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An Innovative One-Year Pathway to a Master's in Computer Science for Non-Computing College Graduates

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An Innovative One-Year Pathway to a Master's in Computer Science for Non-Computing College Graduates: An Experience Report

Introduction

In this experience report, we present our work on developing the Illinois Computing Accelerator for Non-Specialists (iCAN) program at the University of Illinois. iCAN is a new and innovative one-year (fall, spring, summer) online graduate certificate program in computing designed for students with a bachelor's degree (or higher) and little to no background in computing. Technology is among the world's fastest-growing economic sectors, with some of the highest-paying jobs. Yet the current trajectory of the tech talent pipeline falls far short of meeting this demand. Many groups (for example, women, African-American/Black, Hispanic/Latinx, American Indian/Alaskan Native, and people with disabilities) have historically been excluded from this opportunity [1] and [2]. There is a high demand for employees in the computing field, but entry into this field can be challenging. Our graduate certificate in computer science (CS) aims to bridge this opportunity gap by leveraging the unique backgrounds and experiences of college graduates and preparing them for high-demand opportunities in the tech field.

Our graduate certificate in computing fundamentals (programming, data structures, and algorithms) is a 20-credit hour program to be completed in one year (fall, spring, summer) of full-time study. It is designed to support adult professional learners who want to accelerate their knowledge of computing fundamentals. Our program builds on the experience of bridging Master's programs in CS, such as Northeastern's Align program [3]. Our iCAN program is based on a cohort model. All students take the same courses, and class attendance is required. Through the cohort, students learn from and support one another in their learning. Our iCAN program builds on students' broad set of transferable skills (e.g., problem-solving, creativity, dealing with complexity, focus), the knowledge such individuals bring from their respective fields, and fostering a sense of belonging in the computing field [4].

In the following sections of this experience report, we describe our practice and lessons learned from designing a computing curriculum for college graduates without a CS degree, as well as our holistic admissions evaluation criteria. Afterward, we provide program outcomes, including statistics on student demographics, academic standing, retention, and the next steps for our iCAN graduates. We conclude with a summary and implications of our work.

Description of Practice and Lessons Learned

Computing Curriculum for the iCAN program

Courses in the iCAN program are taught synchronously online through Zoom. Students are expected to attend the designated class times and are encouraged to turn on their cameras if they feel comfortable doing so. Courses are structured as a combination of traditional lecture and flipped classroom models, and students are provided with many opportunities to collaborate in Zoom breakout rooms.

Table 1 below gives an overview of our curriculum.

Semester	**Courses**	**Total credits**
Fall	● Accelerated Programming I (3 credits) ● Accelerated Algorithms I (3 credits) ● Excursions Seminar I (1 credit) *	7 credit hours
Spring	● Accelerated Programming II (3 credits) ● Accelerated Algorithms II (3 credits) ● Excursions Seminar II (1 credit) *	7 credit hours
Summer	● Individual Study (3 credits) * ● Graduate CS Elective (3 credits) *	6 credit hours

Table 1: Curriculum overview of our 20-credit hour graduate program. Courses are listed by semester. Courses marked with an asterisk can be transferred to the Master's programs in CS at the University of Illinois.

Our curriculum prioritizes mentorship, individualized instruction, and collaborative activities from a diverse team of instructors and staff members. The first two semesters comprise core CS courses in programming, data structures, and algorithms designed explicitly for non-computing college graduates. Additionally, during the first two semesters, the curriculum incorporates an innovative excursions component that provides students with breadth in computing by reading and discussing CS research papers, participating in hands-on activities with core computing tools, and engaging with guest speakers in the field. The final semester serves as an off-ramp from the iCAN program. The coursework includes a capstone experience (or individual study) and a graduate-level CS elective. Capstone projects can be research experience, a software development project, or an internship. iCAN students are paired with faculty mentors for the capstone project. Overall, we have had 20 faculty mentors, 5 of whom have home departments

outside of CS in areas such as industrial engineering, information sciences, and linguistics. Several of our faculty mentors have mentored several iCAN students across multiple cohorts.

