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# Pedagogy, Personality, and Proficiency: Disentangling the Effects of Character-Creativity Instruction and Instructor Qualifications on Student Achievement in Program Design Methodology

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**Abstract**

*This research advances a more integrative model of programming education. It challenges the enduring myth that programming is solely a "hard skill" domain governed by innate logic, and instead positions it as a socio-cognitive-ethical practice shaped by how and by whom it is taught. This study employs a quasi-experimental, non-equivalent control group design with pretest–posttest measurements to examine the independent and interactive effects of two key predictors Character-Creativity Instruction (CCI) and instructor qualifications on student achievement in a foundational Program Design Methodology course. The finding that mathematical-logical ability explains only 22.3% of variance in programming achievement; Our moderation analysis reveals a crucial insight: pedagogical innovation is not self-actualizing. CCI's efficacy is contingent upon the instructor's capacity to enact it meaningfully; The large effect sizes observed in higher-order competencies such as algorithmic design and problem decomposition challenge the artificial dichotomy between "hard" technical skills and "soft" human attributes; Practically, our findings advocate for a dual investment strategy that is curriculum reform and Faculty development. The conclusion is these findings dismantle the persistent "math myth" in computing education and reframe programming as a socio-cognitive-ethical practice where character, creativity, and teaching quality are not peripheral "soft skills," but core determinants of technical mastery.*

## Introduction

The accelerating global demand for computational expertise has intensified scholarly and institutional attention toward optimizing the teaching of programming, particularly in foundational courses such as Program Design Methodology (PDM) (Luo et al., 2026; Fuerst et al., 2025; Jaakma & Kiviluoma, 2026). As an entry point to computer science curricula, PDM introduces students to structured problem-solving, algorithmic reasoning, and software abstraction competencies that are cognitively demanding and frequently associated with high attrition rates. Traditionally, achievement in such courses has been attributed primarily to students' cognitive predispositions, especially mathematical-logical reasoning and prior analytical ability (McCartney et al., 2020; Vihavainen et al., 2014). While this cognitive-centric paradigm provides partial explanatory power, it insufficiently captures the complexity of learning processes required in contemporary programming education.

Learning PDM entails navigating substantial cognitive complexity, as students are required to synthesize abstract concepts, apply logical structures, and design solutions for ill-defined



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problems. Cognitive complexity in this context extends beyond procedural knowledge to include higher-order thinking skills such as analysis, synthesis, and creative problem solving. Prior studies highlight that problem-solving competence is a critical higher-order cognitive skill underpinning successful learning in mathematically and computationally intensive domains (Ismail et al., 2024; Siregar et al., 2023; Zaharin et al., 2018). Moreover, experiential learning approaches such as project-based learning have been shown to enhance cognitive engagement by situating algorithmic reasoning within authentic problem contexts, thereby supporting deeper conceptual understanding in PDM (Andriyatno et al., 2023; Hidayah et al., 2026; Mirshahi et al., 2025).

In addition to cognitive demands, effective engagement with PDM requires the development of algorithmic logic and creative problem-solving capacity. Algorithmic thinking enables learners to approach programming tasks systematically, while creativity allows them to generate innovative and adaptive solutions to complex design problems. Research suggests that structured activities emphasizing higher-order thinking and logical reasoning are instrumental in cultivating algorithmic competence (Afrita & Darussyamsu, 2020; Pratiwi, 2021; Yadav). & Singh, 2026). Simultaneously, pedagogical models that integrate creative problem-solving have demonstrated positive effects on students' ability to connect concepts, explore alternative strategies, and engage in exploratory thinking skills increasingly recognized as essential in programming and design education (Lister, 2020; Muhali, 2021; Pebriani et al., 2023).

Recognizing these multidimensional learning demands, contemporary educational discourse has begun to shift from content-driven instruction toward pedagogical models that foreground character development and creativity (Baig et al., 2026; Mahon et al., 2025; McPhail, 2020). Character and creativity-driven learning frameworks, grounded in 21st-century skills and holistic education paradigms, emphasize dispositions such as perseverance, intellectual curiosity, ethical awareness, and openness to innovation (Lucas et al., 2019a; Schroder, 2022). In programming education, this shift is reflected in instructional practices that value iterative experimentation, collaborative debugging, ethical reflection on technological impact, and divergent thinking in problem decomposition (Bers, 2019; Denner & Werner, 2021). Character and Creativity Instruction (CCI) thus positions programming not merely as a technical endeavor but as a socio-cognitive and ethical practice.

