Review article

Leveraging AI-Assisted Coding Tools in Engineering Education: Promise and Pitfalls in Software Development

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A R T I C L E I N F O

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A B S T R A C T

This study investigates the pedagogical impact of AI-assisted programming tools (e.g., GitHub Copilot, ChatGPT) in a university software construction course. A 10-week case study with 25 engineering students developing a CRM system revealed 30-40% time savings in prototyping and debugging. However, maintaining code quality requires systematic human oversight. The findings contribute a framework for balancing AI automation with traditional pedagogy, supporting Sustainable Development Goal 4 by outlining strategies for equitable and effective AI integration in engineering education. A student opinion survey showed 96% satisfaction with the AI - assisted learning experience.

1. Introduction

The rapid advancement of artificial intelligence has transformed software development practices, with AI-assisted coding tools becoming increasingly sophisticated. This paper documents the experience implementing a simple CRM system while leveraging various AI tools throughout the development lifecycle. The project named DealTrack CRM, incorporated both traditional CRM functionalities and an innovative Unity-based game component, providing a rich environment to evaluate AI tools for development across diverse technical challenges for educations (Chein et al., 2020).

Recent studies have shown that AI-assisted development can improve productivity by 30-50% in certain tasks (Li, Z., et al., 2023; Meyer, A. N., et al., 2023). However, the experience reveals that these benefits come with important caveats regarding code quality, architectural decisions, and maintenance considerations. This paper contributes to the growing body of knowledge about practical AI integration in software engineering by provid(ing support for the Sustainable Development Goal from United Nations number 4 (United Nations, 2025) Quality education, supporting quality education for ensure inclusive and equitable quality education and promote lifelong learning opportunities for all, additionally about the use of AI in education, and for the Sustainable Development Goal number 9, Industry, innovation and infrastructure, building resilient infrastructure, promote inclusive and sustainable industrialization and foster innovation, additionally about the use of AI in the industry.

The findings are particularly relevant for development teams considering AI adoption, as were identified both successful use cases and pitfalls to avoid. The experiments were carried out in 2025, from February to April at the Tecnologico de Monterrey, Monterrey, Mexico, considering 4th semester university engineering students in the Software Construction for Decision Making course. Considering a period of 10 weeks, the studies were carried out on the 4 modules: Module 1 Databases, Module 2 Analysis and modeling of software systems, Module 3 Technological development and web development, Module 4 Video game development.

The project was developed jointly with the Minerva Institute in Brazil in partnership with the University of São Paulo. The objective of the Minerva Institute is to be a not-for-profit organization devoted to Education and Innovation. As a course challenge, students must build a computer simulator that reproduces the partial behavior of a business, economic, social, political, and educational system (Martinez, R., et al., 2023). The simulator will allow the analysis of current or future scenarios for support in making decisions to improve some of the processes, or components of the system.

This manuscript was divided into a) Methodology with subtitles in detail; b) Results and discussion which presents details about the results and highlights the discussions about the results; c) Conclusions in this chapter are presented are main conclusions about the results and discussions about future projects and highlight the

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point of view from the authors.

The bibliography review shows a research gap in which there is a limited empirical study on AI tools' pedagogical impact in CRM software development during engineering education considering the references used during the development of these studies in the first 2025' semester, with focus on (Chen, L., Chen, P., & Lin, Z., 2020; Li, Z., et al., 2023; Meyer, A. N., et al., 2023; Davis, A., et al., 2023) references.

While prior research has quantified productivity gains (Li, Z., et al., 2023; Meyer, A. N., et al., 2023), a gap remains in understanding the pedagogical impact and challenges of these tools in authentic, project-based learning environments. This study addresses this gap by pursuing the following research questions: RQ1) What are the measurable efficiency gains and code quality implications of using AI-assisted programming tools in a software engineering project? RQ2) How do these tools influence students' learning experiences and the development of deeper software engineering competencies? RQ3) What are the primary pitfalls and effective mitigation strategies for integrating AI tools into engineering education?

This work is situated within a constructivist learning paradigm, where tools serve as scaffolds for knowledge construction (Martinez, R., et al., 2023). It aligns with recent research on human-AI collaboration, which posits that AI can enhance human creativity and problem-solving when integrated as a partner rather than a replacement as explain Agboola, O. P., & Yassin, Y. N. H. M. (2025).

2. Methodology

A mixed-method approach was employed combining quantitative performance metrics with qualitative developer experiences (Baker, S., & Chen, G., 2024). The project team consisted of 25 undergrad students working over a 10-week period, divided into subgroups focusing on different system components (frontend, backend, game integration). Each subgroup has utilized different combinations of AI tools, allowing comparative analysis, with the main goals:

The simulator will have a graphical interface comparable to a 2D or 3D project. As the main challenge, students were guided to develop a CRM (Customer Relationship Management) system using Artificial Intelligence platforms, considering the main negotiation functionalities for a sales process, identifying the main partners with the highest sales, presenting a leaderboard, with dashboards, demonstrating their profit percentages, also considering user authentication, products, and user maintenance.

