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Applying the Extreme-Based Teaching Model in Post-Secondary Online Classroom Setting: A Field Experiment

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***Abstract*—**The first programming course within post-secondary education has long been recognized as a challenging endeavor for both educators and students alike. Historically, these courses have exhibited high failure rates and a notable number of dropouts. Instructors often lament students' lack of effort on their coursework, and students often express frustration that the teaching methods employed are not effective. Drawing inspiration from the successful principles of Extreme Programming, this study introduces an approach—the Extremes-based teaching model—aimed at enhancing the teaching of introductory programming courses. To empirically determine the effectiveness of the model, a comparison was made between a section taught using the extreme-based model and another utilizing traditional teaching methods. Notably, the extreme-based teaching class required students to work collaboratively on projects, while also demanding continuous assessment and performance enhancement within groups. This paper details the application of the extreme-based model within the post-secondary online classroom context and presents the compelling results that emphasize its effectiveness in advancing the teaching and learning experiences. The extreme-based model led to a significant increase of 13.46 points in the weighted total average and a commendable 10% reduction in the failure rate.

***Keywords*—**Extreme-based teaching model, innovative pedagogical methods, project-based learning, team-based learning

I. Introduction

AMONG the myriad of intricate computer science and related courses, the first programming course consistently emerges as a formidable challenge, evoking frustration among educators and learners alike. The attrition and failure rates observed in these initial programming courses surpass those of other introductory courses. In response, educational researchers and practitioners have proactively explored various strategies to enhance the teaching of introductory programming courses [3], [5], [6], [8], fostering successful learning outcomes.

Given the shared characteristics of software development and programming pedagogy, it is only logical to consider integrating efficient and productive software development methodologies into the teaching of introductory programming courses. Among the contemporary software development methodologies, the group-based approach of extreme programming (XP) has emerged as a particularly promising candidate to enhance the teaching and learning experiences in introductory programming. Group-based learning promotes constant communication, mutual assistance, and knowledge exchange among students, reflecting the inherently collaborative nature of software development teams. With instructors assuming a multifaceted role encompassing organization, guidance, facilitation, and supervision, students benefit from a holistic learning process. Instructors not only deliver lectures but also actively oversee project work in labs, fostering a deep assimilation of freshly acquired knowledge and skills. Furthermore, instructors offer timely feedback, guidance, and course adjustments, ensuring a dynamic and effective learning environment. Building on this foundation, we proposed an innovative extreme-based teaching model tailored to introductory programming courses [1]. To assess the model's effectiveness, one course section was taught using this model, while another adhered to traditional teaching methods. Notably, the extreme-based teaching section emphasized collaborative project work and continuous group performance evaluation and improvement, a feature not found in the traditional section.

This paper illustrates the application of the extreme-based model in an online post-secondary classroom setting and presents the empirical results demonstrating its ability to enhance teaching and learning outcomes. Remarkably, the extreme-based model yielded a remarkable increase of 13.46 points in the weighted total average, coupled with a noteworthy 10% reduction in the failure rate.

The subsequent sections of this paper unfold as follows: Section II provides a succinct overview of the extreme-based teaching model. The third section delves into the application of the extreme-based teaching model within the post-secondary online class context. The experiment results are summarized and discussed in Section IV. Finally, Section V clarifies the limitations of the experiment and outlines future avenues of research and exploration.

II. Review of Extreme-Based Teaching Model

The extreme-based teaching model takes advantage of diverse learning approaches and integrates traditional lecture-based, project-oriented [2], [9], and innovative learning paradigms [4], [7], [10]. Aligned with predefined learning objectives, course content is fractionated into manageable units, each supported by corresponding projects. The progression from one unit to the next entails refining and revising, building on the outcomes of preceding units.

