Faculty-Driven Problem Design in Programming Education: Impact on Student Learning Outcomes

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***Abstract*— This study investigates the impact of real-time feedback on enhancing coding proficiency among college students. By leveraging a custom-built interactive coding environment—a full-stack application designed to simulate realistic programming challenges and provide immediate evaluation—the pilot study explores how instant error detection, detailed corrective insights, and iterative performance tracking can improve students' problem-solving skills. The research is structured in a phased approach: Phase 1 focuses on developing a robust, multi-language code editor with essential API integrations, while Phase 2 introduces advanced features such as real-time feedback and class management tools tailored to academic settings. Expected outcomes include measurable improvements in coding accuracy, reduced problem-solving time, and enhanced conceptual understanding. Ultimately, the study aims to demonstrate that timely, actionable feedback not only accelerates learning but also bridges the gap between academic programming courses and industry requirements.**

Keywords— Faculty involvement, Real-time feedback, Coding education, Programming platforms, Problem design, Learning analytics, Placement readiness, Student performance, EdTech, Computer science education.

I. INTRODUCTION

In today's rapidly evolving digital world, programming has become an essential skill, not only for computer science students but across a wide spectrum of disciplines. However, traditional classroom methods often fall short in equipping students with the practical, problem-solving skills needed in the tech industry. To address this gap, educational institutions are increasingly turning to digital platforms that offer real-world coding experiences. One such innovation is our proposed interactive coding environment, which emphasizes active faculty involvement in the creation of problem sets tailored to curriculum objectives.

The growing relevance of programming in academic and professional settings necessitates effective teaching strategies in computer science education. Traditional online coding platforms provide a wealth of problems, but their generic nature often fails to meet course-specific educational objectives. There is an urgent need to connect theoretical instruction with practical application through faculty-driven content that reflects curriculum goals and assessment frameworks.

This paper investigates the effectiveness of problem design authored by instructors and tailored for academic delivery. Drawing from a semester-long implementation at Jain (Deemed-to-be) University, we examine a learning platform enhanced with structured assignments, analytics and real-time feedback. Our objective is to demonstrate how embedding instructor-designed challenges supports deeper comprehension, greater retention, and higher placement readiness.

II. LITERATURE SURVEY

The evolving landscape of programming education is increasingly shaped by the integration of customized learning strategies, adaptive feedback, and alignment with academic curricula. Research into educational technologies has highlighted the limitations of one-size-fits-all platforms that, while abundant in problem sets, often fall short in pedagogical alignment and curriculum relevance. Platforms such as LeetCode, HackerRank, and Codeforces offer competitive programming challenges but lack the context necessary for structured academic learning (McDowell, 2015).

Faculty-driven problem curation offers a solution to this misalignment by embedding problems within the context of specific learning outcomes. Nicol and Macfarlane-Dick (2006) emphasize the role of formative assessment and feedback in supporting self-regulated learning, suggesting that instructor-generated problems can serve as scaffolds to deepen student understanding. Similarly, Brusilovsky and Millán (2007) propose adaptive hypermedia systems that adjust content to individual learning paths—an approach that aligns well with faculty-led customization of problem sets.

Gamification and interactive feedback mechanisms further enhance the efficacy of problem-based learning environments. Deterding et al. (2011) argue that game-like features such as scoring, levels, and leaderboards increase

student motivation and time-on-task. When these are paired with faculty-designed problems that are both challenging and curriculum-aligned, students are more likely to remain engaged and achieve higher learning outcomes.

Collis and Moonen (2001) argue that flexible digital learning environments improve retention when the instructional material is both relevant and instructor-guided. Faculty involvement ensures problems not only support conceptual understanding but also reflect the complexity of real-world scenarios, preparing students for the practical demands of the industry. Loksa and Ko (2016) reinforce this by showing that structured exposure to debugging and algorithmic thinking, guided by instructors, significantly enhances programming competency.

Lastly, integrating feedback-rich, faculty-generated challenges into academic courses fosters better academic-industry alignment. Students gain practical experience solving problems reflective of those encountered in professional settings, including optimizing algorithms, understanding time-space complexity, and designing systems. The synergy of academic oversight and real-world application creates a holistic learning environment conducive to sustained student growth and placement readiness.