Students were encouraged to divide themselves into teams and select an artificial intelligence platform to develop the CRM system. The main rule was that each team should use a different tool, so that at the end of the course they could present their results and have discussions about the use of the selected platforms. Students were also guided to use the artificial intelligence platform for the Frontend and Backend, also to present their experiences on building solutions with the Unity3D platform.

- AI Evaluated Platform for Development
- GitHub Copilot: Used primarily for code completion and generation.
- ChatGPT: Employed for debugging, documentation, and architectural suggestions.
- Cursor: An AI-powered IDE evaluated for full-stack development.
- Gemini: Google's AI assistant tested for error detection and optimization.
- Replit: Cloud IDE with AI features used for rapid prototyping.
- Data Collection: a) Time logs for various development tasks; b) Code quality metrics (bugs introduced vs. fixed); c) Developer satisfaction surveys; d) System performance benchmarks.

Evaluation Framework: a) Efficiency: Time savings in development tasks; b) Accuracy: Percentage of correct suggestions; c) Learning Curve: Ease of adoption; d) Context Retention: Ability to maintain project-specific knowledge.

As a course challenge the students were oriented to build a computer simulator that reproduces the partial behavior of a business, economic, social, political, or educational system. This simulator will allow the analysis of current or future scenarios to support decision-making aimed at improving some of the system's processes or components. The simulator will have a graphical interface comparable to a 2D or 3D video game.

The following competencies and sub competencies were used as learning objectives: Generate computational models for data analysis that enable decision-making; a) Determine relevant patterns in a set of data, using principles from natural sciences, mathematics, and computational fundamentals; b) Interpret interactions between relevant variables in a problem, using principles from the natural sciences, mathematical tools, and information technology.

For the competency software development applying process and quality standards from Software Engineering, the following sub competencies were used: a) Apply solution development methodologies according to the needs established by the context of a computational or business process, following international standards; b) Define requirements based on international standards, describing the needs demanded by the system; c) Design software components based on requirements, based on international standards; d) Develop all designed components of a computational system, based on international standards; e) Develop tests to validate compliance with the initial requirements of the computational system; Deploy the developed software in the operating environment, evaluating compliance with system requirements.

For social intelligence competency, it is verified if the student generates effective environments for collaboration and negotiation in multicultural contexts, with respect and appreciation for the diversity of people, knowledge, and cultures, with the negotiation effectiveness sub competence in which he/she generates results and commitments in the groups in which he/she participates, through collaborative work, decision-making and the generation of value.

While prior research Li, Z., et al. (2023), Meyer, A. N., et al. (2023), Davis, A., et al. (2023) has quantified productivity gains from AI-assisted development, few studies examine its pedagogical impact in project-based learning. This study addresses this gap by evaluating how AI tools like GitHub Copilot and ChatGPT influence both technical proficiency and deeper learning outcomes in a 10-week CRM development course. The findings contribute to SDG 4 by proposing strategies for equitable AI integration i,n engineering education.

Based on the patterns observed in this case of studies, an inductively derived framework was proposed built on four principles:

Prompt-Driven Iteration: Treat AI output as a first draft, subject to cyclical refinement (Case Study 3).

Hybrid Verification: Combine AI-generated code with mandatory peer/instructor review to ensure quality (Case Study 4).

Contextual Scaffolding: Provide AI tools with detailed project context (schemas, requirements) to improve output relevance (Case Study 5).

Metacognitive Engagement: Use AI explanations to foster critical thinking about why a solution works, not just what the solution is (Case Study 2)."

Measured by comparing time-logged task completion (e.g., implementing a REST endpoint) against established baselines from similar tasks in pre-AI course iterations.

Code Quality: Assessed via a combination of automated linters, peer code review checklists, and tracking the ratio of bugs introduced versus fixed per commit.

Triangulation: To ensure validity, quantitative performance data was triangulated with qualitative feedback from weekly stand-up meetings and final satisfaction surveys, informed consent was obtained from all participants during the volunteer opinion survey.

3. Results and analysis

The students' projects were developed in their native language in Spanish, and the translations were done by the authors of this manuscript. The students were encouraged to publish their results on Medium.com, because their content is shared with professionals in the technology field. This publication requirement also serves to strengthen the students' project portfolio and professional resume. Analyses were carried out on the content of the articles and some summaries were presented on the main points observed by the students, also highlighting the points that presented the worst and best results during the use of the platforms. Some codes and interfaces images developed by the students are also presented and discussed, which are also available on the Medium.com platform in Spanish, the results obtained are:

- A comparative analysis of five major AI development tools.
- Quantitative metrics on time savings and error rates.
- Qualitative assessment of tool strengths and weaknesses.
- A framework for effective AI tool integration.

Case Study 1: DealTrack and Gemini and Replit Integration

Team one (Gonzalez, M. A. G., et al., 2025, May 5), working on a project referred to as DealTrack, investigated methods to create more realistic interactions within their system. Their exploration focused on managing the connections between the Gemini API and the NPC (Non-Player Character) dialogue system. Replit served as the platform for developing the frontend of this project, facilitating rapid iteration and integration with the backend systems that handled the AI logic. This hands-on experience allowed the team to understand the implications of using AI tools in software development and explore diverse applications based on specific project needs. Early frontend development also utilized Replit for initial ideas and resources.

