Reforming Discrete Mathematics: a Gateway for Inclusive CS Education

Velibor Adzic, Florida Atlantic University
Dr. Hanqi Zhuang, Florida Atlantic University

Dr. Hanqi Zhuang is a professor in Department of Computer and Electrical Engineering and Computer Science at Florida Atlantic University. His research interests are in Robotics, Computer Vision, and their applications, as well as Engineering Education.

Hari Kalva, Florida Atlantic University
Dr. Nancy Romance, Florida Atlantic University

Dr. Romance is Professor of Science Education in the College of Education at Florida Atlantic University (FAU) and a graduate faculty member in both the College of Engineering and Computer Science and the College of Science at FAU.Her research interests a

Reforming Discrete Mathematics
A Gateway for Inclusive CS Education

Velibor Adzic, Hari Kalva, Nancy Romance, and Hanqi Zhuang

FLORIDA ATLANTIC UNIVERSITY
College of Engineering and Computer Science

ABSTRACT

Discrete Mathematics is a foundational gateway course in the Computer Science curriculum, yet it has historically posed a significant barrier to student progression. When taught primarily from a theoretical perspective, the course exhibited low student engagement and a DWF (Drop–Withdraw–Fail) rate of approximately 30%. To address this challenge, Computer Science faculty redesigned the course to emphasize computing relevance and active learning. The reformed curriculum integrates practical tools such as Python, Git, and LaTeX, and combines large-enrollment lectures with small, collaborative problem-solving laboratories. Following implementation, the DWF rate dropped below 10%, with notable improvements in student engagement and retention. This work presents the motivation, design, and outcomes of the reform, positioning Discrete Mathematics as a more inclusive and effective gateway to Computer Science education.

BACKGROUND

Traditionally, Discrete Mathematics has been taught with strong mathematical rigor but limited connection to computing practice. This disconnect often leads to reduced motivation, lower engagement, and poor course outcomes, especially in large-enrollment settings with limited opportunities for active learning.

At our institution, these challenges were reflected in a historical DWF rate of approximately 30% in the traditional Discrete Mathematics course, effectively closing the pathway to CS and CE degrees for many students. This pattern motivated a comprehensive course redesign aligned with national efforts to improve retention, inclusivity, and degree completion in CS.

OBJECTIVES

This research aims to:

1. **Design and implement** a computing-integrated alternative to the traditional Discrete Mathematics course aligning core mathematics topics with practical computing applications.
2. **Compare** student outcomes between the traditional Discrete Mathematics course (MAD 2104) and the redesigned course (COT 2000C), with a focus on DWF rates and course completion.
3. **Assess** the impact of computing-based laboratories on student engagement, problem-solving skills, and readiness for subsequent CS/CE coursework.
4. **Evaluate** the role of the redesigned course in reducing barriers to progression and improving retention in CS and CE degree pathways.

RESULTS

Year	2022-2023			2023-2024			2024-2025		
College	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN
Engineering and Computer Science	174	44	25.3%	262	23	8.8%	413	37	9.0%
Total	**174**	**44**	**25.3%**	**262**	**23**	**8.8%**	**413**	**37**	**9.0%**

Year	2020-2021			2021-2022			2022-2023			2023-2024			2024-2025		
College	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN	Grade Count	DFWN	%DFWN
Honors College	10	1	10.0%	14	2	14.3%	19	3	15.8%	20	7	35.0%	26	5	19.2%
Science	179	42	23.5%	141	47	33.3%	143	57	39.9%	23	7	30.4%	25	17	68.0%
Total	**189**	**43**	**22.8%**	**155**	**49**	**31.6%**	**162**	**60**	**37.0%**	**43**	**14**	**32.6%**	**51**	**22**	**43.1%**

An important measure of course effectiveness is the DWF rate. The results of the course reform have been substantial: the DWF rate for the redesigned course fell below 10%, accompanied by marked improvements in student engagement and retention. This paper presents the rationale, implementation, and outcomes of the reform, highlighting Discrete Mathematics as a gateway for inclusive and effective CS education.

Enrollment data for MAD 2104, shown in Table 1, include separate honors and regular sections each semester. Following the full launch of COT 2000C in the 2023–2024 academic year, enrollment in MAD 2104 decreased significantly as students transitioned to the redesigned course. For regular sections of MAD 2104, the DWF rates were 32% in 2023–2024 and 43% in 2024–2025. In contrast, during the same period, the DWF rate for COT 2000C remained approximately 9%. Given that this course serves as a gateway for all CS and CE students, the absence of COT 2000C would likely have resulted in the loss of more than 100 students—over one quarter of the cohort—from CS/CE degree pathways.

RESEARCH DESIGN/PROGRAM DESCRIPTION

A central design principle was to teach discrete mathematics concepts alongside their applications in computer science through structured laboratory experiences. Next, we compare the topics offered by MAD 2104 and COT 2000C. As shown, the two courses cover nearly identical core topics; however, COT 2000C includes additional laboratory components, which make a significant difference in student learning outcomes.

MAD 2104 Course Description:	**COT 2000C Course Description:**	
A proof-oriented approach to propositional logic, sets, functions, relations, combinatorics, graphs, and trees.	An introductory computing course covering foundational CS concepts and common software development tools while reinforcing discrete mathematics topics.	
TOPICS	**TOPICS**	**LAB Components**
❑ Logic and Proofs	❑ Set Theory	❑ Ubuntu & Virtual Machine (VMware / WSL)
❑ Sets, Relations, and Functions	❑ Combinatorics	❑ LaTeX Fundamentals (Overleaf)
❑ Induction and Recursion	❑ Logic	❑ Bash Terminal and Shell Scripting
❑ Combinatorics	❑ Mathematical Proofs and Induction	❑ Python Environments (Anaconda & Jupyter)
❑ Graph Theory	❑ Matrix Algebra	❑ Sets, Combinatorics, and Logic with Python
❑ Boolean Algebra	❑ Relations and Functions	❑ Version Control (GitLab & GitHub)
❑ Algorithms and Number Theory	❑ Recursion and Recurrence Relation	❑ Matrix Operations with Python
	❑ Graph Theory and Trees	❑ Visual Studio Code
		❑ Functions with Python
		❑ Sequences and Data Structures with Python
		❑ Graphs and Trees with Python

CONCLUSIONS

Reforming Discrete Mathematics to emphasize computing relevance and active learning significantly reduced barriers to student success in CS and CE programs. By integrating hands-on laboratories, modern computational tools, and collaborative problem-solving into a mathematically rigorous curriculum, the redesigned course reduced DWF rates from approximately 30% to below 10%.

These outcomes demonstrate improved engagement, persistence, and readiness for advanced CS coursework. The results suggest that computing-integrated gateway courses can serve as effective, inclusive models for improving retention and equity in Computer Science education.

This research is partially supported by a grant from Northeastern University's Center for Inclusive Computing and by the NSF S-STEM program under Grant No. 2030854.