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Work in Progress: A New Graduate Certificate to Broaden Participation in Computing

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Introduction

At the University of Illinois at Urbana-Champaign, we have created and piloted the iCAN (Illinois Computing Accelerator for Non-specialists) program. iCAN is a new and innovative one-year (fall, spring, summer) online graduate certificate program in computing fundamentals (programming, algorithms, data structures) for students who have a Bachelors (or higher) degree with 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]. Our graduate certificate fills this opportunity gap by leveraging students' unique backgrounds and experiences to broaden the participation of computing professionals.

The U.S. Bureau of Labor Statistics has demonstrated a need for a larger U.S. workforce in computer science. As a result, there has been a rise in coding bootcamps, MOOC certificates, and micro-credentials to gain access to computing. According to the U.S. Bureau of Labor Statistics (BLS) Occupational Outlook Handbook, employment in computer and information technology occupations is projected to grow 11% by 2029, much faster than the average for all occupations. Within computer and information technology occupations, the employment of software developers is projected to grow 22% by 2029 [3]. Although there is a high demand for employees in the computing field, entry into the field is difficult. Our graduate certificate in computing fundamentals attempts to fill this opportunity gap by leveraging students' unique backgrounds and experiences and preparing them for high-demand opportunities in the tech field.

Our graduate certificate in computing fundamentals is a 20-credit hour program to be completed in one year (fall, spring, summer) of full-time study. Our iCAN program builds on the experience of bridging Master's programs in computer science, such as Northeastern's Align program [4]. Our accelerated graduate certificate provides a strong foundation in computing fundamentals (programming, algorithms, and data structures) to post-baccalaureate students without a computing background so that they can enter the computing field. The 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 fosters a sense of belonging in the computing field [5].

An Innovative Curriculum

Initially, the iCAN program was designed to start as an on-campus program in Fall 2020. However, the COVID-19 pandemic required us to change our plans to offer an online graduate computing fundamentals certificate for non-computing college graduates. Our courses are taught synchronously online through Zoom, and students are expected to attend at the designated class times. Students are also 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, where students are provided with significant opportunities to work together in Zoom breakout rooms.

Table 1 below gives an overview of our iCAN graduate certificate curriculum, where up to eight credit hours can be transferred to the Master's or Ph.D. graduate programs in computer science (CS) at the University of Illinois at Urbana-Champaign.

Semester	**Courses**	**Total credits**
Fall (Bridging phase)	● CS 400: Accelerated Fundamentals in Computing I (3 credits) ● CS 401: Accelerated Fundamentals in Algorithms I (3 credits) ● CS 491: Seminar: Excursions in Computing I (1 credit) *	7 credit hours
Spring (Bridging phase)	● CS 402: Accelerated Fundamentals in Computing II (3 credits) ● CS 403: Accelerated Fundamentals in Algorithms II (3 credits) ● CS 491: Seminar: Excursions in Computing II (1 credit) *	7 credit hours
Summer (Transition phase)	● CS 597: 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 or Ph.D. graduate programs in CS at our university.

Our curriculum prioritizes mentorship and individualized instruction from a diverse team of instructors and staff members. The first two semesters represent the *bridging phase*, consisting of core computer science courses in programming, data structures, and algorithms. All courses in the bridge curriculum are new and have been designed specifically for non-computing college

graduates. The bridging curriculum incorporates group activities across all courses so that students practice the value of working collaboratively. The bridge does not include any elective courses. The bridge also 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 begins the *transition phase*, which also serves as an off-ramp from the iCAN program. The coursework consists of an individual study (a capstone experience focused on industry, research, or entrepreneurship) and a graduate-level CS elective. The transition phase connects program participants to the network and resources they need to succeed in the computing industry or academia.

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 fundamentals. Students who graduate from our program will receive a notation on their transcript (Graduate Certificate in Computing Fundamentals) and a Certificate Diploma.

The curriculum is designed such that students can achieve the high-level learning outcomes given below.

- Exhibit proficiency in the design, implementation, and testing of software.
- Demonstrate skills and experience working in small teams in order to solve problems; design, implement, and test code; and learn from one another.
- Apply algorithmic and theoretical computer science principles to solve computing problems from a variety of application areas.
- Demonstrate the ability to learn and develop competencies in specialized or emerging computer science fields.
- Demonstrate the ability to read, analyze, and discuss research papers in computer science.

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.

Holistic Graduate Admissions

Our graduate admissions process encourages applicants to provide a holistic narrative of their personal and career experiences [6]. The criteria for admissions rely upon academic transcripts, references, résumé, short essays, and a 30-minute virtual interview.