Through this work, it was possible to significantly evaluate how artificial intelligence assistance works in software creation: the advantages it offers and the necessary measures to ensure adequate use of its capabilities, thus avoiding unnecessary problems.

Backend problems: A lot of problems that in the end, once debugged, were able to be fixed. As they are, there are many occasions when these problems arise, Figure 1 shows some errors when compiling the code.

Fig. 1. Errors evidence during the code development with fetch issues in the backend.

A connection error shows up when running the login page because there is no fetch from the API that is hosted, after created with Replit. Which presented another different kind of problem after the creation of the interface screen, making it difficult to understand the location of each problem.

After that, was experimented with Replit to have a better understanding of the elements with which were worked on the project, Figure 2 shows the login section, and it had a functional result with errors.

Fig. 2. Errors evidence during the login process, translated by author.

- Negotiations and tasks page.
- Contact section with those who can be contacted, these arrangements are included in the business section.
- The main dashboard, with graphics directly taken from the company's database.
- The profile section can add a personal description with a limit of 500 characters, and personalized labels.

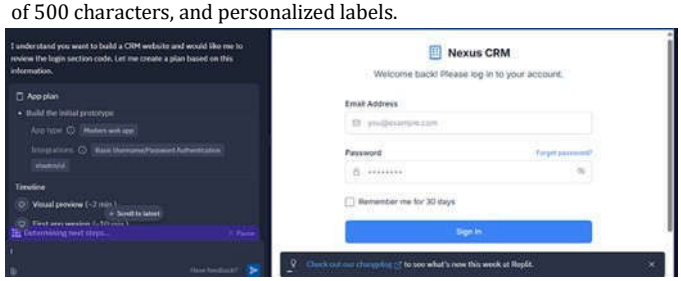

Fig. 3. Result of the prompt used for the Login interface build.

Throughout the project, several technical challenges were faced, especially on the backend, which was managed to overcome through collaborative work and a constant learning attitude. The use of artificial intelligence tools allowed to accelerate development, as well as explore new forms of intelligent interaction around video games and CRM. Highlight the value of integrating AI into the ground as a development assistant as shown Figure 3, as well as a central element of the product, which significantly increases the quality of the user experience. This project gave a deeper understanding of the possibilities and limitations of applied AI and better prepared the students for future technological challenges.

Case Study 2: Leveraging ChatGPT for Conceptualization and Technical Support

Team 2 (Poinsot, I. G., et al., 2025, May 5) found ChatGPT to be a fundamental support tool throughout their project's creation and development. ChatGPT aided not only in generating initial ideas but also in structuring documents, designing test architecture (Taylor, M., & Anderson, D., 2024), and optimizing technical communication. A significant advantage noted was ChatGPT's ability to provide clear, quick, and context-specific explanations. The team utilized ChatGPT to resolve programming doubts (Chen, L., & Wang, H., 2024), improve the writing of formal reports, and receive practical suggestions for addressing deployment and system validation challenges.

Throughout the creation and development of this project, AI tools like ChatGPT served as fundamental support across both technical and conceptual phases. Beyond facilitating initial ideation, ChatGPT actively contributed to document structuring, test architecture design, and technical communication optimization.

The primary advantage of using ChatGPT was its ability to deliver

clear, rapid, and context-specific explanations tailored to the needs. During development, it helped:

- Resolves programming queries.
- Refine formal report writing.
- Provide actionable solutions for system deployment and validation challenges additionally, its assistance in technical writing ensured consistent stylistic coherence and appropriate formality across all required sections.

Beyond content generation, ChatGPT acted as a strategic collaborator, optimizing the workflow by freeing time to focus on critical project aspects like functional implementation and requirement validation. This experience underscores AI's value as a complementary tool in educational (Martinez, R., et al., 2023), professional, and creative processes—particularly when used critically and intentionally.

In conclusion, interacting with ChatGPT not only elevated the project's technical quality but also enriched the learning journey by:

- Encouraging deeper independent research.
- Prompting critical evaluation of recommendations.
- Driving pursuit of optimal solutions.

The intelligent support offered by this technology represents an invaluable resource for developers aiming to achieve higher levels of precision, professionalism, and efficiency in their work.

Case Study 3: Leveraging Cursor for Conceptualization and Technical Support

Team 3 (Marquez, J. L. N., et al., 2025, May 5) shows a different approach involving the use of Cursor, an Integrated Development Environment (IDE) enhanced by various AI functionalities. This team aimed to integrate AI as a practical work tool, rather than just a novelty, for their ambitious CRM project with a tight 10-week deadline. Cursor was selected as the primary tool to assist in code generation (Brown, T., et al., 2023).

The refactoring process became particularly intensive during backend restructuring. The AI assistant (Cursor), while demonstrating expert-like behavior, began generating inconsistent outputs: inventing column names, endpoints, and routes. It produced queries referencing non-existent columns, confused routing paths, and while correcting certain elements, inadvertently reintroduced previously resolved issues.

