

# A Critical Discourse Analysis of Engineering Course Syllabi and Recommendations for Increasing Engagement among Women in STEM

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## Abstract

Men outnumber women in the enrollment of science, technology, engineering, and mathematics (STEM) undergraduate majors. Course syllabi are distributed to students during open enrollment and provide key insights into the courses. A critical discourse analysis of introductory engineering syllabi at a 4-year public university revealed limited to no inclusion of: student learning course outcomes, connections to topics outside of engineering, encouragement of faculty-student or peer relationships, personal growth and societal impacts, or acknowledgment of the underrepresentation of women in STEM. Syllabi should incorporate multicultural engagement factors to help reduce the gender gap and promote the increased involvement of women in STEM fields.

*Keywords:* STEM, syllabus, women, student-engagement

## Introduction

The low enrollment of women in science, technology, engineering, and mathematics (STEM) majors and careers is a major problem in academia (Ceci, Williams, & Barnett, 2009; Landivar, 2013). Women hold less than a quarter of STEM careers as opposed to the 76% held by men, limiting the opportunity for women to provide unique insight into the advancements and discoveries within science (Beede et al., 2011). Nearly one-third of men entering a university choose a STEM major as opposed to 15% of women (Hill, Corbett, & St Rose, 2010). This is particularly salient in engineering, where of women enrolled in a STEM major, only 18% of women choose engineering, as opposed to 48% of men (Beede et al., 2011). It is essential that universities retain women in STEM majors to increase the number of women in areas historically dominated by men (de Cohen & Deterding, 2009). Social and economic justice for women, in the form of providing equal opportunity and access to education in STEM fields, includes acknowledging and transforming societal barriers through higher education that avert women from entering these domains (Smith, 1991; Xu, 2015).

Several factors have been examined for dissuading women from entering STEM fields, including stereotype threat, lifestyle choice, career preference, economic gain,

and social pressures (Ceci et al., 2009; Martin, 2011; Xu, 2015). Steele (1997) focused on explicit discrimination and stereotype threat, present when individuals self-identify with a minority group of which there is a negative societal stereotype. From such, women may believe they are unable to succeed in a math related field, due to societal stereotypes that suggest women do not possess equal quantitative skills as men (Steele, 1997). Cultural barriers have prevented many women from believing they hold the same skills as men, and some women have found they needed to dis-identify with the stereotyped group to remove themselves from the negatively regarded identity. This isolation from other women is an effort to appear more objective and less emotional to be successful (Rhoton, 2011). More recent research has found larger impacts from career disconnects, where careers in STEM fields lack sufficient policies and economic gain to allow for the success and prosperity of both work and family oriented lifestyles, which women today often hold (Ceci & Williams, 2011; Xu, 2015). While this research indicates career and lifestyle opposition prevent women from entering STEM fields, discriminatory views are still upheld within academia, and mediated through psychological well-being, negatively influencing academic performance (Settles, O'Connor, & Yap, 2016). It is essential that universities address deep rooted biases that maintain the norm of who can achieve in STEM and the practices that uphold the stereotypes (Baber, 2015).

## Multiculturalism

The American Psychological Association (APA) (2003) defines culture as the belief systems and orientations present among individuals that are shaped by their individual cultural, ethnic, and racial heritage. Culture is constantly evolving and is learned through beliefs, practices, values, religious, and spiritual traditions while being rooted in historical, economic, ecological, and political factors (APA, 2003). Leistyna (2002) suggests each person creates their own culture from a combination of their lived experiences, while sharing similarities across various communities, to create a classroom that celebrates student diversity. Multicultural education is aimed at institutions providing equal opportunities to learn for

students of all cultures, genders, races, ages, and ethnicities, in any such combination (Banks & Banks, 2009).

Integrative multicultural instructional designs can be used to improve retention through stressing the importance of multicultural differences (e.g., gender, race, class) among students, and emphasizing that faculty must understand these differences in order to practice a pedagogy and create an environment that is equal for all students to share their respected voices (Higbee, Goff, & Schultz, 2012). Since every classroom will vary due to unique and evolving student makeup, it is important for faculty to develop a wide range of pedagogical methods to apply various practices that reach more diverse students and increase engagement. Faculty may be unfamiliar or uncomfortable with the integration of sensitive content into a course traditionally deemed as a "hard science," but should be reassured that this is normative and be provided with the necessary training (Murad, 2004). Acknowledging and accepting the difficulty can help faculty to learn and be a method to engage the students, rather than concealing injustices.