Our holistic application process is designed to eliminate biases typically found in admissions processes. Applicants write short essays related to their computing goals, backgrounds and experiences, and time commitment to the program. Our admissions goal is to take into consideration the students' full experience, including their academic history, work experience, and how our program could support their plans to broaden participation in computing. Application interviews allow students to determine if our program is a good fit for their goals, learn about our commitment to equity, and see themselves reflected in the program's students, faculty, and staff. During the interview, there is also time to talk about any questions or concerns the applicant may have.

Broadening Participation in Computing

The iCAN program is designed to increase groups underrepresented in computing—especially those who live within 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 that leads to high-tech careers as industry leaders, educators, and researchers. Barriers to an accessible computing education include high costs, admissions requirements that disadvantage students who do not have prior coding or math experience, and large class sizes due to the high demand for computing education. Our program is specifically designed for students without prior coding experience and uses a holistic application process. In addition to computing skills, the proposed program focuses on skills like problem-solving, creativity, dealing with complexity, focus, resilience, and having a growth mindset to prepare students to shape the future stories of computing [7] and [8]. Access to university resources such as federal financial aid and health care will allow students to progress through the accelerated path provided by the program successfully.

Finally, for iCAN students, the one-year time commitment and access to a multitude of university resources (including federal financial aid and health insurance) mean that the time and cost structure is less prohibitive and hence more accessible than other pathway programs. Some of our students have chosen to live within driving distance of our university to take advantage of on-campus resources. However, the availability of our program online allows students to pursue a graduate certificate in computing fundamentals even if life circumstances prevent them from moving on-campus.

Enrollment Demographics and Outcomes

Since the program's inception, we have been very intentional about recruiting students from diverse backgrounds such as college majors, gender, age, and race/ethnicity. Our early results show that we are proceeding in the right direction regarding our diversity, equity, and inclusion goals to broaden participation in computer science. Tables 1 and 2 provide detailed enrollment demographics for our two cohorts starting in Fall 2020 and Fall 2021, respectively.

College Major	STEM (3)	non-STEM (4)
Gender	Female (4)	Male (3)
Age	20s (3)	30s-50s (3)

Table 1: Program demographics for the seven students in the Fall 2020 cohort by college major, gender, and age. A value in parentheses represents the number of students for a given category. Students come from STEM and non-STEM backgrounds such as accounting, applied physics, civil engineering, mathematics education, and philosophy. The race/ethnicity of the five domestic students is Asian, Black/African-American, and White.

College Major	STEM (8)	non-STEM (6)
Gender	Female (7)	Male (7)
Age	20s (7)	30s-50s (7)
US Race/Ethnicity	White (5)	Asian, Black/African American, Hispanic/Latinx (8)

Table 2: Program demographics for the 14 students in the Fall 2021 cohort by college major, gender, age, and race/ethnicity of US citizens. A value in parentheses represents the number of students for a given category. Students come from STEM and non-STEM backgrounds such as accounting, art education, biology, business administration, civil engineering, hospitality and tourism management, linguistics, management information systems, and medicine.

Table 3 below shows the retention results of our program.

Cohort	**Still enrolled**	**Graduated**	**Withdrew**
Fall 2020	1	4	2
Fall 2021	10	0	4

Table 3: Retention numbers by cohort. “Still enrolled" indicates the number of students still in the program and taking classes but has not graduated. “Graduated” denotes the number of students who have completed the 20-credit hour graduate certificate program. “Withdrew” signifies the number of students who have formally withdrawn from the program. The Fall 2021 cohort is now in their third semester with an expected graduation date of Summer 2022.

Our preliminary results show that most students stay in the program once they enroll. For the Fall 2020 cohort, seven students started the program, two withdrew after completing the first semester, and four graduated. For the Fall 2021 cohort, 14 students began the program. Four students withdrew from the program by the end of the first semester. Ten students from this cohort have completed their second semester (Spring 2022) of the program, and they have an expected graduation date of Summer 2022.

Overall, our retention results are promising. Our results also indicate that the first semester is the biggest hurdle for students in our program. Once students complete the first semester, our early results show that they are well on their way to graduating from our program. Such observations align with retention rates for Northeastern's Align program [4].

Finally, four students from the Fall 2020 cohort have graduated and have continued to pursue a full Master's degree in computer science. Two students are matriculating Master's students; one student graduated with a Master's in Computer Science in May 2022, and one will graduate from the iCAN program in summer 2022. One of our graduates has also started full-time employment as a software consultant. Although these students had little to no prior experience in computing, they have made a smooth transition into graduate school and secured full-time employment in the tech industry.

Summary

Our iCAN program is the first of its kind in the state of Illinois from a large public university. Our graduate certificate in computing fundamentals provides a high-quality credential from a leading computer science department. Graduates of our program are prepared to pursue tech careers in industry or pursue a full graduate degree in computer science. Thus, our program brings together non-computing college graduates from diverse areas of expertise and backgrounds in an accelerated graduate certificate program that broadens participation in computing.

References

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