INVESTIGATING THE GENDER GAP IN UNDERGRADUATE COMPUTER SCIENCE PROGRAMS

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In Partial Fulfillment of the Requirements for the Degree
Bachelor of Science in Computer Science

By

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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WOMEN MAKE UP ⅕ OF UNDERGRADUATE CS PROGRAMS

Since 1990, while other STEM fields saw an increasing proportion of female workers, computing saw a decrease (Martinez & Christnacht, 2021, p. 1). Men outweigh women at an astounding 3:1 ratio at both large corporations like Google or respected Computer Science (CS) programs like the University of Virginia (Google, 2018, p. 8; Mather, 2019, para. 3). Organizations like Girls Who Code, Black Girls Code (2021), and Kode With Klossy (2019) work at different levels to immediately empower these young women to pursue potential careers in technology.

The technical paper seeks to study the effect of a professional development course on undergraduate CS students at the University of Virginia, taking into account demographic data such as gender. At the University of Virginia, the ratio of males to females in a computer science classroom is seven to three, but the university still ranks sixth out of 252 in the nation for women pursuing an undergraduate degree (Mather, 2019, para. 3). The professional development course described in the technical paper, designed and taught by two professors and a team of five undergraduate students, focuses on increasing the self-efficacy of students in the technical field. While this course was conducted with small class size, the course can be replicated for future studies. The STS paper elucidates the different factors that specifically affect young women in undergraduate programs. Employing the Actor-Network Theory (ANT), this paper analyzes the various relationships that young women in undergraduate CS programs hold with various agents such as their self-confidence or treatment by potential employers. Actor-Network Theory was first formulated by Michel Callon, Bruno Latour, and John Law in the early 1980s. Latour (1996) described the two main aspects of this framework are that there are actors and actants, persons, or things that affect the network, and a network, a transient system that shows the

interconnectivity of each of these different pieces. An understanding of these connections allows for ideation of how to improve the system as a whole.With the union of both the technical and STS paper, possible solutions can be theorized and ideated for future implementations. Though application may be out of this paper's scope, understanding the root cause of the lack of gender diversification in technology will highlight the need for effective systematic change in the future.

LACK OF GENDER DIVERSIFICATION IN TECHNOLOGY HIGHER EDUCATION

The computer workforce lacks gender diversity, whether it is when students pursue a degree or enter their first jobs. Though it is financially beneficial for companies to diversify their workforce and different organizations are doing their best to retain women in computer science (CS), we still only see a quarter of computer workers being women (Sayed, 2021, para. 3; Martinez & Christnacht, 2021, p. 1). At the University of Virginia, the ratio of males to females in a computer science classroom is seven to three and ranks sixth out of 252 in the nation for women pursuing an undergraduate degree. Women make up half the population in the United States yet are only 18 percent of students pursuing a computer science degree nationwide (Mather, 2019, para. 3). Martinez and Christnacht (2021) note that since 1990, the proportion of female computer workers has been decreasing, as seen in Figure 1.