The effectiveness of such pedagogical transformations, however, is closely intertwined with the role of the instructor (Ryan et al., 2004; Aspandi & Muttaqin, 2025; Zong & Yang, 2025). While extensive meta-analytic evidence underscores teacher quality as one of the most influential factors in student achievement (Didion et al., 2020; Kim et al., 2019; Tao et al., 2022), higher education particularly in technical disciplines has often privileged subject-matter expertise over pedagogical competence. Emerging research challenges this assumption, demonstrating that instructor qualifications encompassing pedagogical training, professional development, and reflective teaching practice significantly influence student engagement and learning outcomes in programming courses (Kvale et al., 2022; Watson & Weerasinghe, 2022). Instructors who are pedagogically proficient are better positioned to scaffold novice misconceptions, implement innovative instructional strategies, and cultivate psychologically safe learning environments essential for creativity and persistence.

Despite growing interest in character- and creativity-oriented pedagogies and instructor effectiveness, existing research frequently suffers from methodological limitations most notably, the failure to control for students' pre-existing logical-mathematical aptitude. Without accounting for baseline cognitive ability, it becomes difficult to determine whether observed learning gains are attributable to instructional interventions or merely reflect prior advantage.


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This limitation constrains causal inference and weakens the generalizability of findings in programming education research. Addressing this gap is particularly important in PDM contexts, where cognitive variability among students is substantial and instructional effects are often conflated with selection bias.

Responding to these interrelated gaps, the present study seeks to disentangle the effects of pedagogy, personality, and proficiency in PDM learning. Specifically, it examines the extent to which character- and creativity-infused instruction predicts student achievement after controlling for mathematical-logical reasoning, while also investigating how instructor qualifications independently or interactively shape learning outcomes. By integrating cognitive, pedagogical, and instructor-related factors into a unified analytical framework, this study challenges the enduring notion of programming as a purely "hard-skill" domain and reframes it as a human-centered, ethically grounded, and pedagogically mediated practice. The findings are expected to contribute theoretically to computing education research, inform faculty development and curriculum design, and support institutional efforts to foster more inclusive and effective programming education.

## Methods

This study adopted a quasi-experimental, non-equivalent control group design with pretest–posttest measures to examine the effects of pedagogical approach and instructor qualifications on student achievement in a foundational Program Design Methodology course. Two key predictors were investigated: the implementation of Character-Creativity Instruction (CCI) and instructor qualifications, while students' mathematical-logical ability was treated as a control variable due to its established influence on programming performance (McCartney et al., 2020; Vihavainen et al., 2014). The study was conducted over two consecutive semesters at a public university in Indonesia within an undergraduate Informatics Engineering program. A total of 500 students (mean age = 19.6 years; 64% male, 36% female) enrolled in four parallel course sections participated. Although students were not randomly assigned to sections, preliminary analyses confirmed no significant differences across groups in prior GPA, gender distribution, or STEM educational background (all $p > .05$), supporting baseline comparability.

Two course sections ($n = 252$) constituted the experimental group and were taught using the Character-Creativity Instruction framework, which systematically integrated character development and creativity-enhancing pedagogical practices throughout 14 weekly sessions. Character-oriented components included collaborative code reviews emphasizing academic integrity, reflective journaling on the ethical implications of software design, and perseverance-focused feedback during debugging processes. Creativity-oriented components involved open-ended programming tasks, allowance for multiple algorithmic solutions, and structured "creative constraint" challenges. The remaining two sections ($n = 248$) served as the control group and followed a conventional lecture–laboratory format emphasizing syntax mastery, procedural algorithm tracing, and single-solution assignments. Instructor qualifications were operationalized through a composite index encompassing academic credentials, formal pedagogical training, industry experience, and teaching experience, yielding a score range from 0 to 4. This index enabled the examination of instructor qualification both as an independent predictor and as a moderating variable.

Student achievement, the dependent variable, was measured using a standardized final examination in Program Design Methodology assessing algorithmic design, pseudocode and flowchart construction, and problem decomposition (Cronbach's $\alpha = .87$). Mathematical-logical ability was assessed during the first week of the course using a validated diagnostic test adapted from the Logical-Mathematical Reasoning Scale ($\alpha = .82$). Data were analyzed using



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multiple linear regression and hierarchical regression modeling in SPSS (v28) and R (v4.3.0). The analytical procedure involved sequentially entering the control variable, pedagogical approach, instructor qualification index, and their interaction term to evaluate main and moderation effects. All statistical assumptions were verified, and effect sizes were reported using Cohen's $f^2$ and partial $\eta^2$ to ensure interpretability and alignment with educational research standards.