## Faculty Student Relationships

Faculty-student interactions, practices of student engagement, participation in learning communities, role models, and quality of the interactions all significantly impact student academic performance and retention (Carini, Kuh, & Klein, 2006; Delaney, 2008; Endo & Harpel, 1982; Kuh, Cruce, Shoup, Kinzie, & Gonyea, 2008; Lundberg, & Schreiner, 2004; Steele, 1997; Zhao & Kuh, 2004). Women generally choose to leave a university due to specific faculty attitudes and perceptions of their future lifestyles in the field (Ceci & Williams, 2011; Lundquist, Spalding, & Landrum, 2002). Faculty who have more informal interactions with the students, including being more accessible and relatable, have greater and more positive impacts on first year students and increase active learning (Endo & Harpel, 1982; Umbach & Wawrzynski, 2005). A sense of belonging is associated with increased academic motivation, increased perceived relations with the professors, and sense of acceptance into the university (Freeman, Anderson, & Jensen, 2007). Trust between students and faculty must be established within the classroom and on

a university level to reform STEM education from a culture of historical alienation into acceptance and promotion (Ream et al., 2014).

Engagement is related to how the student perceives his or her relationship with the instructor in terms of feeling as an academic equal, where knowledge is shared among students and the instructor. Freire (2012) argued this shared knowledge is essential in fostering teacher-student engagement and opposes a “banking model” of education, where classes primarily consist of rote memorization that restricts opportunities for dialogue. Gasiewski, Eagan, Garcia, Hurtado, and Chang (2012) found that STEM students were more engaged when faculty showed interest in student questions and responses and openly acknowledged their interest in the success of the student. As evidence for greater engagement expands, faculty must begin implementing revised pedagogical methods within their courses (Fairweather, 2008). Particularly within STEM, students are more engaged in situations with higher levels of classroom and emotional support (Wilson et al., 2015). Higher persistence for women of color students in STEM fields was associated with engagement in the academic community, in co-curricular activities, and creating connections to socially relevant problems (Espinosa, 2011). A more engaged class allows for greater participation from students and empowers them through giving value to their knowledge, and supporting greater communication.

## Syllabi

The syllabus is one of the most important documents provided prior to or on the first day of a course, a time when students can withdraw or add a course without penalty, and serves as an academic contract between the student and professor. It is used as a permanent record for academic history and a learning tool to facilitate student success (Harnish & Bridges, 2011; Parkes & Harris, 2002). Course syllabi are a major tool in promoting effective communication in the classroom and convey faculty-student power dynamics through their language (Liao, 2015; Smith and Razzouk, 1993). Doolittle and Siudzinski (2010) established that syllabi contain general information about the course, but often lack essential components for student success, such as descriptions of student support services.

Effective syllabi use language that clearly depict required academic components contributing to the overall course grade, convey motivation and engagement, include in-class and outside group work to engage students in greater culture mergers, and provide an opportunity for students to integrate their ideas (Harris, 1993; Popov et al., 2012). Universities have recently been adopting a “one size fits all” syllabus template that an instructor uses to create a course syllabus. This base allows for the individuality of the instructor to be expressed and contains

elements that foster student engagement. The language of the syllabus has a crucial impact on the perception of the course and may hinder inclusivity (Ishiyama & Hartlaub, 2002; Parson, 2016; Tokatlı & Keşli, 2009).

## Purpose

The purpose of this study is to explore the extent to which prototypical introductory engineering course syllabi foster engagement and combat stereotype threat using a qualitative analysis investigating how the language used within them facilitates or inhibits women from continuing in the course beyond the open enrollment period. For a successful completion of the engineering curriculum, it is required to complete the engineering course, and withdrawing from the course will likely lead to withdrawing from the STEM major. Syllabi provide critical insight into the expectations and requirements of the course, and may contribute to retention by creating opportunities for student engagement. Investigating themes within syllabi illuminates areas for improvement to increase the recruitment and retention of women and other underrepresented groups.

