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RESEARCH ARTICLE

Pedagogical Modeling and Software-Methodological Support for Developing Students' Practical Programming Competencies Through Amaliylab

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Abstract

This study substantiates a structural-functional pedagogical model and software-methodological support for developing university students' practical programming competencies using AmaliyLab. The model integrates goal setting, content design, individualized practical tasks, instructional feedback, learning-process monitoring and reflective evaluation. Its pedagogical operation follows a cycle of initial diagnosis, selection of tasks at an appropriate difficulty level, independent programming, assessment of performance, differentiated support and subsequent task adjustment. A quasi-experimental pedagogical study conducted during the 2024–2025 and 2025–2026 academic years at Fergana State University, Gulistan State University and Karshi State University involved 307 students in Programming fundamentals (experimental group, n=153; control group, n=154). At baseline, the three-level competency distributions were comparable ($\chi^2=0.0023$; $p\approx0.9989$). The proportion of students achieving medium or high competency increased from 41.18% to 77.78% in the experimental group and from 40.91% to 62.99% in the control group. The final distributions differed significantly ($\chi^2=23.4514$, df=2, $p\approx0.0000081$; Cramér's $V\approx0.2764$). These aggregate findings support the pedagogical promise of the AmaliyLab-supported approach, while not by themselves establishing an isolated causal effect of the software.

KEYWORDS

Practical programming competencies; AmaliyLab; structural-functional pedagogical model; adaptive tasks; feedback; digital pedagogy; quasi-experimental study; Pearson chi-square.

INTRODUCTION

In higher education, developing practical competence requires learners not only to understand programming concepts but also to analyze a problem, design an algorithm, implement and test code, explain the result, and independently correct errors. A digital environment can assist these processes, but its educational value depends on an explicit connection between instructional aims, learning activities, assessment and teacher guidance. The literature on constructive alignment, activity-based instruction and digital competence provides a theoretical basis for such coherence [1–4].

The challenge addressed here is not simply introducing another learning management system. It is organizing a coherent programming practice cycle in which the complexity of assignments and the level of instructional support respond to students' demonstrated needs. This investigation therefore considers AmaliyLab as a component of the pedagogical

interaction "student–AmaliyLab–teacher", rather than a replacement for teacher judgment.

Research aim: to substantiate the software-methodological model supporting practical programming activity and examine differences between experimental and control group outcomes. The research questions concern the model's structure, the organizational role of AmaliyLab, and the observed dynamics of practical competency levels.

METHODS

Pedagogical and methodological basis. The study draws on competency-based and activity-based learning, constructive alignment, and the combination of guided practice with reflection [3–6]. These approaches were operationalized around practical programming tasks in Programming fundamentals. The proposed framework organizes the goals, content, instructional processes, digital mediation, diagnostics and feedback of students' practical work as a unified system.

Structural-functional model and AmaliyLab workflow. The model includes six mutually related components: (1) target, specifying the desired outcomes of practical programming activity; (2) content, comprising programming topics and multistep assignments; (3) procedural, organizing the sequence of student actions; (4) technological, providing digital support through AmaliyLab; (5) results-and-assessment, connecting indicators to competency levels; and (6) reflective, supporting self-assessment, error analysis and corrective action. These are methodological components; claims about particular implemented technical integrations require confirmation against the software documentation.

The instructional cycle is: diagnosis → individual profile → assignment appropriate to current preparation (L1–L3) → independent execution → monitoring of the process and result → feedback and adjustment of support → reflection → next assignment. Two complementary controls are proposed: program-guided adjustment of task difficulty and assistance, and teacher-led interpretation of monitoring results and pedagogical intervention.

L1 tasks emphasize the use of basic programming constructs; L2 tasks require the coordinated application of several constructs; and L3 tasks emphasize independent algorithm selection, testing, error analysis and improvement. Assessment considers not only whether code executes, but also the logic of the algorithm, the quality of testing and the student's explanation. The model allows differentiated feedback without assuming that all assistance is fully automated.

Model component	Function in practical programming
Target	Define outcomes for independent programming activity
Content	Sequence practical problems and L1–L3 assignments
Procedural	Organize diagnosis, practice, monitoring and reflection
Technological	Use AmaliyLab as a digitally supported practice environment
Results/assessment	Evaluate observable performance using shared criteria
Reflective	Analyze errors and identify the next improvement step

Assessment dimensions. Four pedagogical criteria are used to interpret practical activity: motivational (willingness to undertake and complete tasks); cognitive (problem analysis and algorithmic understanding); practical-activity (writing, running, testing and correcting programs); and reflective-assessment (explaining errors, evaluating results and planning improvement). Overall competency was categorized as high, medium or low in the dissertation's aggregated evaluation tables. Exact score cut-offs, weighting coefficients and psychometric reliability values were not independently available in the source materials; they are therefore not fabricated here.

Research context, participants and data analysis. The quasi-experimental comparison is based on data for the 2024–2025 and 2025–2026 academic years from three universities. Students in experimental groups followed the AmaliyLab-supported software-methodological approach, and those in control groups followed the comparison instructional approach. Both groups were summarized at the initial, formative and final assessment stages. The institutional data are aggregated by group and three-level competency category.

University	Experimental	Control	Total
Fergana State University	51	52	103
Gulistan State University	50	52	102
Karshi State University	52	50	102
Total	153	154	307

Pearson's chi-square test on 2×3 contingency tables was used to compare competency-level distributions between groups within each assessment stage. With three categories, the degrees of freedom are (2−1)(3−1)=2. Cramér's V was used as a descriptive association measure. No individual-level mean scores, paired changes, t-tests, Cohen's d, survey reliability estimates or platform-log correlations are reported, because the necessary original records were not established in the underlying aggregate tables.