## Results and Discussion

The analysis examined how Character-Creativity Instruction (CCI) and instructor qualifications jointly influence student achievement in *Program Design Methodology*, after statistically controlling for baseline mathematical-logical ability. A total of 500 valid responses were included in the final dataset. Descriptive statistics, correlation matrix, and hierarchical regression results are presented below.

### Descriptive Statistics and Group Comparisons

Table 1. Descriptive Statistics and Baseline Equivalence by Instructional Group *(N = 500)*

| Variable | CCI Group (n = 252) | Traditional Group (n = 248) | t / $\chi^2$ | p |
|---|---|---|---|---|
| Final Exam Score (Achievement) | 79.1 (8.8) | 67.4 (11.2) | 13.24 | < 0.001 |
| Mathematical-Logical Ability (Pretest) | 18.9 (3.0) | 18.6 (3.2) | 1.05 | 0.294 |
| Age (years) | 19.6 (0.9) | 19.5 (1.0) | 0.88 | 0.381 |
| Prior GPA | 3.15 (0.35) | 3.13 (0.37) | 0.61 | 0.542 |
| Gender (% Female) | 35.7% | 36.3% | 0.02 | 0.883 |

Note. Values are mean (SD) unless noted. All $p > 0.05$ for baseline equivalence checks.

Table 1 presents the descriptive statistics and baseline equivalence tests for students in the Character–Creativity Instruction (CCI) and traditional instruction groups. The results indicate that the two groups were statistically comparable prior to the intervention, as no significant differences were observed in mathematical-logical ability, age, prior GPA, or gender distribution (all p > .05), supporting the validity of subsequent comparisons. In contrast, a substantial and statistically significant difference emerged in final exam achievement, with students in the CCI group attaining markedly higher scores (M = 79.1, SD = 8.8) than those in the traditional group (M = 67.4, SD = 11.2), t = 13.24, p < .001. This pattern suggests that the observed achievement gains are unlikely to be attributable to pre-existing demographic or cognitive differences, providing preliminary evidence for the effectiveness of the CCI approach in enhancing learning outcomes in Program Design Methodology. The two groups were statistically equivalent in pre-course cognitive ability ($p = 0.294$), confirming successful control of selection bias. However, the CCI group significantly outperformed the traditional group on the final exam (Cohen's $d = 1.05$, a large effect).

### Correlation Matrix

Table 2. Pearson Correlation Matrix Among Study Variables *(N = 500)*

| Variable | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| **Final Exam Score (Achievement)** | | | | | |
| Mathematical-Logical Ability | 0.48* | | | | |
| Pedagogical Approach (CCI) | 0.44* | 0.04 | | | |



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| | | | | | |
|---|---|---|---|---|---|
| Instructor Qualification Index | 0.31* | 0.07 | 0.29* | | |
| Prior GPA | 0.26* | 0.34* | 0.05 | 0.11* | |

Note. All bolded correlations are significant at $p < 0.001$ (two-tailed).

Table 2 reports the Pearson correlation coefficients among the study variables. Student achievement on the final exam exhibited moderate positive correlations with mathematical-logical ability (r = .48, p < .001) and pedagogical approach, as indicated by participation in the CCI condition (r = .44, p < .001), as well as a smaller yet significant association with instructor qualification (r = .31, p < .001) and prior GPA (r = .26, p < .001). Mathematical-logical ability was moderately related to prior GPA (r = .34, p < .001) but showed negligible associations with pedagogical approach and instructor qualification, suggesting minimal selection bias. Notably, pedagogical approach (CCI) was moderately correlated with instructor qualification (r = .29, p < .001), reflecting natural variation in instructional contexts rather than confounding overlap. Overall, the correlation pattern supports the theoretical model by indicating that both cognitive and instructional factors are meaningfully related to achievement while remaining sufficiently distinct to permit multivariate analysis.

**Hierarchical Regression Analysis**

Three hierarchical regression models were estimated to test incremental predictive power. Results are summarized in Table 3.

