Does ABET Accreditation Influence the Representation of Women in CS Programs?

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This paper is an extended version of the two page abstract accepted for a poster session at SIGCSE 2025.[1]

Abstract

Curricular analytics can help researchers in computer science (CS) education understand the structural barriers preventing students from discovering and completing the major, especially those underrepresented in tech. Prior research has found an inverse relationship between curricular complexity and percent of CS graduates who identify as women. This study expands upon previous research by focusing specifically on ABET accredited curriculum with respect to complexity and the representation of women. We created curricular maps for 40 ABET and 40 non-ABET programs. Initial findings show that non-ABET programs, on average, have a higher degree of representation of women (33% compared to 21%). Further, the average complexity score for ABET accredited programs is 219, where as non-ABET programs is 133. This paper discusses the use of curricular analytics, our preliminary findings, and further questions to be addressed as part of this work.

1 Introduction

Research in computer science (CS) education aims to understand the barriers preventing students from discovering and completing the major. When curricular requirements enforce a rigid sequencing of courses through pre- and co-requisites, students may be at risk of a delay in graduating or leaving school altogether if they fail to complete course prerequisites. This can be especially true in the strict progressive curriculum often seen in undergraduate CS programs.

Heileman et al. [6] developed a framework for quantifying the structure of a curriculum. In their framework, a curriculum is represented as a directed, acyclic graph, where each vertex is a course and the edges connect courses in sequential order in which they must be taken. From this graph we can calculate 1) the blocking factor, the extent to which a course prevents a student from taking other courses, and 2) the delay factor, delay to completion of the major imposed by the prerequisite chain. A course's structural complexity is an unweighted linear combination of these two metrics, and the overall complexity is the sum of all course complexities. More complicated prerequisite chains lead to higher complexity.

Having a quantifiable way in which to understand curricular design allows researchers to compare curricula structures across programs. These metrics help us understand how course requirements and pre-requisite structures differ, and how those differences impact student outcomes. Lionelle et al. [7] investigated the impact of curricular complexity on the representation of women in the graduates of 4-year bachelor CS degree programs. They found that the percentage of women graduating from CS programs was inversely correlated with the program's curricular complexity.

This study investigates the relationship between ABET accreditation, and the representation of women within 4-year undergraduate CS programs. The two main questions addressed are: 1) How does ABET affect representation of women and 2) What is the impact of ABET on curricular complexity.

2 Background

2.1 Curricular Analytics

Based on Heileman et al. [6], the structural factors of a curriculum can be represented as a directed, acyclic graph. Each vertex represents a course, and the edges represent the prerequisite structure of the curriculum. Three important metrics used in curricular analytics (delay factor, blocking factor, and structural complexity) can be derived from these graphs. Figure 1 illustrates a sample curricular map of the CS requirements of Northeastern University.

Delay Factor: In many STEM curriculum, courses have a prerequisite structure that needs to be completed in a specific order. Failure to complete a course in the sequence can delay students' time to graduation since the remainder of the sequence is delayed by one term. More formally, the delay factor for a given course is the number of course vertices in the longest path in the curriculum graph that passes through that vertex. For example, in Figure 1, Fundamentals of Computer Science I has a delay factor of five. The longest path which includes that course contains four additional courses. The overall curriculum delay factor is the sum of the delay factor for each vertex.