Regular letter grades are used for all courses. Students must maintain a minimum GPA of 2.75 to be awarded a graduate certificate degree in computing. Student learning objectives are assessed in a variety of ways, including (i) coursework performance, which includes faculty in individual courses monitoring student progress on course material; (ii) early and frequent check-in meetings with students during their first semester, end-of-semester evaluations, and evaluation of student engagement in the cohort-based learning model; and (iii) presentations and mentor feedback on individual study projects.

Our curriculum incorporates substantial reflection in our assignments. In an age where many exercises can be found online, reflection allows us to create assignments that encourage students to think conceptually and reduce the likelihood of them copying and pasting solutions.

As mentioned, we designed the curriculum from scratch to enable college graduates without a computing background to complete it in one year. Students are reluctant to enter a program that will take a long time to complete. Once they join our iCAN program, they are excited about learning, and most pursue a Master's degree in CS after graduating from iCAN. Each semester of the one-year iCAN program is a milestone. The first semester is a time for them to get their footing. The second semester is a challenge, and the third semester is where students pursue their computing interests. Finally, the one-year time commitment to our program and access to many university resources, including federal financial aid and health insurance, means the time and cost structure is less prohibitive.

Holistic Admissions for Non-Traditional Graduate Students in Computing

Our iCAN program in computing fundamentals is designed to increase representation among groups underrepresented in computing—especially those who live at the intersections of discrimination based on gender, race, ethnicity, class, sexuality, and disability. Students from underrepresented groups may not have had access to computing education, which leads to high-tech careers as industry leaders, educators, and researchers. Barriers to accessible computing education include high costs, admissions requirements that disadvantage students without prior coding or math experience, and large class sizes resulting from the high demand for computing education. Our program uses a holistic application process to minimize the barriers to entry into our graduate computing program.

Our graduate admissions process encourages applicants to provide a holistic narrative of their personal and career experiences [5] and is designed to minimize biases typically found in

admissions processes. For that reason, we do not use criteria that are habitually used and not essential for success in our program. For example, we do not require proficiency in math beyond College Algebra, a high GPA, or demonstrated knowledge of computing fundamentals. Instead, we have identified three criteria for success in our program: commitment, time, and metacognition. To determine if a candidate meets our admissions criteria, we review academic transcripts, references, and résumés, and rely heavily on a few short essays.

Below, we explain how we evaluate an applicant's readiness for our graduate iCAN program in terms of commitment, time, and metacognition.

Evaluation Criteria #1: Commitment. Our admission criteria do not require a prior CS background. Instead, we have identified clear goals and commitment from applicants as critical criteria that lead to success in our program. Commitment can manifest in several ways, and we look for all of these in an applicant.

First, students need to have a clear understanding of why they want to pursue a graduate certificate degree in computing fundamentals through the iCAN program. This answer is what keeps them going in the face of challenges from coursework and constraints on their time and finances. Second, students need a clear understanding of the steps they have taken to pursue a transition into computing and how they view our iCAN program as a continuation of that plan. Students who have some knowledge of computing and its challenges are better equipped to anticipate the difficulties they will face in the program, appreciate the supportive structures in the iCAN program, and are more likely to overcome them. Finally, computing is broad, encompassing many skills and applicable to various areas. Students perform better when they prepare ahead of time for their application and understand the topics covered in our curriculum. Students who can demonstrate in an essay that they have considered how these topics align with their goals tend to perform better academically and enjoy their time in the program.

Evaluation Criteria #2: Time. Students can succeed in our iCAN program if they allocate sufficient time for practice outside of lecture time. However, our experience has shown that we cannot assume that students will be able to meet this criterion once they join the program. Unlike traditional-aged full-time undergraduate students who spend dedicated time on campus and are expected to devote their entire time to their studies, adult learners often have competing commitments and significant financial and family obligations.
We have observed that our adult learners struggle not because of the course content, which we have designed to be mastered with no prior computing background, but because of time commitments that are not properly anticipated. For this reason, in our essays, we ask students to elaborate on how the iCAN program will fit into their lives. For example, one of the short answer questions applicants must address is, "Discuss your plans for managing the significant time commitment required to be in the iCAN program, given your obligations such as work, family,

etc. Please be specific in your response." The students who do well in our iCAN program answer this question with great care and detail, to the point of identifying which specific times and days of the week they will dedicate to homework. Additionally, students who have jobs and are forthcoming with their employer about their class schedule before applying tend to succeed.