## Critical Discourse Analysis

Syllabi were selected from within the Engineering Department of a large public university in the United States and attained online through the University website, if they applied to (1) first year courses and (2) introductory engineering major-only courses. First year engineering courses were selected to provide the widest net for recruitment of students into the major with the lowest enrollment of women.

A critical discourse analysis (CDA), through textual analysis, was used to analyze the syllabi for multicultural educational engagement, following the seven building tasks of relating function to language from James Gee (2014). Critical discourse analysis has been used to evaluate syllabi in previous research (e.g., Bejerano, & Bartosh, 2015; Liao, 2015; Parson, 2016) as a means to uncover how the language used within the syllabus relates to power dynamics in university courses. Our approach adds to this new field of research through its unique approach of using Gee, to analyze syllabi in terms of: significance, activities, identities, relationships, politics, connections, and sign systems and knowledge (Gee, 2014). Narratives, such as these syllabi, reflect the ideologies held by the professor and are created with every word serving a function. The syllabi are intricately tied to the social practices that the professor believes should occur in the class, which may also reflect the beliefs of the university (Figure 1). Gee (2014) argues that function and language build social practices that form social relationships, which reveal underlying ideologies of status and power. For this reason, this analysis derived from Gee for classroom dynamics,

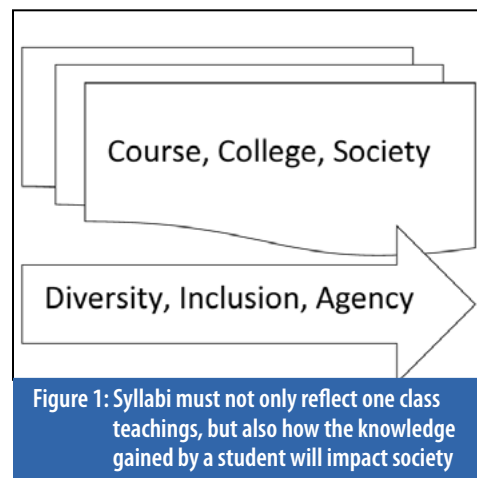


Figure 1: Syllabi must not only reflect one class teachings, but also how the knowledge gained by a student will impact society

can build on the power of the professor over the students through the contract purposes of the syllabi, potentially including hidden messages of control, revealing information from what is both written and excluded, extenuating a culture that denies access of all students to an equal education.

Discourse is assumed in a specific entity, in this case science, and its representation is controlled through the language it portrays itself in, therefore a certain level of power can come from discourse (van Dijk, 2008). Professors are considered experts in the field, therefore the content of the syllabus will be revered by the students as an ultimate source of knowledge, providing the professor with a tremendous amount of power (Apple, 2004; Nesler, Aguinis, Quigley, & Tedeschi, 1993; van Dijk, 2008). On a larger scale, the context of the STEM programs presented at universities will reflect what one must be to enter STEM careers. On a smaller scale, the syllabus reveals generations of societal travesties and power struggles and holds the potential to perpetuate the exclusion of minority groups if not properly addressed. While it is important that students learn the necessary discourse to be successful as an engineer, there must be careful consideration as to who defines the ideologies of what constitutes a successful engineer. Through understanding how identities and relationships are built through language in these syllabi, CDA can be used to analyze the syllabi in terms of multicultural inclusion. If the relationships are weak, CDA can spark transformative reform in terms of social justice.

## Syllabi Overviews

Over a dozen sections of the Electrical Engineering Major at the University were offered during the fall semester of the 2013 – 2014 academic year. Four faculty members taught the sections, three of which used approximately the same syllabus. Two different syllabi were analyzed in this study, designated Syllabus A and Syllabus B. The syllabi are not included here to maintain the integrity of the courses, faculty, administrators, and others at the institution.

Syllabus A lacked course-level learning outcomes and larger outcomes relating the student to society. The

course promoted individualization and suggested success was achievable only under the definition of the professor. It did not engage students to think critically about engineering nor did it promote relationship building between the instructor and the students, or between the students themselves. Outside of engineering, the only connections to other fields were to mathematics and physics, ignoring any relations to social sciences and humanities. Terminology and prior knowledge expectations set a clear line for what type of student should already be in the course. Academic achievement was stressed considerably, with little to no engagement in various forms and methods of learning.