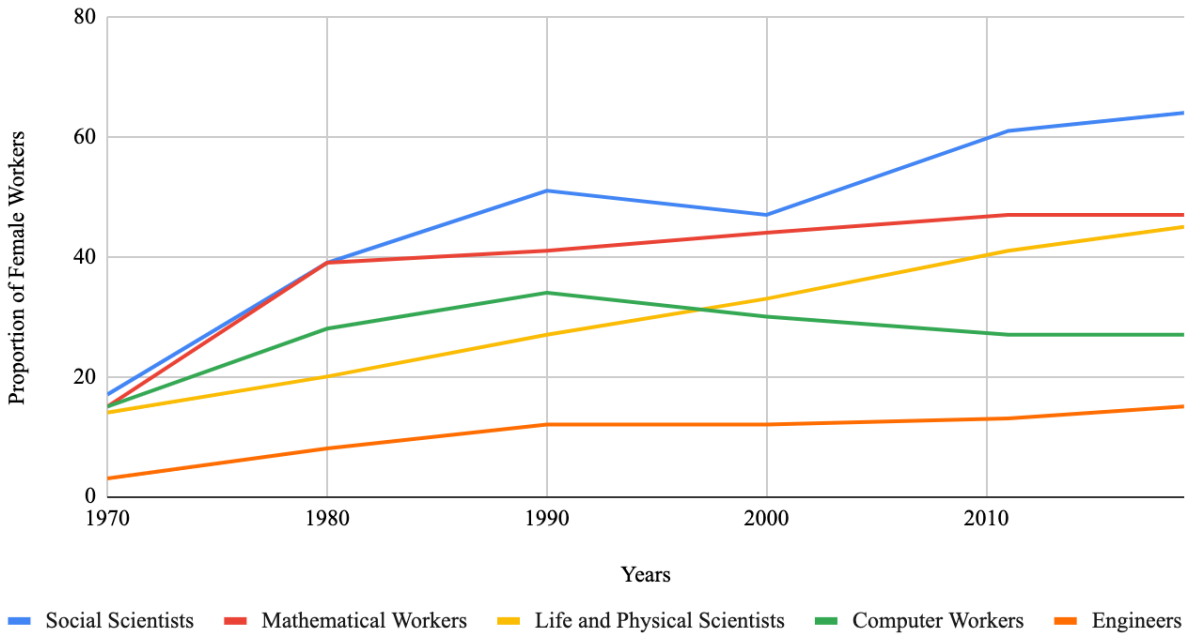

Figure 1: Proportion of women in STEM fields from 1970 to 2019. This figure visualizes the growing proportion in STEM fields, aside from computer workers, (adapted by Mara Hart (2021) from Martinez & Christnacht, 2021).

To remedy the issue of gender homogeneity in the technology field, organizations like Black Girls Code (2021) and Kode With Klossy (2019) focus on encouraging technical skill developments for girls aged 13-18. This early intervention is meant to inspire young women before they reach the undergraduate level. On the other side of undergraduate education, the hiring field is only marginally more diverse. Looking at the environment that undergraduate students enter after their studies, large companies like Google (2018), only 24.5% of 2017 tech hires were female, as shown in Figure 2 on page 4 (pp. 7-8). Though studies show companies with more diversity are "more likely to have financial returns above their national industry medians," we still see the disparity between women and men (Hunt et. al, 2015 as cited in Sayed, 2021, para. 3).