Evaluation Criteria #3: Metacognition. Our admission criteria do not require a high GPA threshold as a criterion for admission. Instead, we ask the students to address their GPA in an application essay. We ask: "Tell us whether your college grades indicate your ability to be successful in the iCAN program. Please consider addressing challenges, triumphs, life experiences, or lessons learned in your response." Students who have metacognitive skills and can address this question honestly and transparently do well. Examples of ways students have addressed this question in the past include acknowledging that they received poor grades, explaining the detailed reasons for the circumstances that led to the poor performance, and providing lessons learned.

Our program attracts students of all ages, many of whom may not have taken a formal class in years. But the past, no matter how long ago, cannot be ignored. In prior iterations of our admission cycle, when we used a different version of this question and admitted students with inadequate grades (i.e., a significant number of Cs, Ds, and Fs on their transcript), we noticed that applicants who addressed the question by providing underlying causes and lessons learned did well, while those who did not struggled. Regardless of their grades, students can share what they want us to know about their academic performance, and we can better evaluate their potential for success in the iCAN program.

Results and Outcomes

iCAN Program Demographics and Outcomes

Since the iCAN program's inception, we have intentionally recruited students from diverse backgrounds such as college majors, gender, age, and race/ethnicity. Figures 1, 2, and 3 provide detailed enrollment demographics for students in our iCAN program.

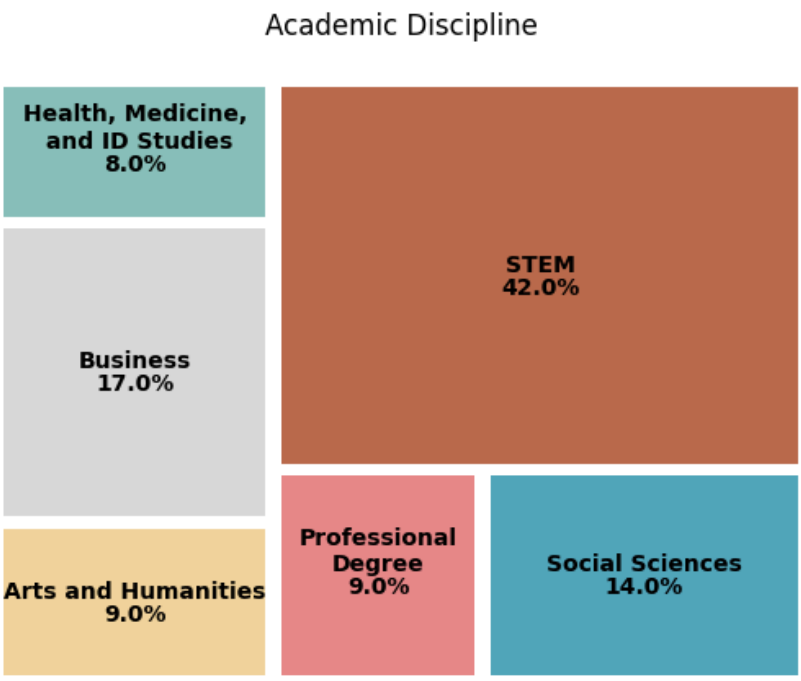

Figure 1: Academic backgrounds of students in the iCAN program (n = 104). Interdisciplinary studies is shortened to ID Studies. Professional degree represents students with degrees in law, for example. In general, iCAN students come from a variety of backgrounds such as accounting, applied physics, civil engineering, art, linguistics, and medicine.