Syllabus B lacked promotion of group work and engagement through continuously stressing the need for individual effort. The class presented students with a strict “sit and listen” attitude, and promoted the professor as an authority figure that provides knowledge, rather than promote shared learning. Outcomes relating the course to society and the impact this course will have on the students’ lives were absent. The syllabus enhances engineering culture as it stands today, not challenging or addressing any of the gendered issues that plague the field. Individualization of students in the class places stress that the student alone is the only one invested in his or her own education, not the other students, faculty, or campus community. The ultimate sense of authority in following the professor and rules exactly presents the professor as gatekeeper into engineering, rather than a gateway.

## Syllabi as a Tool for Agency

Multicultural engagement is essential in providing a sense of community that welcomes all students at a university. Individual courses, especially those in STEM fields, should include a plethora of multicultural methods to increase the recruitment and retention of women and other underrepresented groups. Through analyzing two syllabi, both of which are used in introductory first year electrical engineering courses at a large public university, we find glimpses of promotional multicultural engagement, but primarily a discourse that promotes individualistic ideologies, placing success in the course purely on the individual, with little promotion of course goals relevant to the personal development of the student.

Little information is described in both syllabi in terms of student expectations, aside from learning various engineering subjects to pass the course. The significance of absent course-level student learning outcomes leads to a lack of student engagement by not clearly stating the purpose of the course or how the course will improve the students’ academic, professional, or personal lives. One vaguely described project is presented as a method to learn more about engineering careers, but lacks any detail into the purpose of its outcomes or connections of the course to other areas of student’s lives.

There is no reference to the gender gap that exists in STEM today or any mention of initiatives trying to reduce the gap, which brings little social recognition for women (Fraser, 1995). Acknowledging the gender gap can lead to reductions in stereotype threat and facilitate women to remain enrolled in the course and the major (Steele, 1997). For students, especially women in a field dominated by men, it is important to be able to envision one shaping the future through the career accomplishments, furthering the redistribution of economic wealth (Fraser, 1995; Martin, 2011). For women of color in STEM fields, two of the largest discouraging factors were materials not related greater societal importance as well as the portrayal of STEM as being gender and race neutral (Johnson, 2007). It is essential faculty openly address and reform their courses to address these issues as their omission can perpetuate the gender gap.

The syllabi lack transformative action to move away from an individualized high stake grading policy, which limits collaboration of ideas, dialogue, learning communities, and group appreciation. Higbee and colleagues (2010) stress that group work is essential for students to share their cultures with others by allowing them to express the importance of their personal history and giving them opportunities to realize that their voice is important. It is critical that individual student voices be valued to avoid stereotyping the “type” of woman it takes to “succeed” in STEM courses (Rhoton, 2011). This would allow all personalities and individual cultures to flourish in the course without being pressured to de-identify with one’s self. While the syllabi promote group work in study efforts, it is destabilized by strong arguments for individual submissions of work to prevent plagiarism. If incoming students do not understand plagiarism, they may avoid collaboration to prevent any chance of their work being penalized.

There is a continuous reinforcement of the individual identities of the students, as it is one’s sole personal responsibility to succeed. With prior information from high school and by banking new information from studying, the student should be able to “master” the material under the rules of the professor. The strong focus on previous knowledge does not promote the expandability of intelligence and may further established stereotypes. Prior knowledge of course material has been shown to not be the sole factor in predicting student success, therefore stressing only academic achievement lacks any intention to intervene on such indicators, such as stereotypes (Riegler-Crumb, King, Grodsky, & Muller, 2012). Steele (1997) suggests that stressing the plasticity of intelligence is one way to reduce stereotype threat. Professors should acknowledge that they are not omnipotent authoritarians, although they are viewed as strong leaders, carrying with them the strengths and weaknesses of their academic fields (Freire, 2012). A variety of pedagogical techniques and methods are beneficial for a diverse student body, ensuring that all

students are receiving an equal opportunity for success.

The syllabi include sections where faculty extend outreach to students, but it is presented as a means of academic interaction only if the student begins to fall behind. This does not promote forming relationships between the instructor and students who are performing at an average or above average level in the course. If the syllabi depict faculty as more approachable, available, and can create informal relationships with the students, it may help to increase recruitment into the course and retention within the major via faculty engagement (Delaney, 2008; Endo & Harpel, 1982; Gasiewski et al., 2012; Harnish & Bridges, 2011). Incorporating the personal history of the instructor increases the likelihood that faculty are perceived as approachable and instills greater multicultural discourse into the syllabus. Optimistic student faculty relationships and role models are two ways by which women and other underrepresented groups may combat stereotype threat (Steele, 1997).

