From Java to Python: Revamping CS2 for a Cohesive Curriculum

Muhlenberg College

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Institutional Context

Muhlenberg College's Computer Science Landscape

- Historically, the CS1 courses (Introduction to Game Programming and Introduction to Data Science) were taught in Python, while CS2 shifted abruptly to Java.
- This disjointed approach created a "language whiplash" effect, diluting students' proficiency in both languages and leaving gaps in foundational data structure knowledge.

The Problem of Discontinuous Learning

- The Java-based CS2 course struggled to reconcile two objectives: teaching object-oriented programming (OOP) and preparing students for **Data Structures and Algorithms (CSI 220)**.
- Students faced dual challenges:
    - Mastering Java syntax while grappling with OOP principles, leaving insufficient time for data structures.
- This misalignment forced CSI 220 to compress foundational and advanced topics, compromising depth.

Rationale for Transitioning to Python

Cognitive Load & Industry Trends

- Research demonstrates that switching programming languages between CS1 and CS2 increases cognitive load, as students must simultaneously learn new syntax and advanced concepts (Du et al., 2024).
- At Muhlenberg, the Java-Python discontinuity led to fragmented understanding, with students struggling to transfer OOP concepts between languages.
- By adopting Python for CS2, the curriculum eliminates this barrier, allowing students to focus on computational thinking rather than syntax (Siegfried et al., 2021)

Rationale for Transitioning to Python (continued)

Industry Alignment and Pedagogical Efficacy

Python's dominance in data science, AI, and machine learning makes it a pragmatic choice for modern CS education. Studies show that Python's readability and extensive libraries enable earlier engagement with real-world applications, fostering student motivation and retention.

Rationale for Transitioning to Python (continued)

Data Structure Preparation

The redesigned CS2 introduces complexity analysis, recursion, linked lists, stacks, and queues in Python, addressing a critical gap. Delaying data structure instruction until later courses risk overburdening students in advanced algorithms (Siegfried et al., 2021).

Empirical Support

Language Consistency and Transfer Effects

- A 2024 study by Du et al. examined knowledge transfer between programming languages, finding that students transitioning from C to Java experienced "conceptual interference" (e.g., misapplying manual memory management to Java).
- Similarly, Muhlenberg's Java-Python transition likely induced false equivalences (e.g., Java's `ArrayList` vs. Python's `list`). By standardizing on Python, such interference is mitigated, allowing positive transfer of OOP principles.

Curriculum Evolution and Student Outcomes

Giacaman et al. (2023) documented a decade-long CS2 redesign process, concluding that holistic curriculum updates—not isolated tweaks—drive meaningful improvement. Our approach mirrors this strategy, combining language alignment, content reprioritization, and scaffolded assessments.

Improvements We Hope to See

- Student Proficiency: We hope to see an increase in self-rated Python mastery
- CSI 220 Performance: We hope to see improved grades and fewer students needing remedial help with basic data structures
- Research Readiness: We hope to see more students engaging in machine learning research projects leveraging their Python skills from CS2

References

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