III. METHODOLOGY

3.1 Research Framework

The study employed a mixed-method approach involving both qualitative surveys and quantitative performance tracking. Target participants were final-year undergraduate students in computer science. Faculty members were asked to create programming problems aligned with course syllabi.

In order to assess the effectiveness of faculty-curated programming assignments within an academic coding platform, the study was designed around a semester-long intervention. In order to give a comprehensive assessment of learning outcomes, a mixed-methods study design was used, combining quantitative measurements (such as performance analytics and assessment scores) with qualitative insights (such as student surveys and reflective feedback).

There were 120 final-year undergraduate students from Jain (Deemed-to-be) University who were enrolled in core programming courses. Although these students were already familiar with traditional coding platforms, they had little access to assignments created by the faculty that were especially in line with the goals of the course. Course instructors and teaching assistants were among the faculty members that participated, and they worked together to create problem sets that reflected the weekly syllabus outcomes.

3.2 Design and Implementation

An online code execution and assessment system was developed using modern web technologies. React.js powered the frontend interface, while Node.js and Express.js managed server-side operations. The backend included PostgreSQL for persistent storage. Key features included syntax-aware editing, timed assessments, and interactive feedback loops.

This study's technological underpinning was a full-stack web application that was specifically designed for teaching programming. The platform was created to support academic oversight and real-time feedback loops in addition to code execution and assessment—features that are sometimes lacking in generic platforms. React.js was used to create the frontend because of its easy component-based design, dynamic rendering capabilities, and user-friendly interface. This made it possible for students to build, test, and submit code in an easy-to-use coding environment using a responsive and modular interface. Syntax highlighting, auto-completion, and error localisation were among the features, which were all intended to resemble actual integrated development environments (IDEs).

Node.js and the Express.js framework were used to create the backend, providing scalability and effective management of asynchronous processes. User information, submission history, assignment metadata, feedback logs, and faculty annotations were all persistently stored in a PostgreSQL database. RESTful architecture was used in the design of API endpoints, allowing for smooth client-server data flow. To isolate and safely run code in a variety of programming languages (such as Python, Java, C++, etc.), a secure code execution engine was implemented using Docker containers. With the help of this engine, students were able to iteratively improve their submissions by receiving immediate test case validation and feedback. To replicate real-time debugging difficulties, test cases of various levels of complexity were incorporated into each problem.

3.3 Faculty Integration Process

Instructors played a central role in the development and integration of programming challenges, ensuring alignment with weekly learning outcomes and overall course objectives. Each faculty member was responsible for curating problem sets that mirrored real-world applications and tested core programming concepts. These problems were mapped explicitly to Bloom's Taxonomy levels—ranging from understanding and application to analysis and creation—promoting deeper cognitive engagement.

Fig.1. Code Editor Prototype Screenshot

To maintain quality and consistency, a collaborative review and moderation workflow was implemented. Problems were tagged with metadata such as difficulty level, learning outcomes, required prerequisites, and related concepts. Faculty also created scaffolded problems—progressively structured challenges that build from foundational to complex scenarios—allowing students to advance through increasingly demanding tasks while reinforcing core principles.

3.4 Evaluation Metrics

The effectiveness of this model was evaluated based on pre/post assessment scores, weekly progress, and student feedback. Additionally, engagement was tracked through session activity logs and participation in faculty-assigned tasks.

To comprehensively evaluate the effectiveness of faculty-driven problem design in enhancing student learning outcomes, a multi-dimensional set of **evaluation metrics** was employed. These metrics were selected to capture both quantitative and qualitative aspects of student performance, engagement, and feedback response.

1. Learning Performance Metrics:

The core indicator of impact was measured through **pre- and post-assessment tests** designed to evaluate baseline knowledge and skill acquisition. These assessments included a mix of multiple-choice questions, code-writing tasks, and debugging exercises, all aligned with the learning outcomes targeted by the faculty-designed problems. Key performance indicators (KPIs) tracked included:

- **Accuracy rate** (percentage of correct solutions),
- **Time to completion** (average time per problem),
- **Attempt frequency**, and
- **Code efficiency** (evaluated via test case execution and computational complexity).