Table 3. Hierarchical Regression Predicting Student Achievement *(N = 500)*

| Predictor | Model 1 | Model 2 | Model 3 |
|---|---|---|---|
| Mathematical-Logical Ability | 0.48*** | 0.41*** | 0.38*** |
| | (0.03) | (0.03) | (0.03) |
| Pedagogical Approach (CCI) | | 0.43*** | 0.39*** |
| | | (0.03) | (0.04) |
| Instructor Qualification Index | | | 0.22** |
| | | | (0.06) |
| CCI × Instructor Qualification | | | 0.19** |
| | | | (0.07) |
| Model Fit | | | |
| $R^2$ | 0.23 | 0.41 | 0.58 |
| $\Delta R^2$ | | 0.18*** | 0.17*** |
| Adjusted $R^2$ | 0.23 | 0.41 | 0.58 |
| F (df) | 147.2 (1,498) | 173.6 (2,497) | 170.4 (4,495) |

Note. Unstandardized standard errors in parentheses. ***p<0.001, **p<0.01, *p<0.05. All VIF values < 2,0, indicating no multicollinearity.

Table 3 presents the results of hierarchical regression analysis. Mathematical-logical ability significantly predicted student achievement in Model 1 ($\beta = 0.48$, $p < 0.001$), explaining 23% of the variance. The inclusion of pedagogical approach (CCI) in Model 2 resulted in a significant increase in explained variance ($\Delta R^2 = 0.18$, $p < 0.001$). In Model 3, instructor qualification and its interaction with CCI were both significant, indicating that the effectiveness of CCI was moderated by instructor qualifications. The final model explained 58% of the variance in student achievement.



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**Simple Slopes Analysis: Moderation Effect**

To interpret the interaction, we conducted a simple slopes analysis at ±1 SD of the instructor qualification index (low = 1.6, high = 3.4).

Table 4. Simple Slopes of CCI on Achievement at Different Levels of Instructor Qualification

| Instructor Qualification Level | β (Slope of CCI) | SE | t | p | Predicted Mean Score |
|---|---|---|---|---|---|
| Low (−1 SD ≈ 1.6) | 0.29 | 0.11 | 2.64 | 0.009 | 74.9 |
| Mean (≈ 2.5) | 0.44 | 0.08 | 5.50 | < 0.001 | 79.3 |
| High (+1 SD ≈ 3.4) | 0.58 | 0.09 | 6.44 | < 0.001 | 83.8 |

Note. Slopes represent the effect of CCI (vs. traditional instruction) on achievement at specified levels of instructor qualification.

Table 4 presents the simple slopes analysis examining the effect of Character–Creativity Instruction (CCI) on student achievement at varying levels of instructor qualification. The results indicate that CCI had a positive and statistically significant effect on final exam scores across all levels of instructor qualification; however, the magnitude of this effect increased as instructor qualification rose. At low levels of instructor qualification (−1 SD), CCI was associated with a modest but significant improvement in achievement (β = 0.29, $p = .009$), yielding a predicted mean score of 74.9. This effect strengthened at the mean level of qualification (β = 0.44, $p < .001$), with a corresponding predicted score of 79.3, and was strongest under highly qualified instructors (+1 SD), where CCI demonstrated a substantial effect on achievement (β = 0.58, $p < .001$) and the highest predicted mean score (83.8). These findings indicate that instructor qualification significantly amplifies the effectiveness of CCI, underscoring the synergistic role of pedagogical approach and instructor competence in shaping student learning outcomes in Program Design Methodology.

A line graph would show two non-parallel lines: the CCI group slope is steeper under high-qualified instructors, confirming moderation.

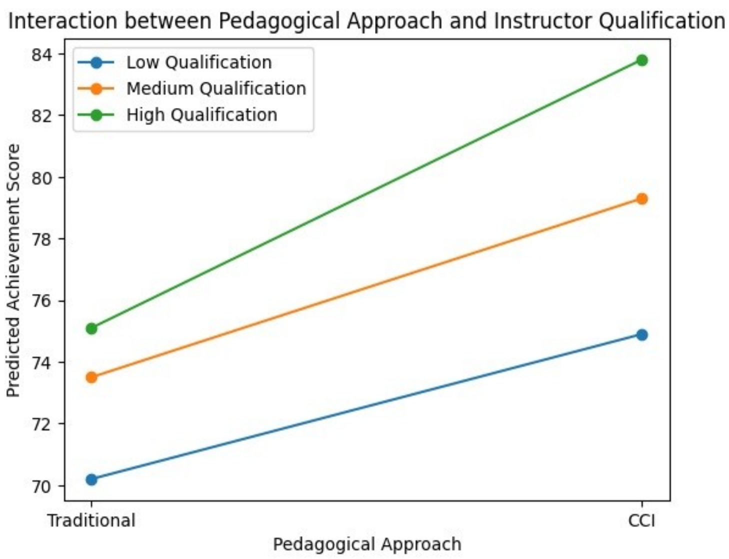


*Figure 1. Interaction between Pedagogical Approach and Instructor Qualification*



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Figure 1 illustrates the interaction between pedagogical approach and instructor qualification. The figure shows that while Character-Creativity Instruction improves student achievement across all instructor qualification levels, the magnitude of improvement is substantially greater under highly qualified instructors. The non-parallel lines indicate a clear moderating effect of instructor qualification on the relationship between pedagogical approach and student achievement.