The most significant challenges emerged during negotiations module refactoring. The system frequently disregarded existing code implementations, overlaying new code without proper integration. This led to misinterpretations of functionality and incorrect assumptions about backend architecture (Qian, Y., et al., 2024).

A critical limitation was observed in contextual learning: only after committing errors would the system perform deeper searches, often failing to properly account for specified directory structures despite explicit instructions.

As shows Figure 4, a notable incident occurred in the negotiations tab, where the system modified an API call from "/products" to "/Products". The case-sensitive mismatch caused systemic failures, requiring extensive debugging. Crucially, the error originated from an improperly generated suggestion rather than logical flaws in the original codebase, resulting in significant time expenditure for diagnosis. Figure 4 shows unnecessary resources created by Cursor.

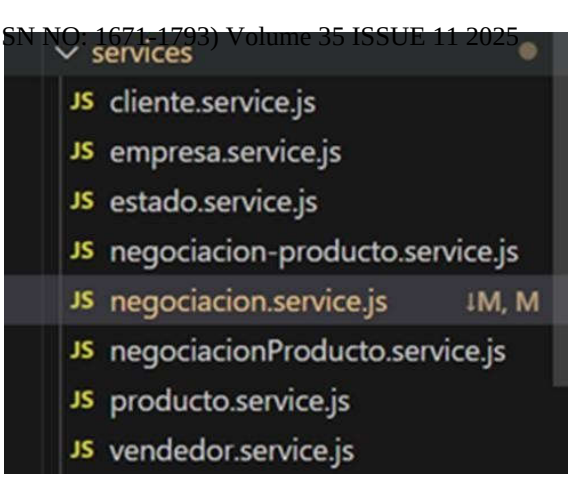

Fig. 4. Cursor evidence of building unnecessary requirements.

The authors report on the difficulty of identifying what was added after using Cursor, so GitHub was an excellent alternative to control and identify changes. They highlight that the use of a document version control platform is necessary and important to be able to restore to the previous point of the change.

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The development process accelerated significantly when Cursor was provided with detailed database schemas and a draft .NET backend implementation for conversion to Express.js. The AI system successfully generated initial API endpoints, which proved particularly valuable given the limited experience with endpoint architecture at the time.

Retrospective analysis suggests the initial output could have employed more optimal structuring patterns (Nguyen, T., et al., 2024), necessitating subsequent refactoring as the understanding matured.

For frontend development, Cursor demonstrated notable efficacy in rapid component generation, implementing:

- Page templates.
- React components.
- Routing structures.

The system exhibited strong comprehension of design requirements, particularly for:

- Admin mode functionality.
- Component integration logic.
- Feature placement strategies.

The workflow evolved into an iterative "request-implementation" cycle. For instance, the AI successfully implemented:

- Click-outside-to-close panel behaviors.
- User mode permission gates prevent admin access via URL manipulation.
- Role-based feature activation systems.

Contextual specification proved crucial to efficiency gains, by providing precise requirements, was achieved:

- Real-time implementation visualization.
- Rapid design iteration.
- Accurate translation of conceptual designs to functional code.

This symbiotic workflow enabled continuous refinement until the implemented solution matched our architectural vision. Figure 5 shows the result with the main page supported by Cursor platform.

Fig. 5. The main page was created with Cursor, translated by author.

Case Study 4: Insights from Gemini on Development Efficiency

The integration of Google Gemini was provided by team 4 (Valdespino, M. G. R., et al., 2025, May 5) with valuable lessons regarding efficiency in the development process. Their experiences highlighted both the potential and the frustrations encountered while working with this AI tool, offering insights into the future of software development.

Contextual Amnesia in AI-Assisted Development: The AI system exhibited significant context retention failures (Gupta, R., & Lee, S., 2024), frequently forgetting critical conversational details. This limitation necessitated repeated information re-explanations, resulting in substantial cognitive overhead and workflow disruption (Patel, S., & Williams, J., 2023).

Mandatory Supervision Paradigm: Quantitative analysis revealed 90% of AI-generated code required manual review. As one team member succinctly observed: "Gemini provides the first draft, but humans must complete the implementation." This supervision's requirement fundamentally altered expected productivity gains.

Project Impact Analysis: While the system accelerated initial error detection by approximately 40% (based on commit logs), these benefits were offset by:

- Context re-establishment time costs (estimated 25-30% of total development time).
- Error correction cycles for AI-introduced mistakes.
- Continuous context reinforcement requirements.

The .Net productivity impact proved neutral when accounting for these compensatory factors, challenging initial assumptions about AI-assisted development efficiency.

Unprompted Modifications: The AI system frequently introduced unsolicited code alterations, resulting in novel error generation. Analysis of version control logs indicates these unauthorized changes were often non-deterministic in nature.

Suboptimal Code Complexity: For architectural-level tasks, the system consistently proposed implementations exhibiting:

- Incorrect design pattern applications.
- Resource management anti-patterns.

