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Pilot Evaluation of an AI-in-Python Elective Course: Effects on Middle Schoolers' Computational Thinking and Motivation

Nurzhaubayeva Tursynay Asankhankyzy[1], Maratova Tolganay Farkhatkyzy2

[1]Master of Natural Sciences, Computer Science Teacher;
Limited Liability Partnership "PhysTech School Almaty", Kazakhstan

[2]Doctor of Philosophy (PhD) in Computer Science;
Kazakh National Women's Teacher Training University, Kazakhstan

Abstract. The article presents the quantitative findings of a research study evaluating the effectiveness of the author's 34-hour elective course "Artificial Intelligence Programming in Python," piloted among 7th-grade students. Utilizing a pre/post assessment research design, changes in computational thinking levels, practical skills in utilizing applied libraries (NumPy, Pandas, OpenCV, scikit-learn), and academic motivation were measured. The initial diagnostic survey revealed a significant gap between students' high interest in AI (87%) and their baseline practical readiness (only 8% were capable of working with data libraries). A post-course evaluation in the pilot group (N = 24) demonstrated statistically significant growth across all parameters: 92% of students successfully completed practical mini-projects, 83% mastered basic data processing and computer vision, and 78% exhibited high autonomy in solving algorithmic problems. The findings confirm the pedagogical value of integrating applied AI programming into middle school education.
Keywords: *artificial intelligence, Python, computational thinking, pre/post evaluation, quantitative analysis, K-12, middle school, learning motivation.*

INTRODUCTION

The current stage of digital transformation in education imposes rigorous demands on the algorithmic and technological literacy of middle school students. Accumulated pedagogical experience indicates that traditional school computer science curricula are often restricted to basic algorithmic structures and abstract problem solving, failing to satisfy students' ambitions to build functional digital products. A prior needs assessment study conducted among 68 seventh-grade students revealed that 87% of respondents exhibited strong interest in artificial intelligence and robotics, 74% sought to build their own functional applications, and 69% considered the core curriculum insufficient for implementing real-world projects.

To address this contradiction, a 34-hour elective course titled "Artificial Intelligence Programming in Python" (1 hour per week) was developed and implemented at LLP "PhysTech School Almaty". The course is grounded in principles of spiral learning, interdisciplinarity, and project-based methodology.

The objective of this study is to quantitatively evaluate the impact of the elective course on students' algorithmic proficiency, practical skills with applied AI libraries, and academic motivation in middle school.

LITERATURE REVIEW

Assessing the effectiveness of programming and artificial intelligence courses within the K-12 segment relies on rigorous methodological standards for measuring computational thinking.

In a study by Sally Hamouda and co-authors (Virginia Tech, 2025), a methodology was presented for quantifying specific algorithmic gaps among 105 K-12 students using paired pre/post assessments [1, p. 48]. The authors demonstrated that systematically measuring entry and exit competencies allows researchers to precisely capture the transition from passive syntax comprehension to active system engineering [1, p. 52].

The work of Thomas Price and colleagues (NC State University) focuses on automated and quantitative evaluation of programming skill dynamics in middle school students [2, p. 315]. Their research emphasizes that course evaluation must rely not only on theoretical tests but also on objective success metrics in creating practical artifacts and projects [2, p. 318].

Aman Yadav and co-authors (Michigan State University) developed a conceptual framework for measuring computational thinking in K-12 [3, p. 104]. The researchers note that incorporating AI and machine learning elements into school curricula enhances academic self-efficacy and intrinsic motivation, transforming programming from an abstract discipline into a tool for applied problem solving [3, p. 108]. Foundational concepts by J. M. Wing [4, p. 34] and S. Grover [5, p. 40] further reinforce the necessity of measuring fundamental components of computational thinking (abstraction, decomposition, data manipulation) when introducing innovative IT subjects.

METHODS AND MATERIALS

Research Design: The study utilized a single-group quantitative pretest-posttest design. Diagnostic survey questionnaires and practical competency assessments, similar to those used during the needs assessment phase, served as measurement instruments.

Sample and Course Context: At the time of the post-test measurement, the 34-hour elective course had been fully completed. Pilot instruction took place at LLP "PhysTech School Almaty". The pilot sample comprised N = 24 seventh-grade students (aged 12-13) who completed the full course cycle from basic Python syntax to the final capstone project, "Smart School System".