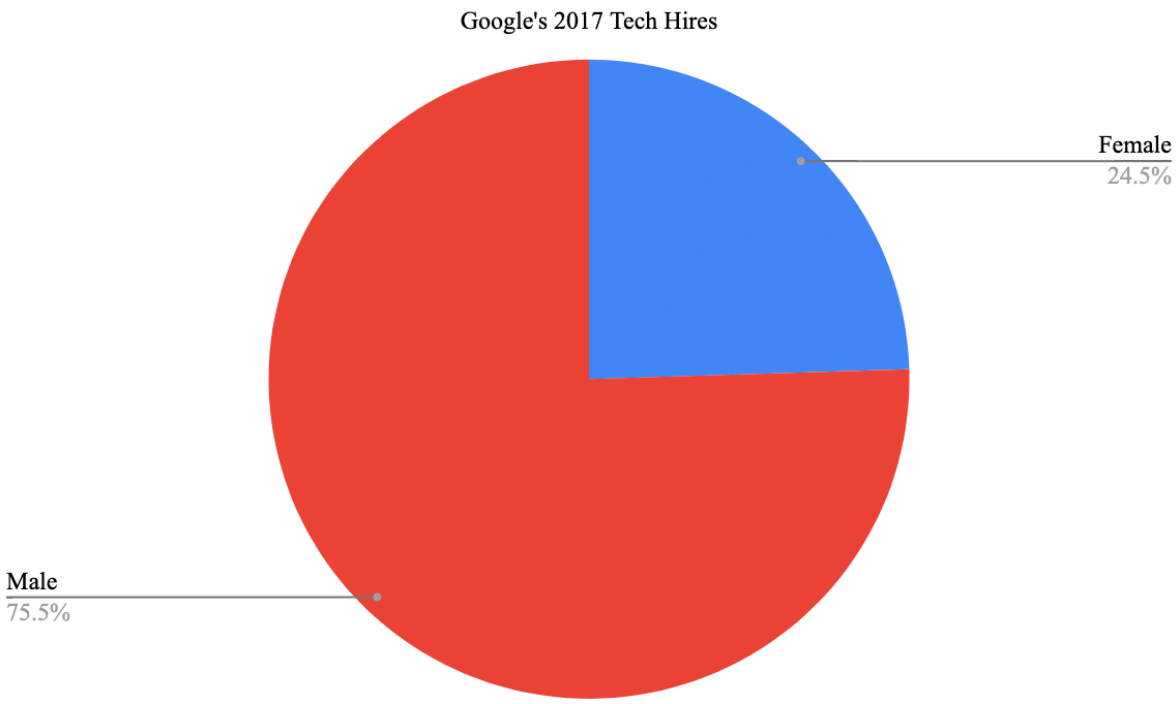

Figure 2: Google's 2017 tech hires by gender. This figure visualizes that only 24.5% of all 2017 tech hires were female, a ratio of 3 men to 1 woman, (adapted by Mara Hart (2021) from Google, 2018).

UNCERTAINTY OF ROOT CAUSE

When looking at the gender diversity in undergraduate computer science programs, it is important to conceptualize young women's upbringings. This means that the root cause is not always centered on just what happens in one's college career, but the opportunities surrounding it. Whether the root cause is due to their exposure to the topic before undergraduate studies or the job prospects after graduation, young women have historically shied away from the field.

When looking at pre-undergraduate exposure, Wadley (2012) found young girls perceive that femininity in STEM is unachievable (para. 10). Eidelman (2011) found that a 2-hour visit to a Google office would have an immediate effect on high school girls' interest in computer science, citing a possible reason is due to the appearance of female role models in the industry

(p. 70). However, once female students finish their undergraduate degree, they are faced with a series of obstacles, like lack of pay or a barrier of stereotypes. Coinbase, a popular start-up, underpaid their female employees by $13,000 dollars (Popper, 2021 as cited in Sayed, 2021, para. 6). Aside from financial compensation, women were found to be more interested in computing science after reading a doctored newspaper article created by the study that stated that the industry is breaking out of its stereotypes (Cheryan et al., 2013 from Khan and Luxton-Reilly, 2016, p. 2). The stereotypes in computer science are technology-oriented, intelligent, masculine, lacking interpersonal skills, singularly focused on computers. Women are less likely to pursue computer science when interacting with a classroom or peer that embodies these stereotypes (Cheryan et. al, 2013, p. 10).

WHY ARE NOT MORE WOMEN STUDYING CS IN COLLEGE?

This research aims to shed light on the multifaceted issue of gender inclusion in the classroom. While many reasons have been hypothesized - lack of interest or lack of skill-there has been no pinpointed reason or systematic improvement to increase this diversity. By analyzing the different systems that are in place to inspire all genders studying computer science, administrators, faculty, and students will see what has proven to work. Therefore, the research question remains: how can administration, faculty, and students improve the current educational system to encourage more gender diversity in computer science departments in universities nationwide?

RESTRUCTURE OF PROGRAM AND EARLIER INTRODUCTION

To improve retention rates and increase gender diversity in computer science higher education, systems must be restructured to focus on inclusion and conceptualization while also encouraging students, especially female students, to explore computer science at an early age.

Research has shown that stereotype breaking whether in the industry or the classroom correlates with increased female interest. One can see in Figure 3 that undergraduate women face barriers like lack of experience, inaccurate stereotypes, lack of representation, lower pay, and disinterest in strictly coding classes.