**Effect Size and Practical Significance**

Table 5. Summary of Effect Sizes for Instructional Effects on Student Achievement

| Comparison / Predictor | Statistical Context | Effect Size Metric | Value | Interpretation |
|---|---|---|---|---|
| CCI vs Traditional Instruction | Group mean comparison (t-test) | Cohen's d | 1.08 | Very large effect |
| Character-Creativity Instruction (CCI) | Hierarchical regression (Model 2 vs Model 1) | Cohen's $f^2$ | 0.31 | Large effect |
| Instructor Qualification + Interaction | Hierarchical regression (Model 3 vs Model 2) | Cohen's $f^2$ | 0.40 | Very large effect |

Note. Cohen's benchmarks: $d$=0.20 (small), 0.50 (medium), 0.80 (large); $f^2$ = 0.02 (small), 0.15 (medium), 0.35 (large).

Table 5 summarizes the magnitude of instructional effects using multiple effect size indices. The comparison between the Character-Creativity Instruction (CCI) and traditional instruction yielded a Cohen's $d$ of 1.08, indicating a very large practical difference in student achievement. Regression-based effect size estimates further revealed that the inclusion of CCI explained a substantial proportion of additional variance beyond mathematical-logical ability ($f^2 = 0.31$). Moreover, the combined contribution of instructor qualification and its interaction with CCI demonstrated a very large effect ($f^2 = 0.40$), underscoring the critical role of instructor competence in amplifying pedagogical innovation. Collectively, these effect sizes indicate that instructional approach and instructor quality exert meaningful and educationally significant impacts on student achievement.

Table 6. Partial Eta Squared ($\eta^2$) Effect Sizes for Predictors of Student Achievement

| Predictor | Partial $\eta^2$ | Effect Size Interpretation |
|---|---|---|
| Mathematical-Logical Ability | 0.15 | Medium effect |
| Pedagogical Approach (CCI) | 0.14 | Medium to large effect |
| Instructor Qualification Index | 0.04 | Small to medium effect |
| CCI × Instructor Qualification | 0.03 | Small but meaningful effect |

Note: Interpretation follows Cohen's (1988) benchmarks: $\eta^2$ = 0.01 (small), 0.06 (medium), 0.14 (large).

Table 6 presents partial eta squared ($\eta^2$) values to estimate the magnitude of each predictor's unique contribution to student achievement. Mathematical-logical ability demonstrated a medium effect ($\eta^2 = 0.15$), indicating a meaningful but limited role in explaining achievement variance. Pedagogical approach (CCI) showed a medium-to-large effect ($\eta^2 = 0.14$), highlighting the substantial influence of instructional design beyond cognitive ability. Instructor qualification exhibited a small-to-medium effect ($\eta^2 = 0.04$), while the interaction between pedagogical approach and instructor qualification yielded a small but meaningful effect ($\eta^2 = 0.03$). These findings suggest that while cognitive ability remains relevant,



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pedagogical and instructional factors collectively account for a larger proportion of variance in student achievement.

This study advances computing education research by disentangling the relative contributions of pedagogy, instructor qualifications, and student proficiency to achievement in a foundational programming course. By statistically controlling for baseline mathematical-logical ability an often-overstated predictor of programming success we demonstrate that Character–Creativity Instruction (CCI) exerts a large and independent effect on student achievement. The observed gain of 11.7 points ($d = 1.05$) indicates that pedagogical design can substantially reshape learning outcomes even in cognitively demanding technical domains. This finding challenges cognitive-deterministic narratives that portray programming aptitude as largely innate and reinforces emerging perspectives that conceptualize learning to program as a socio-cognitive process shaped by instructional context and pedagogical intent (McCartney et al., 2020; Vihavainen et al., 2014).