RESULTS

Initial, formative and final competency distributions

Assessment stage	Group	High	Medium	Low	n
Initial	Experimental	16	47	90	153
Initial	Control	16	47	91	154
Formative	Experimental	37	53	63	153
Formative	Control	19	61	74	154
Final	Experimental	58	61	34	153
Final	Control	22	75	57	154

At the initial stage, group distributions did not differ appreciably ($\chi^2 \approx 0.0023, p \approx 0.9989$). At the formative stage, a between-group difference emerged ($\chi^2 \approx 7.2271, p \approx 0.0270$). At the final stage, the contrast became more pronounced ($\chi^2 \approx 23.4514, p \approx 0.0000081$). These statistics assess the association between group membership and competency category at each stage, not within-student changes.

Stage	Pearson χ^2	df	p-value	Cramér's V
Initial	0.0023	2	0.9988669	0.0027
Formative	7.2271	2	0.0269553	0.1534
Final	23.4514	2	≈0.0000081	0.2764

Changes in medium-or-high competency. The combined medium-or-high share rose from 41.18% (63/153) to 77.78% (119/153) in the experimental group, an increase of 36.60 percentage points. In the control group it rose from 40.91% (63/154) to 62.99% (97/154), an increase of 22.08 percentage points. The difference between these aggregate increases was 14.52 percentage points. The final medium-or-high share differed by approximately 14.79 percentage points between groups; the dissertation reports a 95% confidence interval of 4.71–24.87 percentage points for this final between-group difference.

Group	Initial medium + high	Final medium + high	Change (pp)
Experimental (n=153)	41.18%	77.78%	+36.60
Control (n=154)	40.91%	62.99%	+22.08

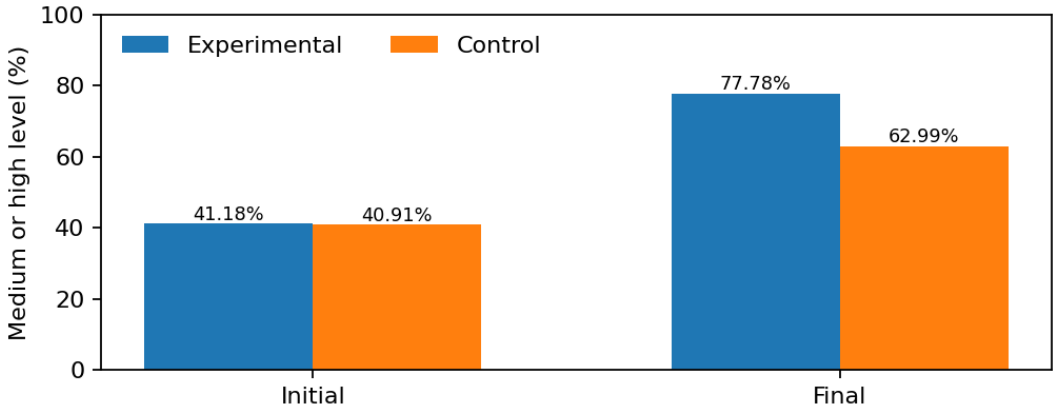


Figure 1. Aggregate share of students with medium or high practical competency.

DISCUSSION

The results are consistent with the proposition that systematic practice supported by diagnostic selection, differentiated feedback and reflection can be associated with stronger practical programming outcomes. In pedagogical terms, the principal contribution of the model is the coordinated relationship between the student's performance evidence, assignment complexity, the amount of support and the teacher's response. This differs from interpreting a digital platform merely as a repository of materials.

The near-identical initial distributions support descriptive baseline comparability on the reported three-level measure. The formative and final group differences are statistically significant under the aggregated chi-square analyses. Nevertheless, a quasi-experimental comparison does not, on its own, prove that AmaliyLab caused the entire difference: student selection, prior experiences, instructional delivery and other uncontrolled factors may have contributed.

Several reporting limitations must be acknowledged. The published aggregate tables do not identify individual students across assessment stages or definitively resolve whether academic-year cohorts were independent; this constrains individual growth analysis. The original article proposed LMS-specific tools, reliability coefficients, duration and a weighted index without measured evidence. These details have been replaced with the documented methodological description or identified as requiring verification. Future analysis should report validated rubrics, anonymized individual observations and platform usage records, with clear cohort identification.

CONCLUSIONS

A six-component structural-functional pedagogical model linking practical programming outcomes, L1–L3 task design, monitoring, adaptive support, teacher guidance and reflection was articulated around AmaliyLab.

The aggregated pedagogical experiment covered 307 students at three Uzbek universities. At the final stage, the experimental group had a higher share of students at medium or high competency (77.78%) than the control group (62.99%); a significant group-level difference was observed across the three competency categories ($\chi^2 \approx 23.4514, df=2, p \approx 0.0000081$).

The findings offer evidence supporting the educational relevance of the software-methodological approach, subject to verification of primary assessment records and more controlled evaluation of its independent contribution.

DECLARATIONS

Ethics and consent: institutional approval and consent procedures should be specified from the study records before submission. Funding: to be confirmed by the author. Conflicts of interest: to be confirmed by the author. Data availability: availability of anonymized primary records requires author confirmation.

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