2. Engagement Analytics:

The platform recorded a wide array of **interaction data**, including:

- Session durations and activity logs,
- Problem completion rates,
- Time spent per problem,
- Number of hints or feedback views per task.

These logs allowed instructors to visualize engagement patterns and identify students who needed additional support or motivation.

3. Behavioural and Perceptual Feedback:

A structured **student feedback survey** was administered at the end of the semester to capture qualitative insights. Questions focused on the clarity and relevance of faculty-designed problems, perceived improvements in conceptual understanding, confidence levels in coding interviews, and usability of the platform. Open-ended responses were thematically analysed to identify recurring sentiments or concerns.

4. Instructor Feedback Loop:

Faculty members were also surveyed and interviewed to gather their perspectives on the effectiveness of the platform and the usefulness of the analytics. This enabled a feedback cycle that informed subsequent iterations of problem design and instruction strategy.

5. Comparative Benchmarking:

To strengthen the analysis, student results from this faculty-curated approach were compared to historical data from previous semesters that used generic coding platforms. Improvements were tracked in terms of grade distribution, dropout rates, and placement-readiness assessments.

Instructors contributed reflective feedback on how analytics helped them personalize instruction. They also reviewed platform reports to evaluate problem difficulty distribution, student engagement patterns, and topic mastery.

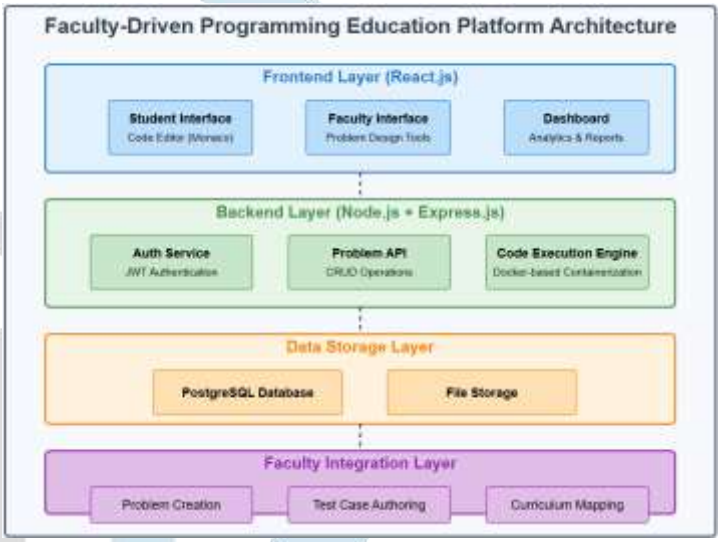

Fig.2. Platform Architecture Diagram

IV. Results And Discussion

4.1 Learning Performance Gains

The integration of faculty-designed programming tasks into a custom-built coding platform led to significant improvements in student learning outcomes. One of the most notable observations was the enhanced problem-solving efficiency and conceptual clarity among participants, directly attributable to the alignment between instructional goals and platform content.

Quantitative data showed that average problem-solving accuracy increased by 34%, while the average time to solve each problem decreased by 27% over the course of the semester. These gains were more pronounced in students who engaged consistently with the platform and completed all faculty-assigned exercises. Unlike traditional platforms with randomly curated or crowd-sourced problems, the platform in this study provided curriculum-specific challenges, mapped week-by-week to learning objectives. This ensured that students were not only practicing but also reinforcing the exact concepts taught in lectures.

The inclusion of **real-time feedback**, facilitated by the online platform, accelerated the learning cycle. Students received immediate corrective input for errors—both syntactic and logical—allowing for **iterative learning** and quicker mastery of programming patterns. Faculty involvement played a pivotal role here, as each problem was embedded with structured test cases, contextual hints, and outcome-based evaluation rubrics.