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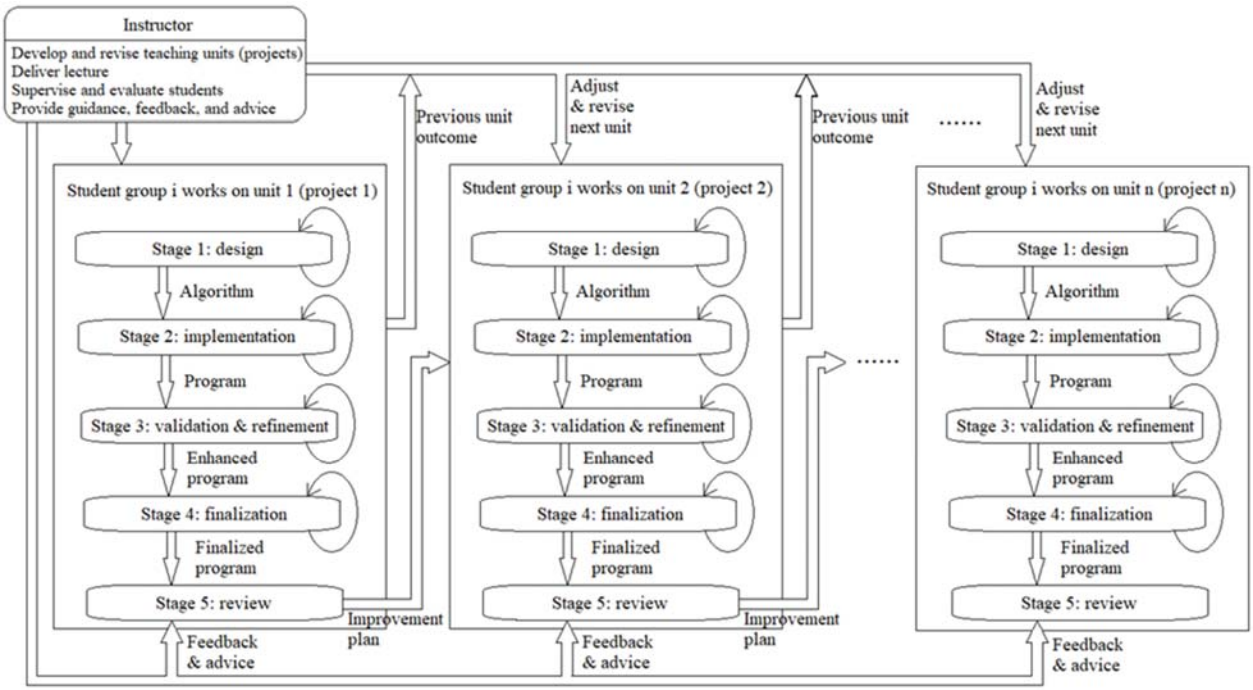

Fig. 1 Extreme based teaching model for one group of students

Central to this model is the active engagement of both instructors and students throughout the learning journey. Beyond the conventional role of educators, instructors' function as organizers, guides, facilitators, and supervisors, deeply entrenched in students' learning trajectories. The instructors meticulously shape and organize the course material into achievable units, replete with corresponding projects that align with the learning objectives. Their responsibilities extend beyond lecture delivery to encompass close supervision and guidance during project work in the lab, fostering a robust comprehension of acquired knowledge and skills. Furthermore, instructors assess students' progress, offering timely feedback, guidance, and refining future teaching units as needed.

On the other hand, students, embarking upon a dynamic collaborative journey, work in pairs to navigate the multistage project lifecycle encompassing design, implementation, validation, refinement, finalization, and comprehensive review. This intricate synergy between student and instructor ensures an unwavering support structure, timely feedback loops, and adaptive adjustments in response to evolving student progress.

A visual representation of the extreme-based teaching model is reprofiled in Fig. 1 [1].

III. Application of the Extreme-Based Teaching Model in the Post-Secondary Online Classroom

The experiment involved two sections of COMP 150, a first programming course, delivered online during the fall of 2022 due to the impact of COVID-19. The experimental design dictated that one section (referred to as ON3) adopted the extreme-based teaching model, while the other (ON2) adhered to traditional instructor-led teaching approaches. For clarity, the section embracing the extreme-based model is hereafter designated the "extreme-based section," while the traditional teaching section is termed the "traditional section."

To ensure a controlled experimental environment, meticulous efforts were undertaken to eliminate the influence of confound variables. Both sections were exposed to identical topics, assignments, projects, midterms, and final exams. The final exams were conducted at the same date and time. Moreover, the requirements for assignments and projects, encompassing algorithm design and program development, remained consistent across both sections. Evaluations of assignments and projects were performed with uniform standards by the instructor and the same teaching assistant (TA), who provided identical feedback and suggestions.

While the assignments, designed to be straightforward and fundamental, were completed individually by students in both sections, the extreme-based model necessitated collaborative efforts on the projects in the extreme-based section. In contrast, students in the traditional section pursued individual projects. As per the principles of the extreme-based model, students in the extreme-based section worked in pairs, alternating the writing of program segments, engaging in self-evaluation, and perpetually seeking avenues for group performance enhancement after completing each project. Students enjoyed the liberty to self-organize groups, with instructor intervention reserved for instances where students encountered difficulty in forming pairs. During lab sessions, instructor and TA offered guidance to individual students in the traditional section, whereas they supervised pairs in the extreme-based section.