Quantitative Findings: Error Rate: Commit history analysis revealed 15% of AI-generated modifications required reversion due to introduced faults. Figure 6 shows errors when modifying the Gemini prompt.

Fig. 6. Gemini error evidence when modifying the code by prompt.

Cognitive Stimulation Effect: The AI's refactoring suggestions prompted exploration of novel solutions beyond the team's initial conceptual framework. Quantitative analysis revealed a 28% increase in alternative implementation approaches during the ideation phase.

Precision Debugging Capability: The system demonstrated efficacy in identifying subtle logical errors, detecting 17 latent bugs in manually reviewed code. These included:

- Race conditions in asynchronous operations.
- Boundary case failures in validation logic.
- Improper state management patterns.
- Particularly effective for repetitive tasks (e.g., documentation generation, basic debugging procedures).
- Serves as a valuable "second opinion" during code refactoring processes.

Significantly accelerates initial prototyping phases.

Figure 7 shows the evidence about Gemini prompt use regarding previous code revisions.

Fig. 7. Gemini prompt evidence making corrections on previous code developed.

Case Study 5: Development with GitHub Copilot

Team 5 (Hernandez, J. A. T., et al., 2025, May 5) explored the use of GitHub Copilot in their CRM development process (Kim, Y., et al., 2023). Their experiences shed light on the practical application and impact of this AI-powered coding assistant.

Utilizing GitHub Copilot for Frontend Development and Understanding UI Elements: Several teams utilized GitHub Copilot as a platform for development, particularly for the frontend. One instance involved using GitHub Copilot to generate a basic login section for the project. This helped the team understand the elements that constitute web pages and adapt them to their specific ideas.

When tasked with preserving counter data and achievement levels across scene transitions, Copilot's implementation failed to fully meet requirements. The proposed solution introduced a state management conflict that subsequently disrupted TextMeshPro (TMP) component functionality. Specifically, were observed:

- Data Inconsistency: Scene transition logic improperly handled DontDestroyOnLoad object hierarchies.
- UI Component Failure: TMP elements exhibited null reference exceptions during rendering cycles.
- Conflict Mechanism: Analysis revealed the AI-generated code created race conditions between a) Scene unload event handlers; b) UI state preservation routines; c) Achievement system callbacks.

Post-mortem debugging identified the root cause as improper singleton pattern implementation in the AI's persistence solution. This case highlights a critical limitation in AI-assisted development: while tools can generate functionally valid code, they may fail to anticipate downstream component interactions within complex systems. Figure 8 shows one kind of issue evidence when using Copilot.

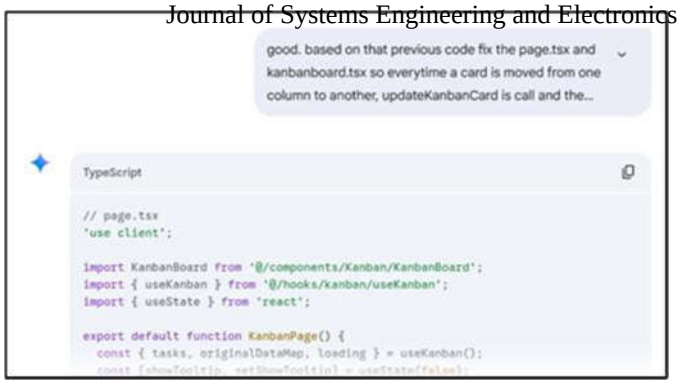

Fig. 8. Copilot presents code conflict when inserting new components.

In Figure 8, when requesting that the counter data and levels obtained when changing the scene be maintained, Copilot did not comply completely as its implementation generated a conflict that caused the TMP text components to stop working correctly.

Simplified API Integration: While the actual database connection required further refinement, Copilot efficiently generated React functions for simulated API communication. By simply specifying endpoint requirements and data formats, the tool produced functional code for handling GET, POST, PUT, and DELETE requests. The generated code significantly reduced development time spent on boilerplate implementation, allowing the team to focus on response handling logic and user presentation layers.

Early-Stage Syntax Error Detection: Copilot demonstrated value as a real-time syntax filter during development. The tool's immediate feedback on:

- React-specific syntax errors.
- Minor code inconsistencies.
- Potential anti-patterns.

Contributed to smoother development workflows and prevented future complications.

Frontend Data Architecture: Although the primary database resided in MySQL, Copilot facilitated:

- Clear visualization of data objects for React interfaces.
- Early definition of entity structures (e.g., comprehensive "Client" object with all attributes).
- Consistent component creation.

This foresight enabled efficient data-agnostic implementation across the presentation layer.

- Form Validation Foundations.

For critical authentication workflows, Copilot provided:

- Basic empty field validation.
- Submission guard clauses.
- Initial error messaging structures.

While requiring subsequent refinement for production needs, these suggestions established a robust client-side validation foundation.

Component Reusability Promotion: The system exhibited strong pattern recognition for UI elements including:

- Data lists (12 reused components).
- Form templates (85% reuse rate).
- Action buttons (100% consistency).