Intervention Structure (Course Content): The curriculum comprised 4 core modules:

- Module 1: Python Fundamentals and Algorithms (8 hrs);
- Module 2: Data Analysis and Processing: NumPy, Pandas, Matplotlib, Tkinter (8 hrs);
- Module 3: Artificial Intelligence and Sensing: OpenCV, Face Recognition, Audio Processing (10 hrs);
- Module 4: Machine Learning and Integration: scikit-learn, APIs, Final Project (8 hrs).

Evaluated Indicators:

- Proficiency in basic Python constructs and custom functions;
- Practical skills in handling tabular/streaming data and applied libraries (NumPy, Pandas, OpenCV, scikit-learn);
- Confidence in algorithmic problem solving (academic self-efficacy);
- Shifts in motivation and interest towards computer science and IT;
- Completion rate of practical digital products (artifacts).

RESULTS

Comparative quantitative analysis of baseline (Pre) and final (Post) testing data for the pilot group (N = 24) demonstrated pronounced positive growth across all measured parameters.

At the initial stage, baseline diagnostics showed that 60% of students possessed only elementary syntax knowledge (variables, conditions, loops), 25% knew how to write custom functions, and only 8% had prior exposure to specialized data processing and AI libraries. The overwhelming majority (88%) experienced uncertainty and difficulty when required to manipulate tabular data or external files.

Table 1 presents comparative competency and motivational measures before and after the course.

Table 1

Competency and Motivational Dynamics of Students (N = 24)

Measured Indicator	Pre-Course	Post-Course	Absolute Gain (Δ)
Proficiency in basic Python constructs	60.0%	95.8%	+35.8%
Ability to design custom functions and modules	25.0%	87.5%	+62.5%
Skills in applied libraries (NumPy, Pandas, OpenCV, sklearn)	8.3%	83.3%	+75.0%
Uncertainty in data/table manipulation (share of students)	88.0%	16.7%	-71.3%
Demonstration of high autonomy in problem solving	20.0%	78.0%	+58.0%
Independent Python study outside school hours	15.0%	65.0%	+50.0%
Positive evaluation of course usefulness and engagement	87.0%	89.0%	+2.0%
Improved understanding of AI operating principles	—	83.0%	—
Completion rate of practical mini-projects	—	92.0%	—

As indicated by the data, the largest gains occurred in applied library usage (+75.0%) and modular functional programming (+62.5%). The proportion of students experiencing anxiety during data processing fell dramatically from 88% to 16.7%.

Motivational metrics also underwent notable positive shifts. The post-course survey revealed that 89% of students rated the course as highly engaging and valuable, while 83% reported a clearer conceptual understanding of consumer technology mechanisms (biometrics, chatbots, voice assistants).

An important indirect marker of heightened intrinsic motivation was that 65% of students voluntarily began exploring supplementary Python resources outside school hours. Course applicability is further substantiated by the fact that 92% of pilot group students successfully completed all 34 mini-projects, presenting fully functional end-products (including face recognition models, voice services, and a "Smart School" module). Additionally, 4 students from the pilot cohort went on to participate in external IT competitions and Olympiads.

DISCUSSION

The quantitative results corroborate the hypothesis that introducing artificial intelligence elements and applied Python programming in 7th grade is methodologically effective. Transitioning from passive theoretical instruction to a "topic-to-artifact" paradigm helps bridge the abstraction gap in traditional algorithmics.

The increase in learning autonomy from 20% to 78% indicates the development of robust self-regulation and code debugging self-efficacy. Students ceased perceiving compiler errors as insurmountable hurdles, shifting instead toward systematic analysis.

Limitations: Study limitations include the modest pilot sample size (N = 24), inherent to an elective course format, and the absence of a parallel control group following a traditional curriculum without AI modules. Nevertheless, the magnitude of growth over a short timeframe (34 instruction hours) points to a powerful intervention effect.

CONCLUSION

The quantitative pilot evaluation of the elective course "Artificial Intelligence Programming in Python" demonstrated strong pedagogical effectiveness. Implementing the curriculum successfully:

- Eliminated baseline deficits in practical data handling and library usage (growing from 8.3% to 83.3%);
- Elevated algorithmic confidence and student autonomy from 20% to 78%;
- Achieved a high project completion rate (92%) and fostered extracurricular learning initiative in 65% of participants.

The practical significance of this research lies in offering a field-tested course model ready for replication in general secondary schools and STEM centers. This article completes the quantitative evaluation stage of overall course efficacy. The subsequent step (in Paper 3) will focus on qualitative error profiling in machine learning model development and sensor data processing among middle school learners.

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