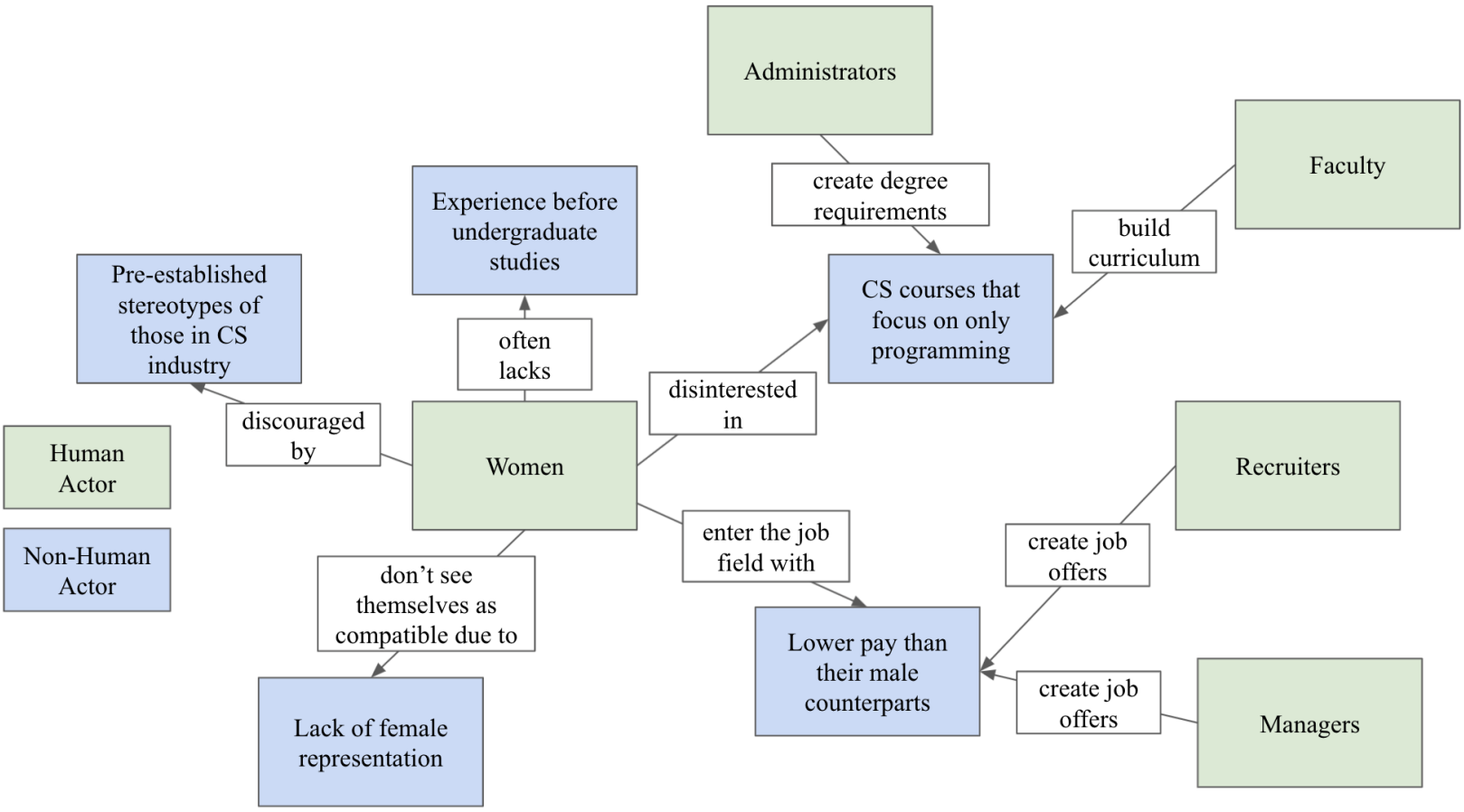

Figure 3: Actor-Network Theory analysis of the existing lack of gender diversity in undergraduate CS programs. This figure visualizes the different barriers that women face regarding their education, (Mara Hart, 2021).