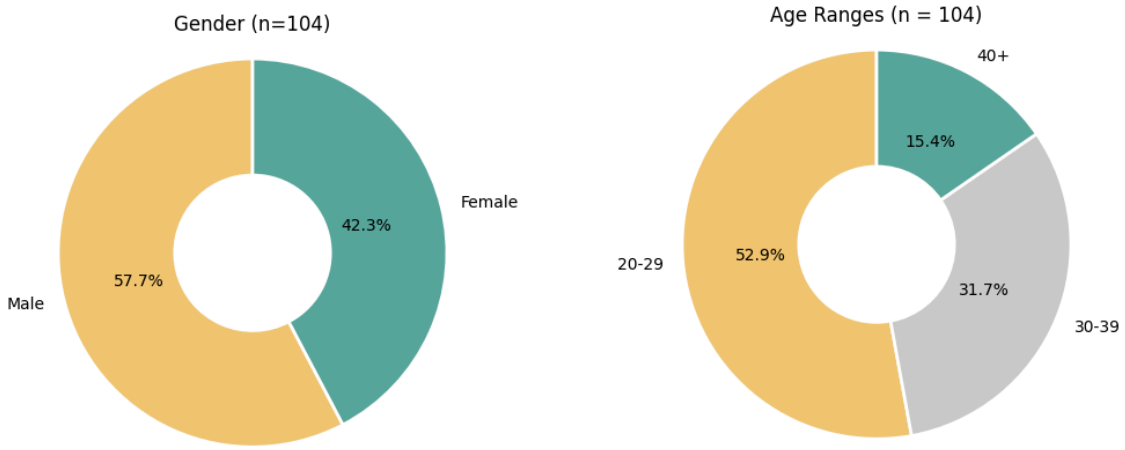

Figure 2: Gender and age ranges of the students in the iCAN program.

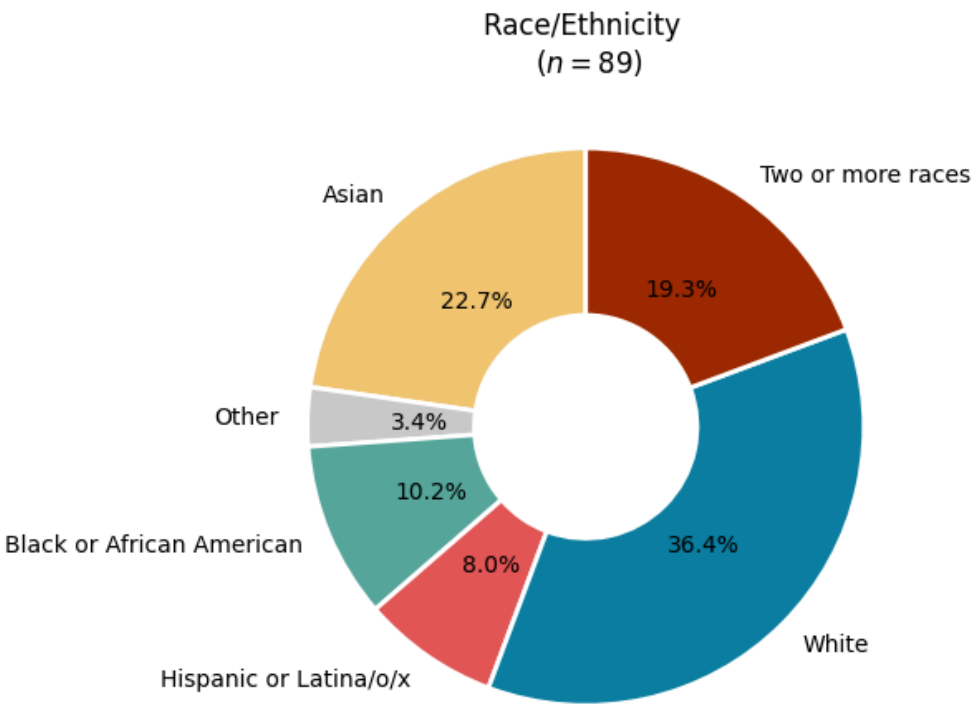

Figure 3: Race/ethnicity of iCAN students. 89 (85.6%) of our students are domestic and 15 (14.4%) are international. For confidentiality protection, Other includes racial categories that are too small to categorize separately.