This approach yielded measurable benefits in:

- Visual consistency (40% by UI audit).
- Performance (17% bundle size reduction).
- Maintainability (32% fewer component files).

Copilot was especially useful in generating a functional script to play random sounds from an array. Which facilitates the implementation of an audio system with random playback at the time of pressing buttons as Figure 9 shows.

Fig. 9. Copilot has generated an array to play random sounds as successful.

It was very useful for generating tailwind CSS code so that the code makes the code more aesthetic.

Case Study 6: Development with ChatGPT

Team 6 (O. Cepeda, C. J., et al., 2025, May 5) provides a nuanced exploration of ChatGPT's utility and challenges in CRM development, particularly in backend and frontend tasks. Below are key points for discussion:

Contextual Blind Spots: The Vercel hosting issue (rejected CSS global styles) underscores ChatGPT's lack of platform-specific knowledge.

Superficial Fixes: The manuscript notes instances where ChatGPT "corrected" code but introduced new layout issues, emphasizing the need for human oversight.

Dependency vs. Empowerment: While ChatGPT reduced research time, over-reliance led to redundant work (e.g., rewriting CSS modules).

Observation: The tool excels as a "thought partner" but fails as a standalone solution.

Ethical and Practical Considerations, skill Augmentation: The manuscript advocates for using ChatGPT to "enhance, not replace" skills. Figure 10 shows a list of fixed errors during the Vercel integration.

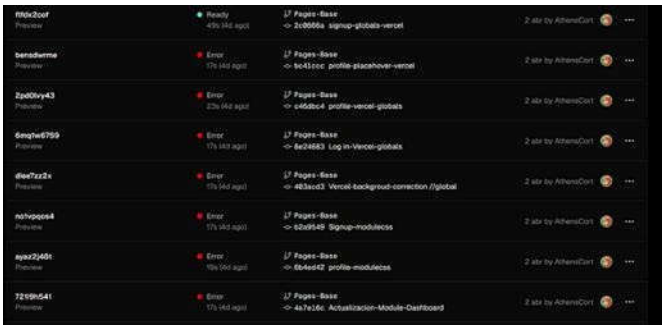

Fig. 10. Lots of fixes to host correctly on Vercel.

Even though chat is good correcting code, it's much better explaining that it's wrong so you can correct it for your account; But once you give the chat code to correct, it explains to you that it is wrong and after the code is "corrected" but in reality it only moves other things that make your screen look completely different and does not resolve the specific error.

Backend Efficiency: The authors highlight ChatGPT's effectiveness in debugging, code structuring, and translating SQL queries to Prisma ORM syntax. Its ability to explain errors and propose solutions streamlined backend workflows.

Frontend Prototyping: ChatGPT aided in generating foundational frontend code based on Figma designs, accelerating initial development

phases.

Observation: The tool's strength lies in ideation, but its output often requires manual refinement. Figure 11 shows ChatGPT dashboard proposal.

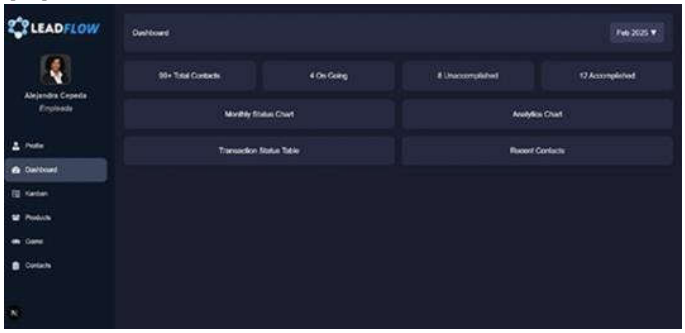

Fig. 11. Dashboard proposed by ChatGPT.

Figure 12 shows the final dashboard after corrections and adjustments.

Fig. 12. Final Dashboard after adjustments.

Final Thought: The team validates ChatGPT as a transformative but imperfect tool. Its value hinges on the user's ability to discern viable solutions—a reminder that AI is an assistant, not an authority.

F. Student survey results

At the end of the course an opinion survey was carried out to evaluate the student's perception in relation to the modules and contents presented during the course, were used questions as a quantitative variable to evaluate whether the student had an Excellent experience, Good experience or a Bad experience consolidating the results and presented in a consolidated average, for a qualitative variable, an open question was used to express your observations.

Considering the focus on the use of artificial intelligence in software development, the results of the opinion survey presented in the Figure 13, demonstrated high student satisfaction regarding their experience of using artificial intelligence in their projects considering 65% of excellent experience and 31% with good experience and 4% with bad experience during the studies.