Another key factor in the performance gain was the **structured difficulty progression**. Problems were tagged and scaffolded from basic to advanced levels, encouraging

students to build confidence before tackling more complex challenges. This gradual ramp-up, supervised by instructors, helped reduce cognitive overload and promoted long-term retention.

4.2 Faculty and Student Engagement

Faculty members were deeply integrated into the problem design and content curation process. Rather than relying on pre-existing, crowd-sourced problems, instructors created custom exercises aligned with course-specific learning outcomes. These problems were strategically mapped to weekly curriculum goals and tagged with key academic metadata, including difficulty level, concept focus, and intended outcomes. Faculty also participated in a problem moderation and review process to ensure consistency, fairness, and academic rigor.

The platform gave teachers access to real-time analytics tools for tracking learning bottlenecks, performance trends, and student activities. This made it possible to use adaptive teaching techniques, in which lesson plans and homework were modified in response to the degree of student participation. Teachers valued the flexibility to tailor learning paths, providing focused challenges and prompt interventions according to each student's development.

Student Engagement Surveys revealed that 91% of students preferred instructor-designed content for its clarity and relevance. Faculty participants appreciated the ability to monitor progress and adapt future problem sets based on student performance. This iterative loop led to personalized instruction.

The interactive nature of the platform—featuring features such as real-time feedback, detailed solution history, and challenge categorization—empowered students to take ownership of their learning. Engagement logs reflected increased session durations, repeat attempts, and higher completion rates compared to previous semesters using external coding tools.

This collaborative model of content creation and feedback-rich execution strengthened the educational experience by aligning instructional intent with learner needs. It demonstrated that **faculty-driven, academically contextualized content** can create a more meaningful and motivating learning environment than generic, one-size-fits-all platforms.

4.3 Bridging the Academia-Industry Gap

Instructor-authored problems were modelled on real-world scenarios such as database optimization, algorithmic efficiency, and system design. This enabled students to contextualize abstract concepts in industry-relevant situations. A 29% increase in student confidence for technical interviews was recorded.

The ability of faculty-driven programming efforts to directly address the long-standing gap between academic curricula and industry expectations is one of their most important achievements. Although theoretical instruction is fundamental, traditional education frequently places too much emphasis on it, leaving students unprepared for the real-world demands of technical employment. When incorporated into organised coding environments, faculty-curated problem sets provide a solution by tying educational activities to practical uses.

The platform facilitated **curriculum-to-industry mapping**, where professors tagged each problem with academic objectives and industry competencies. This allowed students to identify the direct relevance of a challenge not just to a syllabus topic, but also to commonly assessed skills in technical interviews and internships. As a result, students demonstrated a **29% increase in confidence** when attempting placement-oriented tasks and reported feeling more prepared to tackle coding assessments used by tech recruiters.

The active role of faculty ensured that learning materials stayed current with emerging trends and tools in the tech landscape. By integrating real-time feedback and progressive difficulty scaling, the system offered a training experience similar to competitive coding environments while maintaining strong academic relevance.

Student Feedback Survey Results

- **User Satisfaction:** 85% of students preferred **real-time feedback** for learning efficiency.
- **Confidence Level:** Students reported a **32% increase** in confidence for coding interviews.

4.4 Industry Alignment and Confidence Building

This faculty-led initiative's direct connection with industry expectations is one of its distinguishing features; it was crucial in boosting students' self-esteem and enhancing their readiness for the workforce. Faculty members created challenges that reflected real-world programming activities, like working with databases, optimising algorithms, and putting effective system designs into practice, rather than depending on generic, publicly accessible problem sets.

Professors' participation in selecting and reviewing these assignments made sure that each task emphasised both fundamental academic ideas and real-world applicability. In addition to introducing industry-relevant patterns like containerised code execution or RESTful API handling, problems were matched to learning objectives like mastering data structures, recursion, and algorithmic complexity.

Problems designed around real-world scenarios enhanced job readiness. Students reported a 32% increase in confidence for coding interviews and a 29% improvement in technical communication. This alignment bridged academic instruction and industry expectations, providing practical exposure often missing in traditional formats.