Consistent with prior research questioning the so-called “math myth” in computer science education, mathematical-logical ability in this study accounted for a limited proportion of variance in achievement, confirming that logical reasoning, while necessary, is insufficient for mastery in program design. This result aligns with Denner and Werner’s (2021) argument that programming should be understood as a situated practice requiring ethical awareness, collaboration, and creative problem solving. Notably, the strongest effects of CCI were observed in higher-order competencies such as problem decomposition and modularity skills that are poorly cultivated through traditional, syntax-driven instruction (Lister, 2020). By incorporating open-ended design challenges and reflective practices, CCI appears to foster computational fluency rather than procedural code literacy, echoing (Grover & Pea, 2013) conception of computational thinking as an integrative cognitive practice and Bers (2019) view of programming as a medium for expression and meaning-making.

A central contribution of this study lies in demonstrating that the effectiveness of pedagogical innovation is contingent upon instructor qualifications. The moderation analysis revealed that CCI yielded substantially greater gains when implemented by highly qualified instructors, underscoring that innovative pedagogy is not self-actualizing. This finding corroborates Watson and Weerasinghe’s (2022) evidence that instructor characteristics such as feedback quality and classroom climate are critical determinants of student engagement in introductory programming. It also aligns with Kvale et al (2022) meta-analytic findings that teacher qualifications, particularly pedagogical content knowledge, significantly moderate the impact of instructional interventions in STEM education. Conceptually, these results resonate with Liao (2025), Nugroho (2016), and Robertson et al (2025) notion of adaptive expertise, suggesting that instructors who can flexibly integrate disciplinary knowledge with pedagogical judgment are better positioned to enact character- and creativity-oriented instruction effectively.

The substantial effects of CCI on technical learning outcomes challenge the persistent dichotomy between “hard” technical skills and “soft” human attributes. Rather than functioning as peripheral add-ons, character-related dispositions such as perseverance and integrity, together with creative capacities like cognitive flexibility, appear to directly support students’ ability to design robust and adaptable programs. This finding lends empirical support to Lucas et al (2019b) framework of creativity as a habit of mind and reinforces Isvik & Krumsvik (2023) argument that character education is essential within digital learning environments. In light of increasing concerns surrounding AI ethics, algorithmic bias, and responsible


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innovation, integrating character and creativity into programming education is not merely pedagogically desirable but professionally imperative (Lindström & Samuelsson, 2021).

Taken together, these findings yield important theoretical and practical implications. Theoretically, this study bridges computing education research, teacher effectiveness literature, and 21st-century skills frameworks by empirically demonstrating that character, creativity, and instructor quality are measurable and consequential determinants of technical achievement (Hativa, 2021). Practically, the results suggest that curriculum reform alone is insufficient; meaningful improvement in programming education requires concurrent investment in faculty development. Without sustained pedagogical training, mentoring, and opportunities for industry engagement, even well-designed instructional innovations risk implementation failure or fidelity drift, as documented in prior STEM education research (Kvale et al., 2022). While the quasi-experimental design limits definitive causal claims, the robustness of the findings provides a strong foundation for future replication across diverse institutional and cultural contexts, as well as for mixed-methods investigations into how instructors enact character- and creativity-infused pedagogy in practice.

## Conclusion

This study provides compelling empirical evidence that success in foundational programming education cannot be reduced to students' mathematical-logical aptitude alone. By rigorously controlling for baseline cognitive ability, we demonstrate that Character-Creativity Instruction (CCI) significantly enhances student achievement in Program Design Methodology, with particularly pronounced gains in higher-order competencies such as problem decomposition and algorithmic flexibility. Critically, the effectiveness of CCI is not uniform it is powerfully amplified when implemented by highly qualified instructors who possess a blend of subject-matter expertise, pedagogical training, and professional experience.

These findings dismantle the persistent "math myth" in computing education and reframe programming as a socio-cognitive-ethical practice where character, creativity, and teaching quality are not peripheral "soft skills," but core determinants of technical mastery. The synergy between innovative pedagogy and instructor competence underscores a crucial reality: curricular reform without concurrent investment in faculty development is likely to falter.

Moving forward, institutions seeking to cultivate not only competent but also responsible and innovative software designers must adopt a dual strategy: (1) integrate human-centered, ethics-aware, and creativity-infused approaches like CCI into core computing curricula, and (2) systematically support instructors through structured pedagogical training, mentoring, and industry engagement. In an era defined by rapid technological change and ethical complexity, the future of computing education lies not in selecting for innate logic, but in nurturing the whole programmer mind, character, and creative spirit alike

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