Our results show that we are proceeding in the right direction regarding our goals to broaden participation in computing. First, our iCAN program is not only attractive to STEM students. 58% of students in our program come from a background other than STEM (Figure 1). Second, 57.7% and 42.3% of students identify as male and female, respectively (Figure 2). Early evidence shows that we are on track for reaching gender parity in our iCAN program. Moreover, students across all lived experiences, as represented by age, are in the program. There is nearly a 50% split between students in their 20s (52.9%) and students that are 30 or older (47.1%), as shown in Figure 2. Third, in our program, some racial groups historically underrepresented in computing, such as Black or African American students, have significant representation compared to CS programs in general (Figure 3).

Figure 4 shows the retention results of our program, where the number of students per cohort is provided in Table 2. Most students stay in the program once they enroll.

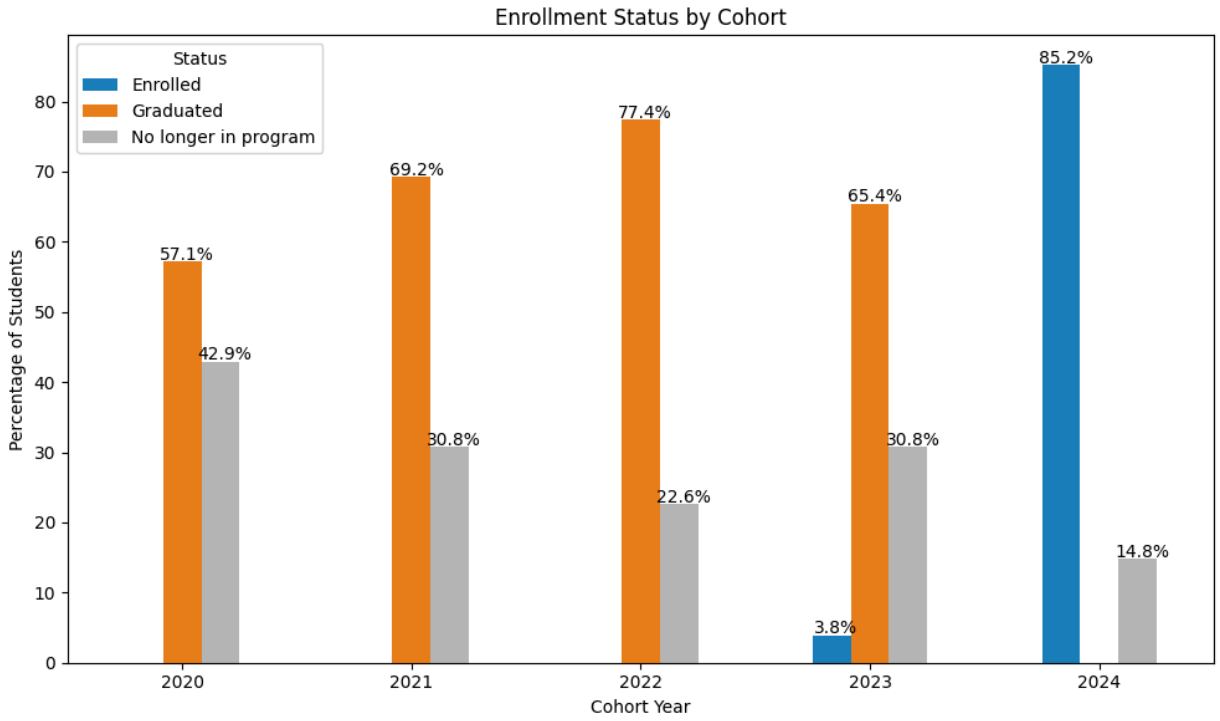

Figure 4. Retention numbers by cohort. “Enrolled" indicates a student is in the program and taking classes but has not graduated. “Graduated” means that the student has completed all program requirements. “No longer in the program” indicates that a student has stopped taking classes or has officially withdrawn. The Fall 2024 cohort is in its second semester and is expected to graduate in August 2025.

2020	2021	2022	2023	2024	Total
7	13	31	26	27	104

Table 2: The number of students in each cohort.

As shown in Figure 4 and Table 2, for the 2020 cohort, seven students started the program, four graduated, and three withdrew. For the 2024 cohort, 23 students (or 85.2%) are enrolled in the program, and they have an expected graduation date of Summer 2025. There was a dip in retention for the 2023 cohort. Based on our observations and in talking with students, some of the students misunderstood the expectations of the iCAN program. In particular, these students did not have time to commit to the program to perform well academically. As mentioned in the previous section on our holistic admissions process, we now have students respond to short answer questions related to the time commitment for being in the program.