Researchers at the University of Auckland found women were more interested in computing science after reading a doctored newspaper article made for research that stated that the industry is breaking out of its stereotypes (Cheryan et al., 2013 from Khan and Luxton-Reilly, 2016, p. 2). With actants like stereotypes and media, women can be encouraged

by the disruption in current CS culture. This in turn introduces more women as actors, potentially disrupting stereotypes to create a more inclusive network, promoting gender inclusivity. UC Berkeley's "Introduction to Symbolic Programming" class was transformed to "Beauty and the Joy of Computing" which taught the same material but focused on pair exercises and class discussions of technology news articles. Brown (2014) found that 2014 was the first time since 1933 (their oldest digital record) that there were more women than men in introductory computer science (para. 3). A major actor in introducing women to computer science in undergraduate education is the class itself. At Berkeley, the number of computer science majors nearly doubled between 2009 and 2013; after a 2008 reimagination of Stanford's introduction course, their female CS enrollment went from 12.5% to 21% between 2008 and 2013 (Brown, 2014, para. 22-23). This is due to the increase of women enrolling in the introductory computer science class and learning more about the field. The undergraduate computer science program is a network that consists of the course itself as well as each student and faculty member. With reimagination, faculty members can inspire students to join computer science, diversifying the field.

Inside the undergraduate CS network is another actor: a student's experience. Even in high school, college-level courses like AP Computer Science Principles can inspire students to pursue a new interest. AP CSP is a class that focuses on foundational knowledge which Mike Petran, an AP CSP teacher at Hammond High School in Maryland, describes as "so relatable" (Anderson, 2020, para. 5). Compared to students who did not take CSP, Collegeboard (2020) found students who took the class in high school are more than three times likely to pursue a computer science degree in college (para. 2). Unlike AP Computer Science A, AP CSP talks about the Internet and cybersecurity to help conceptualize programming in everyday terms, not just a focus on the language itself. Showing how computer science plays a role in the world helps

inspire students to explore a new field. In St. Louis, local teacher Alexander Schenk shares that "the creative component and the collaborative component are huge in drawing students, especially for underrepresented groups," (Anderson, 2020, para. 7).

By tackling these issues and reforming the current undergraduate system in place, undergraduate programs can encourage more gender diversity, increasing financial return that benefits not just the individual, but the market as a whole (Hunt et. al, 2015 as cited in Sayed, 2021, para. 3). Experience before undergraduate programs allow women to learn about the field before choosing their degree focus and CS courses that focus on real-world applications push the relevance of computer science outside the classroom. By remedying these problems and increasing gender diversity, after studies, women will look forward to diversity in the workforce whether it's in skills, attributes, or gender.