Blocking Factor: Blocking factor measures the extent to which a course prevents a student from taking subsequent courses. The blocking factor for a course increases as the number of subsequent courses needing that course as a prerequisites increases. Therefore, the blocking factor measures the number of courses reachable from given course vertex. As seen in Figure 1, Fundamentals of Computer Science I has a blocking factor of 16. For 16 courses in the curriculum,

[1]SIGCSE2025 Poster and 2-page submission available at https://github.com/NeuCurricularAnalytics/papers

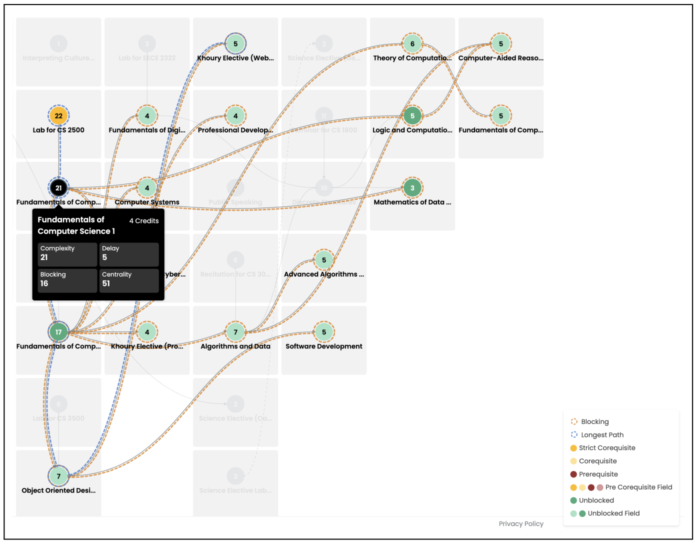

Figure 1: Sample degree map of NEU CS program created via curricularanalytics.org

Fundamentals of Computer Science I is in the prerequisite chain. The overall curriculum blocking factor is the sum of the blocking factor for each vertex.

Structural Complexity: For an individual course, structural complexity is the unweighted linear combination of the course's blocking factor and delay factor. In Figure 1, the complexity of the Fundamentals of Computer Science I is 21, the sum of a blocking factor of 5 and a delay factor of 16. A curriculum's structural complexity is an unweighted linear combination of the curriculum's overall blocking factor and overall delay factor.

2.1.1 ABET Requirements

For this study, we were interested in the representation of women and complexities for a particular set of curriculum. Founded in 1932, Accreditation Board for Engineering and Technology (ABET) is non-profit organization who certifies engineering and technology college programs. For CS, ABET's Computing Accreditation Commission puts forth guidelines that schools must follow. The 2024-2025 ABET CAC accreditation requirements state that curriculum must consist of 40 credit hours (or equivalent) of computing instruction and include the below topics.[2]

- Substantial coverage of algorithms and complexity, computer science theory, concepts of programming languages, and software development.
- Substantial coverage of at least one general-purpose programming language.
- Exposure to computer architecture and organization, information management, networking and communication, operating systems, and parallel and distributed computing.
- The study of computing-based systems at varying levels of abstraction.
- A major project that requires integration and application of knowledge and skills acquired in earlier course work.

In addition, students must have at least 15 semester credit hours (or equivalent) of math at the rigor of introductory calculus or higher and include discrete math, probability, and statistics. A science component is also required with coursework that uses the scientific method in a non-computing area.

3 Methods

To understand the impact of ABET, we compared 40 ABET and 40 non-ABET programs. ABET programs were determined based on the list of ABET accredited CS programs from abet.org on February 24, 2024 [3]. Schools were selected based on data collected from the National Center for Education Statistics' Integrated Postsecondary Education Data System (IPEDS) [5]. We selected our sample of schools as follows:

- Identified all 4-year degree-granting schools which had three years of IPEDS completion data for CS CIP-codes (11.0701 and 11.0101), from the 2020-2022 datasets.
- Filtered for schools that graduated at least a total of 150 students in CS in the three year period.
- To ensure consistency, technical schools, online schools, and ABET schools with multiple degree options were removed.
- Qualifying schools were split into two groups, ABET and non-ABET, and each group sorted by percent of CS graduates who identify as women based on IPEDS demographic data. Following the methodology used in Lionelle et al. [7], we normalized the representation of women CS graduates relative to the university population overall and scaled that ratio to the theoretical 50/50 gender split using Equation 1.
- For both the ABET and non-ABET programs, the 20 schools with the highest percent women CS graduates ("top") and the 20 schools with the lowest percent women CS graduates ("bottom") were selected. This allowed us to compare the best programs in terms of percentage of women and evaluate against the programs with lowest percentage of women.