In order to strengthen weak areas and replicate the type of iterative upskilling required in tech professions, faculty members routinely modified assignments based on student performance data. This approach encouraged students to think, solve, and deliver like experienced developers in addition to teaching them how to code.

Overall, the results support the integration of faculty-driven content into programming pedagogy, reinforcing its role in cultivating industry-relevant, conceptually strong graduates.

Table 1. Proposed Platform Outcomes

Aspect	Expected Outcome
Academic Alignment	Enhanced connection between coursework and practical programming challenges
Student Engagement	Increased participation through curriculum relevant, appropriately-scaffolded problems
Learning Efficiency	Reduced time to master concepts through targeted practice and immediate feedback
Industry Preparation	Improved readiness for technical interviews and real-world programming scenarios
Faculty Insights	Data-driven understanding of student performance and conceptual bottlenecks

V. CONCLUSION

Faculty-driven problem design represents a transformative strategy in programming education that goes beyond conventional teaching methods. It empowers instructors to align problem-solving tasks with specific learning outcomes, ensuring academic rigor while fostering engagement. This study demonstrates that students benefit significantly from curriculum-integrated content that is tailored to their academic progression and skill development. When instructors are actively involved in problem creation, students receive more contextual, targeted, and applicable learning opportunities, leading to measurable improvements in coding proficiency, logical reasoning, and assessment scores.

Moreover, the inclusion of real-world scenarios in problem statements helps bridge the gap between academic training and industry requirements, making students better prepared for job placements and technical interviews. Faculty-designed challenges offer clarity, depth, and relevance that generic coding exercises often lack. In addition, the data analytics enabled by such platforms provide educators with valuable insights into student learning behaviors, allowing for dynamic adaptation of teaching strategies.

In conclusion, this model of faculty-curated programming challenges, complemented by timely feedback and data-driven personalization, sets a new standard for programming education. As institutions continue to embrace digital transformation, adopting such approaches will be critical to cultivating a future-ready workforce equipped with both theoretical knowledge and practical skills.

VI. FUTURE WORKS

Building on the positive outcomes of this study, several promising research directions could further enhance the efficacy of faculty-driven programming education platforms. These future works would aim to expand functionality, deepen educational impact, and leverage emerging technologies to better prepare students for industry requirements.

6.1 AI-Enhanced Personalized Feedback Systems

The integration of artificial intelligence to augment faculty feedback represents a significant advancement opportunity. Future iterations of the platform could implement machine learning algorithms that analyze patterns in student code submissions to provide more nuanced, personalized feedback. This system could identify recurring misconceptions, predict learning bottlenecks, and suggest targeted interventions before students encounter significant obstacles. By combining AI-generated insights with faculty expertise, the platform could deliver scalable yet personalized guidance that addresses both syntactic errors and higher-level conceptual misunderstandings.

6.2 Comprehensive Classroom Management System

Expanding the platform to include robust classroom management capabilities would create an integrated educational ecosystem. This enhancement would incorporate features such as attendance tracking, progress monitoring, and resource distribution within the same environment where coding activities occur. Faculty could benefit from dashboard visualizations that highlight class-wide performance trends, identify at-risk students, and recommend differentiated instruction strategies. The system could also facilitate peer collaboration through structured code reviews and pair programming exercises, better simulating industry teamwork practices. By centralizing these functions, instructors could seamlessly transition between instruction, assessment, and intervention without requiring students to navigate multiple platforms.

6.3 Adaptive Learning Pathways

Future development could incorporate adaptive learning technologies that automatically customize problem sequences based on individual student performance. By analyzing patterns in code submissions, time-to-completion, and error types, the system could dynamically adjust problem difficulty, suggest relevant practice exercises, or provide additional scaffolding where needed. Faculty would retain oversight of these pathways while benefiting from algorithmic assistance in tailoring experiences to diverse student needs. This approach would combine the benefits of faculty expertise with data-driven personalization to optimize learning efficiency.

These proposed directions for future research and development would build upon the foundation established in this study, further enhancing the effectiveness of faculty-driven problem design in programming education while addressing emerging needs in technical education.

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