IV. Results and Discussion

Initially, during the early weeks, discernible differences in behavior and performance between the two sections were not

evident. However, as the semester unfolded, the advantages of the extreme-based model progressively became apparent. In the extreme-based section, students exhibited heightened activity and competence. Increased participation in classroom activities, willingness to tackle challenging questions, enhanced speed and accuracy in completing in-class exercises, and an elevated frequency of inquiring uncovered questions (topics) marked their active engagement. Additionally, the quality of assignments and projects in the extreme-based section surpassed that of the traditional section. Notably, the average exam scores in the extreme-based section were consistently better than those in the traditional section.

A comparative analysis of student performance across key components, including assignments, exams, dropout rates, pass rates, and weighted total class averages, is presented in Table I.

TABLE I
COMPARISON OF KEY COMPONENTS BETWEEN TRADITIONAL AND EXTREME-BASED TEACHING SECTIONS

Comparing items \ Section	Extreme-Based	Traditional
Number of students at the beginning of semester	30	24
Number of students at the end of semester	26	21
Drop out rate	13.3%	12.5%
Assignments and projects average	87.72%	69.54%
Midterm average without curve	76.38%	73.87%
Final exam average without curve	56.45%	49.86%
Quiz average	84.5%	75%
Weighted total average	66.93%	53.47%
Failure rate	23%	33%

Table I unambiguously exhibited the superior performance of students in the extreme-based section across all measured aspects. Notably, the extreme-based section exhibited a remarkable 18.18% higher average in assignments and projects, a 2.51% increase in midterm scores, and a noteworthy 6.59% enhancement in final exam scores. Consequently, a discernible trend emerged: students in the extreme-based section demonstrated more significant progress than their counterparts in the traditional section.

The students' feedback echoes the effectiveness of the extreme-based teaching model. A survey of the extreme-based section revealed that an overwhelming 76.5% of students enjoyed collaborative project work within pairs, and 70.6% believed that such collaborative efforts significantly facilitated their navigation of the challenging programming course. The following testimonies from students further underscored the benefits of the extreme-based teaching model:

"I learnt a variety of skills through group projects and labs that are very crucial in the working world. Positive group experiences have also been demonstrated to improve my learning, retention, and overall performance in this course. When planned properly, group projects and labs strengthen abilities that apply to both group and individual work, such as the capacity to:

1.Dividing difficult jobs into components and processes
2.Organizing my time.
3.Improving comprehension through discourse and clarification
4.Providing and receiving performance feedback

Additionally, group work assisted me in developing abilities related to teamwork, and understanding the C++ language more easily."

"There are many advantages when we work in groups. Two people collaborate to do one task where they can do the task with more accuracy and successfully. Both can share their views to each other to clarify the problem. Whenever any of them feel uncomfortable with any assignment or project, he/she knows that their partner is always there to help them. Overall, working in groups is very good experience for me as I got to know many new things. Thank you."

Contrastingly, only 40% of students in the traditional section acknowledged that collaboration could enhance their performance, while 26.6% expressed disagreement.

V. CONCLUSION

The conducted experiment decisively demonstrates the efficacy of the extreme-based teaching model in enhancing the outcomes of the first programming course at the post-secondary level. Students enrolled in the extreme-based section displayed superior performance, higher engagement levels, and increased success rates. Most notably, the extreme-based section witnessed a commendable 10% reduction in the failure rate, thereby affirming the model's positive impact. Although the extreme-based section experienced a slight rise (0.8%) in the dropout rate, the overall results resoundingly support the model's effectiveness.

VI. LIMITATIONS AND FUTURE WORK

The implementation of the extreme-based teaching model in the classroom gave rise to two challenges. Firstly, issues arose regarding group organization. When a team member was absent or withdrew, there was a need to efficiently restructure the group either temporarily or permanently. Additionally, certain students with prior experience expressed frustration over extended project completion times due to their less experienced partners. Hence, it became imperative to allocate students with similar experience levels to the same group. Furthermore, it was observed that certain students did not fully engage in certain extreme-based activities, like self-evaluation and performance enhancement. To instill greater seriousness in students towards these activities, partial marks will be allocated to these aspects as an incentive.

In the forthcoming journey, the extreme-based model will be further tested within in-person classroom settings and higher-level programming courses. As well, the iterative refinement of teaching materials based on the evaluation of the previous project will be strengthened. Moreover, hybrid approaches, amalgamating diverse teaching models, such as extreme-based and agile-based models, will be investigated to offer students a well-rounded educational experience.

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