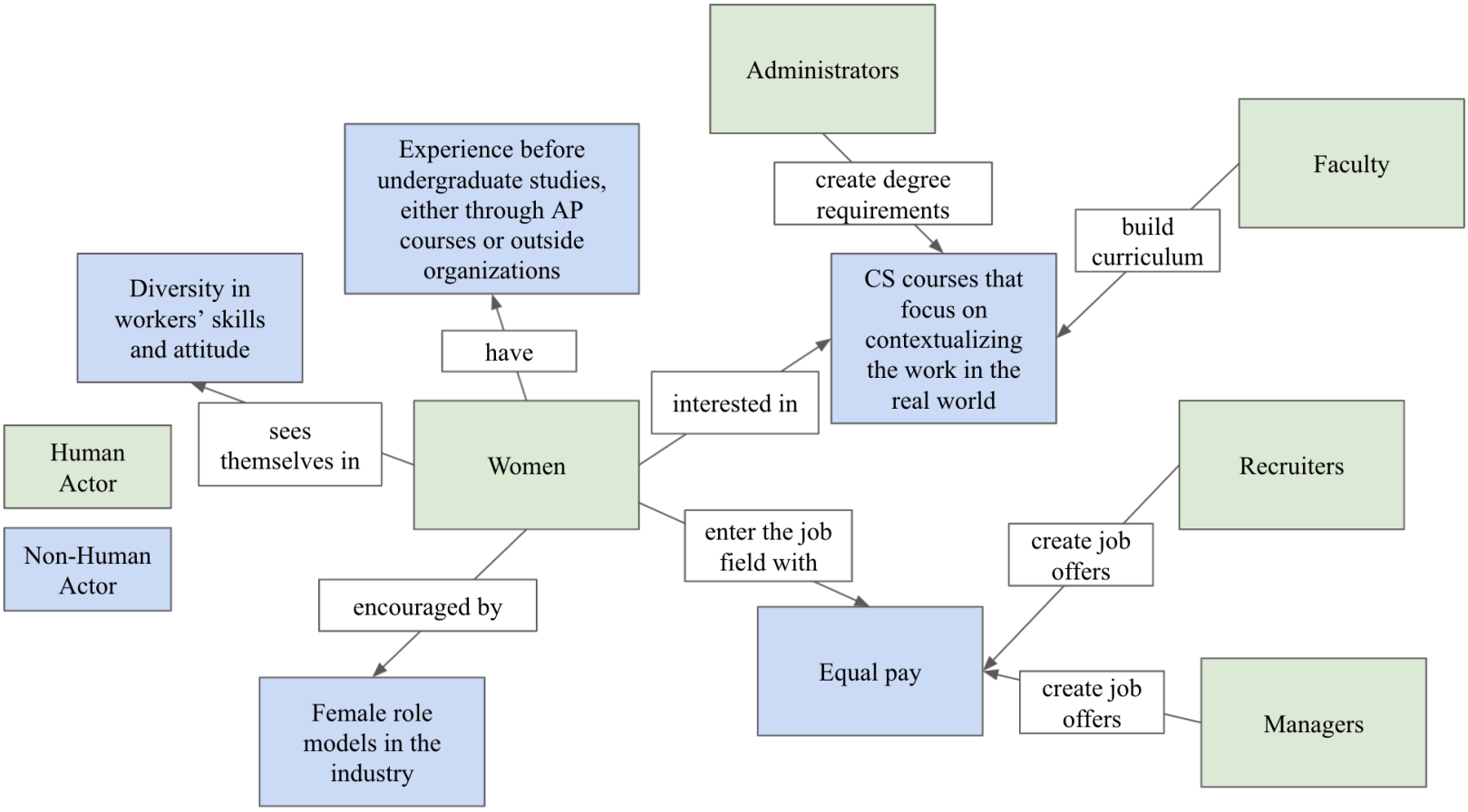

Figure 4: Actor-Network Theory analysis of the potential solutions targeting the lack of gender diversity in undergraduate CS programs. This figure visualizes the different barriers that women face regarding their education, (Mara Hart, 2021).

TO INCREASE GENDER DIVERSITY,

COMPUTER SCIENCE EDUCATION MUST BE RESTRUCTURED

The lack of representation in the computer science industry leads to a lack of self-perceived compatibility from women (Cheryan et. al, 2013, p. 10). Gender diversity in undergraduate CS departments is a complex network, containing actors like stereotypes, media, faculty, the course itself, and more. When looking at cases like AP CSP or Berkeley's "Beauty and the Joy of Computing," stereotypes of the traditional nerdy, the stereotype of the antisocial

computer programmer isn't as prevalent in women's minds. By introducing more diversity, not just in those teaching, but in the way students are taught, higher education can cater to a large variety of students. Higher education facilities could introduce more creative methods of problem-solving and encourage collaboration in the classroom. Though the lack of gender diversity is still a problem today, higher education must be conscious of their stereotypes and be willing to adapt to the needs of all students, not just males, as they work to tackle this problem.

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