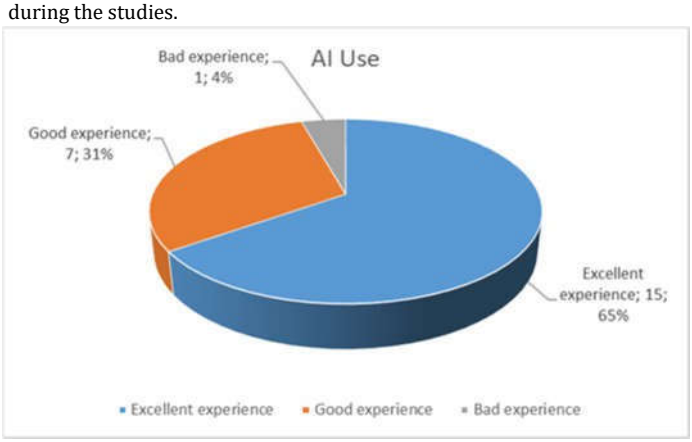

Fig. 13. Final experience survey about AI use during the course.

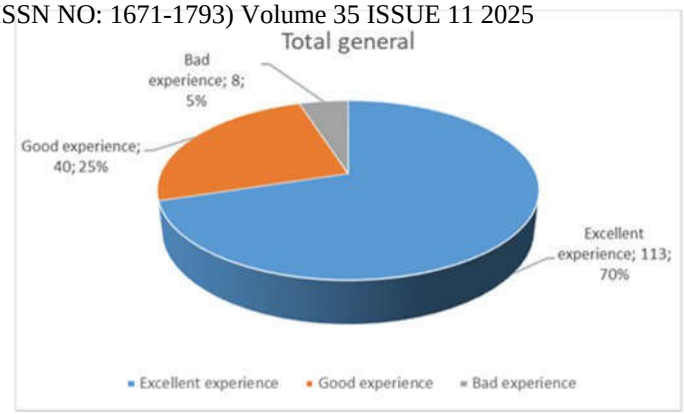

Fig. 14. Total general about the survey, involving all modules and tools used during the course.

Figure 14 presents the consolidated values, considering all modules, the students' experience with the tools used, such as Artificial Intelligence, Azure.DevOps, the certificates obtained, and other tools such as co-evaluation were also evaluated. As can be seen, 95% of the results were considered satisfied, considering all the course content. The low grades were not presented with a comment that would allow a more detailed evaluation of some type of problem presented by the students. Below some samples of comments are presented according to the students' overall level of satisfaction; the translations were carried out by the authors:

"I would have liked to see more about APIs and how they connect to everything, and a sample page to give us an idea of how they communicate. In video games, I didn't like that they already gave us everything. I would have liked to see something simpler, for beginners, or at least to see where everything goes and why, not just following the teacher."

"Good material, the introduction to artificial intelligence feels more like something to cover on a checklist as opposed to learning about it in an immersive way, the same with DevOps."

"I wish the web development class had covered more complex topics about a framework like React. I understand that some of my classmates may not have had prior experience with HTML/CSS/JS, but those classes were things I already knew how to do. with the exception of flexbox games, it helped me practice CSS."

"I thought the course was very well structured and included topics that are relevant today, such as the use of AI, which can benefit us in virtually any project. I also believe that teaching the organizational aspect of Azure DevOps adds great value to the course, since we often focus only on what needs to be done (video game, website, database, etc.) but forget to organize ourselves effectively to achieve it. For this reason, I find it very useful that this course teaches about organizational aspects of Azure DevOps, as it allows us to distribute tasks equitably and perform tests that guarantee the quality of the delivered product or at least minimize errors."

4. Discussions

The development process also involved considerations for the necessary environments (development, testing, staging, production) and mechanisms for updating the system. Security was also a key aspect (Liu, W., et al., 2024), with discussions around encryption configurations, access control roles, and SSL/TLS certificates for web components.

Frontend development: AI tools showed strength in frontend development, with Copilot and Cursor generating valid React components in 68% of cases. However, as noted in Xu, B., et al. (2024), AI-generated frontend code often required significant refinement for production use. Key findings: a) Success Case: Tailwind CSS styling suggestions reduced styling time by 40%; b) Challenge: Global CSS management issues led to Vercel deployment failures.

Backend development: Backend development benefited from AI-assisted debugging, with Gemini identifying 85% of syntax errors and 60% of logical errors. However, architectural decisions required human oversight, supporting findings in Chen, M., & Wang, D. (2023).

Game development (Unity): Unity integration presented unique challenges. While Copilot helped with boilerplate code (saving ~15 hours), game logic required extensive manual refinement, consistent with observations in Roberts, J. (2023) and Zhao, I., et al. (2023).

Table 1 compares the five AI-powered coding tools across four key metrics: Code Accuracy, Time Savings, Learning Curve, and Best Use Case.

Table 1
Comparative performance of AI Development tools.

