# *Reports from students and instructors on a new synthesized pedagogical model for CS1 in Python*

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## Institutional and departmental context

Location: Hamilton, New York

Undergraduate student body size: 3,206

Degree(s) offered: Major and Minor

Department/major name: Computer Science

Number of contributing faculty: 10 tenure faculty, 4 lab instructors and 3 VAPs

Number of majors annually: 65-85

Does the department offer any graduate programs? No

Other context:

## Description of Curricular Innovation

Many of the effective practices studied in Computer Science Education Research (CER) tackle a common issue, which is that forming correct theories about programs and programming is challenging for novices and, therefore, rife for developing misconceptions. In addition, teaching novices (that is, in introductory CS courses like CS1) and in the context of liberal arts colleges brings about additional challenges and opportunities. Many of our CS1 students are first year undergraduates that may not possess the necessary learning skills for a college course. They may also not have a strong concept of what or how a college course should be like, which creates opportunities for us to define that. Furthermore, many of our liberal arts students don’t necessarily have prior knowledge or experience with CS or programming, and in part because of it, many of them don’t think about majoring / minoring in CS. Lastly, and arguably, since liberal arts institutions pride themselves on their teaching standards, with smaller class sizes and individualized instruction, many of our students also have a preconceived expectation of increased support in their courses, and in many cases, high grades. While challenging, these issues also present opportunities for us to make our curriculum accessible to broader audiences by attracting non self-selecting (and potential underrepresented) students to the field.

Combining aspects from all these practices, we developed a teaching model focused on providing students with different support structures for their learning and for developing robust (life-long) learning skills. It shifts the narrative about the role of the instructor from the “sage on the stage” to an active facilitator of learning, and the narrative about the role of students from consumers to empowered learners that are able to construct their own understanding on their own, supported by peers and instructors. In addition, students practice different roles in self-managed teams and develop process skills, such as communication, teamwork, critical thinking and problem solving. Students’ learning is supported by a process of guided discovery (explore-invent-apply) employed by POGIL (Process Oriented Guided Inquiry Learning) and by a number of interconnected model-based external representations of different modalities, such as a physical model of the programmable internal-state machine implied by Python, a corresponding written model using a table, tracing tables for loops and memory diagrams for depicting information about the memory model. Further information on this pedagogical model can be found here: <https://dl.acm.org/doi/abs/10.1145/3633053.3633064>.

Focus groups were conducted in the second to last week of the semester with a total of eleven students randomly selected to participate with Educational Studies faculty member Margery Gardner. The group was composed of a majority of females, with five in total self-identifying as white. There were three self-identifying males, one of which was an international student of color. A majority of the group were first or second year undergraduates but a few were in their third year. Several students mentioned that they had an affinity towards STEM more broadly and were attracted to this course because CS is a deeply relevant field of study to society.

In the focus group setting, ideas of instructor support surfaced immediately including the normalization of collaboration during class time. Group work was a common practice that the participants cited as vital for their success. Students with STEM anxieties in particular felt seen in smaller group settings and this format allowed for a low-risk environment to ask questions. “She [the instructor] will come around and your question will be answered and this speeds up the process of learning”. Participants noted that didactic instruction was reserved for specific moments in the class when students needed access to more abstract concepts to continue to fully engage with the content. The use of interactive materials, including an online interactive textbook, was a resource that the participants found offered greater accessibility. Instruction was differentiated so that students with no previous exposure to CS would be able to find success. The process of persisting when fixing code was a rewarding experience for these participants and allowed them to activate their theoretical knowledge. Participants acknowledged the frustrations involved in debugging code and they recognized this competency as an explicitly learned skill. Participants drew parallels with language learning, for example, when they were required/instructed to refactor and improve the readability of their code.

The small liberal arts context emerged as offering greater opportunities for peer-to-peer and peer-to-faculty interactions. One participant, Mitchell, noted that when he compared his experience to a friend’s experience at a larger institution he felt as though he’s gained a much greater understanding, “he [friend] hasn’t touched a lot of the content we’ve touched. Our ability to go through so much content is not even on a cursory level, we’ve gone really in depth, speaks a lot to the teaching and how we’ve done things”. These initial results suggest that there is a sense of belonging curated in the classroom through strategic use of collaborative group projects and general approachability of the faculty instructor.

The most notable benefit the instructor has experienced was the creation of many feedback loops about students' learning that she leveraged for devising intervention as well as reflecting on the material and process.

## Challenges/Limitations

Students found their experience to be at times frustrating but overall rewarding as they learned content, methods to troubleshoot, and interpersonal skills. The most notable limitation from the students’ perspective was the lack of “lecturing” (expressed by a couple of students) which seemed driven by expectations based on prior experience and is a common challenge with active learning. The challenges from the instructors perspective had to do with a resistance from collaborating lab instructors and course instructors to accommodate the changes it incurred.