$$\frac{\textit{Percent Women CS Graduates}}{\textit{Percent Women Graduates Overall}} = \frac{x}{50\%} \qquad (1)$$

We created degree maps for each of the 80 programs from publicly available plans of study accessed from the Universities' websites. For non-ABET programs with multiple degree options, BS degrees were mapped. Degree maps contained all required courses for the CS major and general education courses required by the university for graduation. For CS elective requirements, a course was selected with the least number of prerequisites, biasing the degree maps toward lower complexity. We used curricularanalytics.org [1] to generate the degree maps and calculate the complexity scores.

4 Results

The distributions of the percentage of women CS graduates give insights on the impact of ABET curricula on the representation of women. Figure 2 illustrates the distribution of percentage of women CS graduates for the four groups of

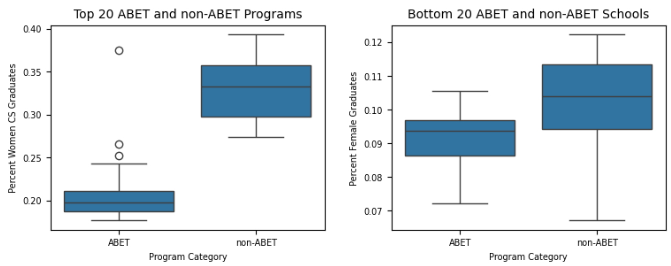

Figure 2: Distribution of percent of women graduates from the "top" (left) and "bottom" (right) 20 ABET and non-ABET CS programs.

programs. Differences in distributions for the "top" ABET and non-ABET programs were significant (p < .001) using a two sample t-test. On average, for the "top" programs, 33% of students graduating with a CS major from non-ABET programs were women, whereas for ABET programs, 21% were women. This difference in distribution is not seen in the "bottom" schools. For these schools, the non-ABET group had larger variability than ABET with some programs performing better than the ABET schools overall and some programs performing worse.

Looking at the distributions of curricular complexity for the four groups in Figure 3, the curriculum of ABET programs on average is more complex than the non-ABET schools. Differences for "top" and "bottom" groups were significant (p < .01) using a two sample t-test. This is especially true for the "top" schools where the average complexity for ABET and non-ABET is 225 and 108 respectively.

The complexities for ABET schools are at least 150. In figure 4, only a few ABET programs fall below 150, all of which have minimal math prerequisites for CS coursework. Further, there is an inverse relationship between complexity and representation of women, especially for "top" programs (right graph in figure 4). Programs with lower complexities have higher percentage of women. The inverse relationship between complexity and representation of women was also found in previous research by Lionelle et al. [7], confirming their findings. From these results, we wonder if ABET requirements unintentionally impose a systemic barrier (and/or an interpretation of the requirements) that reduces the representation of women.

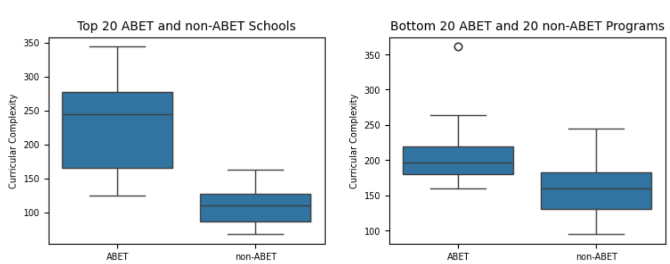

Figure 3: Distribution of curricular complexity from the "top" (left) and "bottom" (right) 20 ABET and non-ABET CS programs.