There is little effort made to promote connections with other students outside of their course, major, department, school, or community, nor are there any efforts made for students to understand how this course will relate to the betterment of society. One syllabus briefly describes a project to learn more about the university and offers the peer-tutoring center for aid, but only in terms of improving the grades of the student. The courses are depicted as existing in a vacuum and the students within them are expected to work individually. Science education must promote students to become life-long learners that are not only able to enrich their lives, but are also able to use their knowledge to enrich society (Šorgo and Špernjak, 2012). Nasser and Romanowski (2016) find that engineering students must learn to think critically to analyze human societal problems to better social relations, not solely focusing on technical formulas which can intellectually inhibit the students and keep them from becoming strong leaders. Syllabi should be more reflective in establishing how the student will interact with colleagues and others outside their major, instilling a sense of importance to others, and that others are important to them. Careers in engineering require both independent work and working with others in teams, and thus engineering courses should reflect this dynamic and promote multidisciplinary projects.

Both syllabi are presented in very short bulleted forms, which are effective for conveying information, but do not delve into the details necessary to explain how the course fits into the larger aspects of the student’s life. Harnish and Bridges (2011) suggest that syllabi be written in a positive and welcoming tone to influence how students view the instructor and course. The syllabi expose students into the scientific discourse without explanation as to what it truly means to be a scientist and how the course relates to their personal lives. Saville and colleagues (2010) note that clear, detailed syllabi provide a valuable insight into the course and that engaging syllabi provide an avenue towards an

engaging course. This research aligns with previous literature suggesting a contributing factor in leaving the engineering major was a lack of program guidance (Godfrey, Aubrey, & King, 2010). Furthermore, students who viewed detailed syllabi reported the instructor to be more personable, encouraging, effective, flexible, open-minded, and knowledgeable. This translated into students reporting that they would recommend the course to others and take another course from this instructor. It is important that students, particularly women, can complete the required courses within the major and envision themselves making future accomplishments within the field (Martin, 2011).

Syllabi that act purely as contracts do not promote multicultural engagement and continue the deeply rooted androcentric domination of the field (Bejerano & Bartosh, 2015; Parson, 2016). Students may be forced to accept and follow the ideologies underlying the syllabus of individual masculinity if they remain in the course, and ultimately in the major. Research has shown that for women, this may translate to dissociating themselves from femininity (Rhoton, 2011). This dis-identification may lead to decreases in longitudinal motivation, which may decrease the likelihood of completing the curriculum.

## Recommendations

It is essential that changes occur on the institution-level, faculty-level, and the student-level. Institution-level changes include providing opportunities for peer mentoring and intensive tutoring for women and other underrepresented groups. This includes course syllabi that describe learning centers and classrooms that engage in active learning (Table 1). Active learning is known to increase student engagement through collaboration and teamwork, thus increasing student retention. Establishing

a co-dependence among students in the form of teams fosters a sense of community that will provide them with both intrinsic and extrinsic motivation to attend class and remain enrolled in the course.

Institutions should provide students with career counseling and raise awareness of professional role models in the workforce. For example, creating relationships between women in engineering careers and undergraduate students would provide students with a role model as an example of success.

Faculty must reflect and respect diverse talents and ways of learning, acknowledge that each individual student learns in his or her own unique way, and represent these ideals in their course syllabus. The university should promote incentives for faculty to increase attendance at multicultural workshops that promote teaching and learning as an avenue towards tenure. Such workshops must not gloss over what culture represents, but must tackle key historical concepts and factors that perpetuate STEM stereotypes and gaps (Baber, 2015). Faculty may not always have to be explicit in cultural diversity, but should be open, flexible, and accepting for all cultures to be expressed and succeed in the course.

Advancements of faculty-development include a faculty workshop session similar to a pilot initiative at the University of Pittsburgh. The University of Pittsburgh funded a two-week Faculty Diversity Seminar that supported faculty in integrating multicultural topics within an engineering curriculum (Murad, 2004). Murad (2004) suggests that integrating multiculturalism throughout course topics will foster a multicultural society, but to have a true effect, faculty must transform their courses and be supported by the university. Results indicate that students in the pilot courses experienced increased confidence in their ability to work with diverse others in diverse environments

and felt an increased connection to the global world.