Figure 5 shows when students leave the program. Of the 104 students who enrolled in the program, 25 have left. Of these 25 students, most left during their first semester. Once students complete the first semester, they are well on their way to graduating from the iCAN program.

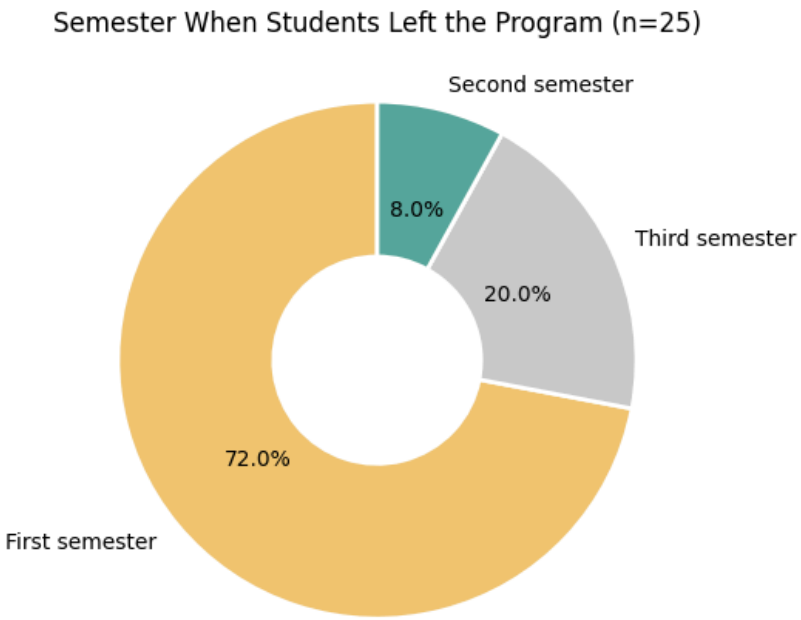

Figure 5. When did students stop making progress in the program? The “First semester” label means that during that time, the student either withdrew from the program, completed their courses but did not return for the second semester, or withdrew from all their classes but did not return after a year to continue the program. The “Second semester” and “Third semester” labels represent similar information in their respective data.

iCAN Program to Master’s in Computer Science

One significant outcome of the iCAN program is that it has been a pathway to a Master's program in Computer Science (MCS). iCAN and related programs are part of the MS Pathways to Computing Consortium [6]. Of our 54 graduates, 45 (83.3%) have applied to our university's non-thesis MCS program, and 93.3% were admitted (see Figure 6).

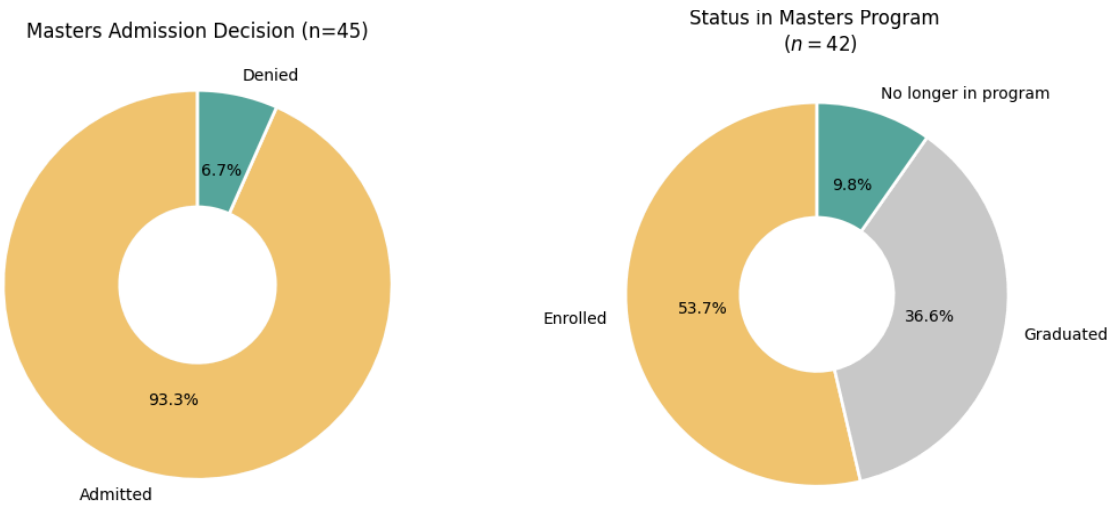

Figure 6. The Master's program status for iCAN graduates. 15 iCAN students have graduated from the MCS, and 21 are currently enrolled.