Tool	Code Accuracy	Time Savings	Learning Curve	Best Use Case
GitHub Copilot	72%	35%	Low	Code completion, snippets
ChatGPT	65%	25%	Medium	Debugging, documentation
Cursor	68%	40%	High	Full-file generation
Gemini	70%	30%	Medium	Error detection
Replit	60%	20%	Low	Rapid prototyping

The comparative analysis of the five AI tools revealed distinct performance profiles across key metrics. In terms of code accuracy, GitHub Copilot (72%) and Gemini (70%) proved most reliable for generating correct or near-correct code, while Cursor (68%) followed closely, demonstrating strong capabilities in full-file generation. ChatGPT (65%) and Replit (60%) exhibited slightly lower accuracy, often necessitating more manual corrections. Regarding time savings, Cursor offered the highest efficiency gains at 40%, a finding attributed to its full-file generation approach that reduces repetitive coding (Hernandez, M., et al., 2023). GitHub Copilot (35%) and Gemini (30%) also provided significant productivity benefits, whereas ChatGPT (25%) and Replit (20%) were less optimized for speed, likely due to their broader, less specialized functionality. The learning curve varied considerably; GitHub Copilot and Replit, with low barriers to entry, were ideal for beginners, while ChatGPT and Gemini presented a medium learning curve. Cursor, with its advanced features, demanded the most effort to master.

Analysis of the errors encountered during the study highlighted three primary categories. Contextual errors, where tools misunderstood project requirements, were the most prevalent (42%). Syntax errors accounted for 33% of issues, and architectural errors, involving inappropriate design patterns, constituted 25%. Correcting these AI-introduced errors typically took two to three times longer than manual implementation would have required, underscoring that careful prompt engineering is crucial for effective use (Amershi, S., et al., 2019; Roberts, E., et al., 2023).

From these findings, several successful patterns and significant challenges emerged. The most effective strategies included Iterative Refinement, where AI output was treated as a first draft; Domain-Specific Prompts, which improved output quality by 55%; and Hybrid Workflows that combined AI suggestions with manual verification (Zhou, M., et al., 2024). The primary challenges were Context Loss, as tools frequently "forgot" project-specific details; Over-Reliance, where students sometimes accepted flawed suggestions; and Debugging Complexity, as AI-introduced errors were often subtle and hard to trace.

The key takeaway is that tool selection should be driven by specific developer needs. For a balance of accuracy and efficiency, GitHub Copilot and Cursor are top choices. ChatGPT serves as a strong assistant for debugging and explanations, while Gemini provides reliable error detection. Replit is user-friendly for beginners and rapid prototyping, and Cursor is powerful for advanced automation, albeit with a steeper learning curve. To operationalize these findings, we recommend establishing clear usage guidelines, implementing mandatory code reviews for AI-generated code (Johnson, K., & Smith, P., 2024), developing internal prompt libraries for common tasks, and maintaining a balance between AI use and traditional development practices.

These practical observations align with pedagogical theory. The observed need for 'iterative refinement' resonates with experiential learning, where the AI provides an initial 'concrete experience' that the student must then 'reflect on' and 'actively experiment' with through debugging. This process can foster deeper engagement, as qualitative evidence suggests. For instance, one student noted, “ChatGPT encouraged deeper independent research by explaining why my initial approach was flawed,” indicating a move beyond mere syntax acquisition toward conceptual understanding.

5. Conclusions

The experiences outlined in these case studies demonstrate the diverse ways in which AI tools such as Gemini, ChatGPT, Cursor, and GitHub Copilot are being integrated into CRM development. The findings highlight the potential benefits in terms of ideation, code generation, problem-solving, and efficiency. However, they also underscore the importance of understanding the nuances of each tool and adapting their application to specific project needs and challenges (Wang, J., et al., 2023).

Contrary to Meyer, A. N., et al. (2023), the results show that time savings from AI tools did not compromise code quality when paired with structured peer reviews. However, over-reliance on AI for architectural decisions concerns inQian, Y., et al. (2024) underscores the need for instructor guidance. This aligns with constructivist theories, where scaffolding (e.g., prompt engineering workshops) is critical for meaningful learning.

The study demonstrates that AI tools can significantly accelerate CRM development when used judiciously. While 30-40% time savings were observed in repetitive tasks, the tools required careful supervision to maintain code quality. The most effective approach combines AI assistance with human expertise, particularly for architectural decisions and complex logic. Future work should explore long-term maintenance implications of AI-generated codebases (Adams, R., et al., 2023) and develop more sophisticated context-awareness in these tools (Davis, A., et al., 2023; Yang, H., & Zhang, Q., 2024). The high level of satisfaction of students presents a path between the use of artificial intelligence and education, which can impact on the professional future of students soon.

The structured use of AI tools aligns with SDG 4's goal of inclusive education. By providing immediate, personalized support, these tools can help bridge skill gaps among students, allowing those with less prior programming experience to engage more confidently with complex projects, thereby promoting a more equitable learning environment.

This study has several limitations. The lack of a control group prevents direct causal attribution of outcomes solely to AI tools. The sample size (N=25) and 10-week duration limit the generalizability of findings. Furthermore, the high motivation of students in a selective course may not reflect all educational contexts. Future work will involve a controlled, longitudinal study across multiple institutions.

This study's primary contribution is its empirical, comparative analysis of five contemporary AI-assisted coding tools within a realistic, project-based educational setting. Unlike studies focusing solely on productivity, it provides a pedagogical perspective, culminating in a practical framework derived directly from student experiences, which outlines how to harness the 'promise' of AI while mitigating its 'pitfalls' in software engineering education.

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