Student-level initiatives include participation in undergraduate research opportunities and building peer groups. Working with peers on difficult assignments may foster a sense of community, but also increase self-efficacy when problems are solved correctly. It is particularly important that self-efficacy be promoted in women and other underrepresented groups to reduce stereotype threat. Faculty can help students to realize their own success through simple yet effective motivators, such as value-affirmation interventions. Miyake and colleagues (2010) found that such interventions, tailored to aid students in identifying their own unique strengths abilities, increased test scores and grades of women in the physics major.

## Limitations and Future Directions

Our study analyzes two syllabi from a single course of one department at a public university limiting generalizability. While the discourse gained from analyzing these syllabi is critical, a deeper and richer understanding could be gained from observing classrooms, as faculty may conduct the course different from what is written, as well as interviewing faculty and students, and obtaining statistics on retention. Future research should investigate other underrepresented groups based on multiple multicultural factors including, but not limited to race, ethnicity, disability status, and social class, as well as their intersectionality. Each of these experiences will include fundamental differences from a unique perspective based on which aspects of their identity are most salient to them, which identities are marginalized, and which identities are privileged. The use of one-on-one semi-structured interviews regarding acceptance in STEM fields and dynamic focus groups that illuminate barriers towards achievement of student learning outcomes may allow for a deeper understanding and appropriate avenues for change. Conducting quantitative surveys and qualitative focus groups where students reflect on course syllabi in their own courses would provide rich insight into the student experience.

## Conclusions

Low recruitment and retention among women in STEM fields may be partly due to disengaged syllabi, which enforce androcentric ideologies that are provided during a time of open enrollment. A qualitative analysis from two syllabi from introductory engineering courses provided evidence of a lack of faculty-student relationships, limited encouragement of teamwork, and no acknowledgement of underrepresented groups in STEM, all of which are pedagogical recommendations to reduce stereotype threat. Faculty development workshops and initiatives are one method to assist instructors in making these essential changes to promote transformative social justice. These recommendations should not be viewed as

Recommendation of Methodologies to Create Inclusive Syllabi		
	Non-Inclusive Syllabi	Inclusive Syllabi
Student Learning Outcomes (SLOs)	<ul style="list-style-type: none"> <li>SLOs are absent</li> <li>Written in terms of mastery of knowledge</li> </ul>	<ul style="list-style-type: none"> <li>SLOs are present and indicate what the student will know or be able to do at the end of completion of the course</li> <li>Include how learning in the course knowledge translates to multiple disciplines</li> </ul>
Course Activities	<ul style="list-style-type: none"> <li>Primarily lecture based</li> </ul>	<ul style="list-style-type: none"> <li>Includes multiple course activities, including lectures, group work, and active learning components</li> </ul>
Assessment Methods	<ul style="list-style-type: none"> <li>Summative assessment only</li> <li>Exam focused</li> </ul>	<ul style="list-style-type: none"> <li>Provides opportunities for formative and summative assessment</li> <li>Multiple assessment methods to allow all students to demonstrate strength (e.g., presentations, research papers, exams)</li> </ul>
Language	<ul style="list-style-type: none"> <li>Uses terms such as "mastery" or "I"</li> </ul>	<ul style="list-style-type: none"> <li>Uses terms such as "we"</li> </ul>
Additional Information	<ul style="list-style-type: none"> <li>Focuses on delivering information</li> <li>Includes limited information about the instructor</li> </ul>	<ul style="list-style-type: none"> <li>Promotes sharing of knowledge and between the instructor and the student</li> <li>Includes a brief biography of instructor</li> </ul>

Table 1: Key factors of influence in language of syllabi, in forms of mock non/inclusive syllabi.

a burden, but rather engage faculty with new ideas and research to promote reflection on their course climate and how it impacts the cultures of their students. By adjusting both the syllabus and the curriculum to encompass greater multicultural engagement, women and other underrepresented groups may experience increased self-efficacy and remain enrolled in the course, ultimately leading to novel advancements in science and the start of social justice for marginalized and oppressed groups.

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