugin or a Enhanced Asana. This can be used to effectively manage resources.

5.4 Personal Project Planning

For **individual students** doing solo projects or independent study:

AI-Generated Roadmaps

AI planning tools can:

- Generate a complete **step-by-step roadmap** for project execution.
- Recommend tutorials, datasets, or libraries based on project type.

Example:

> **Project:** "Build a personal budgeting app"
> **AI Plan:**
>
> - Week 1–2: UX research + wireframes
> - Week 3–4: Learn React Native
> - Week 5–8: Code core app features
> - Week 9: Test with users
> - Week 10: Polish UI and finalize

Self-Assessment & Skill Mapping

AI agents can:

- Evaluate a student's readiness by mapping required skills (e.g., Firebase, JavaScript).
- Suggest learning modules before development begins.

Example:

> "You're missing database experience. Recommended: Do Firebase Crash Course before Week 3."

Solo Workflow Automation

AI integrations in tools like Notion, Obsidian, or Monday.com can:

- Automate progress tracking.
- Link notes, todos, and code commits for self-monitoring.

6. Ethical and Pedagogical Implications

Delegating planning tasks to AI has deep implications. Ethically, concerns include data privacy (AI systems need student and faculty data), bias (recommendations must not reinforce inequalities), and transparency.

Pedagogically, one must consider whether students lose agency or learning by outsourcing planning. Some argue AI can free students from logistical burden so they can focus on learning; others worry about over-reliance. A balanced view is reflected in the motto: *"It's not whether AI is greater than you. It's whether you plus AI is greater than you."*.

In other words, the goal is human–AI synergy. AI can suggest and optimize, but educators and students remain responsible for final decisions and ethical judgment. The *epistemological* question (how knowledge is constructed) also arises: if AI chooses courses or content, whose definition of "important knowledge" is being followed? Ensuring diverse input into the AI's design and keeping humans in control helps address this.

7. Research Methodology

7.1 Participants

- Final-year undergraduate CS students (n ≈ 30–50)
- Project supervisors and academic advisors (qualitative input)

7.2 Phases

1. **Tool Prototyping** (with open-source CSP + LLM framework)
2. **Pilot Deployment** (6–8 weeks of project support)
3. **Data Collection** (see below)

8. Data Collection Plan

These interventions should allow the collection of Qualitative by measuring the efficiency of scheduling with these tools, possibly with the percentage of conflict-free schedules or the amount of time saved to be used valuably else where. It could also be possible to establish a milestone completion rate system which at each milestone engagement metrics such as time on task or tool interaction frequency could be monitored. Finally the most accurate indicator i would say, academic performance and the overall quality of projects being created.
Along with this data, Quantitative data must also be collected this could be through surveys, possibly on the usability of tools and engagements with them. Personal interviews on time subjects who saved time or their teaching/learning methodologies have improved or being impacted, and more importantly discussions between focus groups which can help improve trust and ethical concerns allowing the impact of this project to be effectively measured.

9. Impact Measurement

The perspective impact of these interventions should be comprised of comparisons of engagement, performance, project quality and success rates, initial preintervention, through possible surveys and interviews which will assist in the visualization of perceptions of Agentic tool learning space. Each tool should have suggested analytics which log data, recommendations and acceptance rates measuring the efficacy.

10. Analysis Plan

It would be beneficial, to assist users and educators through the use of analysis on engagement patterns, academic performance and assess any possible improvements on completion rates of FYP Students which would intern allow for the evaluation of time saved for faculty. This along with recommendations on changes of teaching practice may allow for tool efficacy to be compared to intended outcomes when comparing expected results and actual results overall, while highlighting transparency and fairness.

11. Expected Outcomes

Highlighting these problems, it may be probable that software developed using agentic tools have the ability, with proper implementation, to successfully increase student engagement. By personalizing planning and student information acquisition with hopes to improve academic performance and FYP Success rates by efficiently enhancing student and faculty efficiency while

reducing administrative burdens. These tools along with many other tools could be implemented to deploy sustainable change through scalable transparent agentic AI Tools.

12. Generalization of These Tools for Future Projects

This intervention model with successful implementation could be adapted rapidly, easily and scalable to other disciplines or institutions, which would allow these tools to be applied to different academic programs, projects and scenarios. Generalization of these tools could promote the assistance of scaling data collection for larger cohorts and inform its findings to institutional policy makers to promote the adaptation of this intervention.

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