Figure 6 shows that iCAN graduates are well-prepared to do well in our MCS program. Of particular note is that iCAN graduates in the MCS have a built-in community from their fellow peers. Since many iCAN graduates continue to the MCS, they don't feel isolated and have a solid base to strengthen existing relationships and start new ones. While the iCAN program does not promote or require that students continue to the MCS, most do. The students have enjoyed learning from each other and the material and want to continue learning more. In addition, eight credit hours from the iCAN program transfer to the MCS. So, iCAN graduates have 24 credits remaining of a 32-credit MCS. A few students have completed these 24 credit hours in as few as two semesters, but most have required three or more semesters.

While some students came to the iCAN program with the goal of continuing to the MCS, a few did not continue to the MCS. A lot can happen in adult life, and people's paths and interests can change. The goal of the iCAN program is to welcome individual professional goals and prepare students to be successful in leveraging their computing education.

Summary and Implications

We have created a new innovative one-year graduate certificate degree program in computing for students with a bachelor's (or higher) degree and no background in computing. Our program does not require programming experience or math beyond college algebra. Our holistic application process requires students to respond to short essay questions concerning their motivation, professional goals, time commitment, and prior academic performance. The 20-credit hour curriculum focuses on teaching computing fundamentals and consists of eight classes on

programming, data structures, and algorithms. Our bridging program is entirely online and employs a cohort-based learning model that provides advising and mentorship and expects attendance and reflection. Our program does not teach skills that could be rapidly outdated. Instead, by focusing on fundamentals, our students are empowered to continue to specialize their learning and apply it according to their choice.

Demographics from our five cohorts since inception show that we are proceeding toward our goals to broaden participation in computing. Of our program's 104 students, 42% identify as female, 58% come from an academic field other than STEM, and some racial groups that are historically underrepresented in computing, such as Black or African American students, have significant representation compared to CS programs in general. Agewise, we have a 50% split between students in their 20s and 30 or older.

One of the major outcomes of the iCAN program is that it has been a pathway to a Masters program in Computer Science (MCS). Of our 54 graduates, 45 (83.3%) have applied to the non-thesis MCS program at our university. 93.3% of those who applied were admitted. Of those students, 38% graduated and 53% are still enrolled.

Our most recent outcome is that six iCAN to MCS graduates were admitted to the PhD in CS program at Illinois for Fall 2025. Each of these students had little to no prior experience in computing before they started the iCAN program, and now they are pursuing a PhD in CS. Their research experience began in iCAN during their summer capstone course and continued as they progressed through the MCS. Our iCAN-MCS-PhD students demonstrate that flexible pathways, combined with supportive faculty mentorship, solid computing fundamentals, and student community networks, are essential for broadening participation in computing at all levels of graduate education.

Our work is not without limitations and challenges. While federal financial aid is available, the iCAN program is costly for our one-year program. Our graduates have done well after graduating from our program by pursuing a Master’s degree in CS. Unfortunately, we do not have sufficient opportunities for students who are interested in going into industry or the non-profit sector. As a result, we are missing opportunities to reach an even broader base of students.

Our new graduate certificate in computing fundamentals is the first of its kind in Illinois and from a large Midwestern public university. Our graduate certificate provides a high-quality credential from a top-ranked computer science department. In addition to computing skills, our iCAN program emphasizes skills such as problem-solving, creativity, dealing with complexity, focus, resilience, and adopting a growth mindset to prepare students to shape the future of computing [7] and [8].

Our future work includes continuing to grow the program, providing more industry, non-profit, and research experiences, and providing exposure to AI fundamentals.

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