5 Discussion and Future Work

While the preliminary results of the study provide insight into the impact of ABET accredited curriculum on complexity and representation of women, the study does not address why ABET accredited curriculum tend to have higher complexity. A further deep dive into the implementation of accreditation requirements is needed. The ABET accreditation requirements specify the number of credits students should receive and the topics that should be covered in coursework, however, requirements do not specify specific courses within a curriculum, giving programs flexibility in implementation.

We suspect that some of the increased complexity in ABET accredited programs can be attributed to the math course requirements. While specific courses are not required for accreditation, the coursework for ABET accredited programs tend to require more math courses than non-ABET programs. We also know that calculus tends to be a prerequisite course for discrete structures (which is then a prerequisite for subsequent CS course)[4]. Whether or not math requirements are more likely to be prerequisites for early CS coursework in ABET vs non-ABET programs still needs to be determined.

Further, for the schools in our sample, the majority of the ABET accredited programs were located within the School of Engineering, while the non-ABET programs varied more in the academic school that contained CS. This brings up the question of whether ABET is driving our results or if the results are a function of the school containing the CS program. Programs in Schools of Engineering may naturally have more complex curriculum due to general education requirements for the school. Current follow-up research is being conducted to look at the impact of academic school placement on curricular complexity and representation of women. Following this research, we can further parse apart the effects of ABET accreditation and academic school placement on curricular complexity and representation of women.

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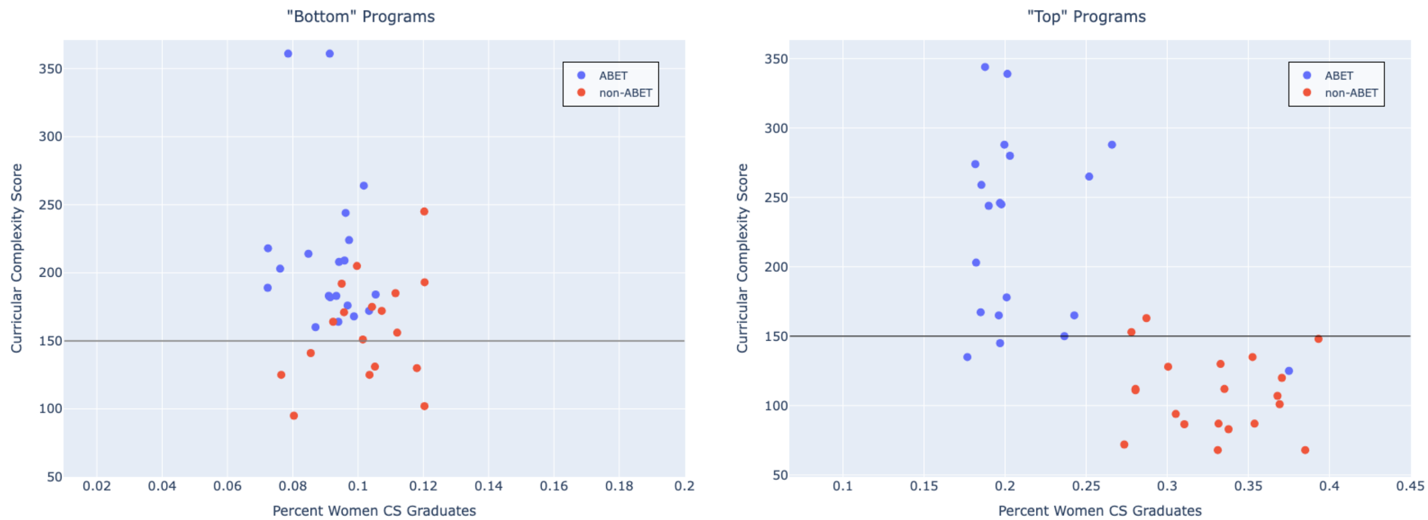

Figure 4: Complexities and percentage of women graduates for ”bottom” (left) and ”top” (right) CS programs, comparing ABET and non-ABET accreditation.

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