

Anonymity: A Double-Edged Sword for Gender Equity in a CS1 Forum?

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ABSTRACT

The term “double-edged sword” refers to something that may have both favorable and unfavorable consequences. We posit that allowing students to post anonymously in a CS course forum may fit this metaphor with regard to gender and belongingness. In this work, we test a theory that patterns of anonymous posting in a course forum for a CS1 class may reinforce gender stereotypes even as the underlying patterns of interaction debunk those stereotypes. We examine forum interactions from a CS1 class with an even gender split and find that women engage in anonymous posting more often than men; thus, a student’s view of the class’s gender distribution is different from the actual distribution. We hypothesize this is a missed opportunity to combat stereotypes of gender in computer science. Possible solutions and further work are discussed.

CCS CONCEPTS

•Social and professional topics~Professional topics~Computing education~Computing education programs~Computer science education~CS1

KEYWORDS

CS1, gender, web forums, anonymity

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SIGCSE 2022, March 3–5, 2022, Providence, RI, USA

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ACM 978-1-4503-9070-5/22/03...\$15.00

<https://doi.org/10.1145/3478431.3499289>

ACM Reference format:

David A. Joyner, Lily Bernstein, Ian Bolger, Maria-Isabelle Dittamo, Stephanie Gorham, and Rachel Hudson. 2021. Anonymity: A Double-Edged Sword for Gender Equity in a CS1 Forum? In *Proceedings of the 53rd ACM Technical Symposium on Computer Science Education (SIGCSE '22)*, March 3–5, 2022, Providence, RI, USA. ACM, New York, NY, USA, 7 pages. <https://doi.org/10.1145/3478431.3499289>

1 Introduction

In web forums—especially those used as part of a class—anonymity is offered with favorable consequences in mind. Although anonymity may serve multiple purposes, one of the most significant is allowing students to feel comfortable asking questions in front of their classmates—and in particular to allow women to feel more comfortable interacting in a class dominated by men. This is one of the main motivations cited by Pooja Sankar for creating the popular forum tool Piazza [43]: in classes where a woman may be “one of three women [out of 50] in my undergraduate Computer Science class” [42], the ability to interact from behind a veil of anonymity may comfort those who perceive themselves as outsiders for the class content.

The phenomenon of women electing to appear anonymous to their classmates more often than men has been documented in the past [43], and we perceived this same trend in an undergraduate CS class that we teach. On the surface, this would seem to suggest that the feature is working as intended. Through our observations of interactions on the course forum and interactions with students outside the forum, however, we began to feel a troubling side effect was emerging: while the ability to post anonymously was allowing women to feel more comfortable posting in a class where they may not feel they belonged, that same anonymity was disguising opportunities for those same women to learn the extent to which they *do* belong. In conversations during office hours and via private email, we saw occasional references to the class and the forum being male-dominated, when in reality enrollment was evenly split and forum participation was dominated by women.

Anonymity seemed to hide this trend, reinforcing the same insecurities about identity and belongingness that sparked anonymous posting in the first place.

This is the unfavorable outcome we refer to when we theorize that anonymity is a “double-edged sword”: its benefit is that it allows women to feel more comfortable interacting in what they perceive to be a male-oriented field, but its drawback is that its use reinforces that perception even when it is inaccurate.

In this research, we set out to examine this theory. We specifically formulate four hypotheses:

- (a) in line with prior research, women elect to post anonymously more often than men;
- (b) as a result of (a), the gender distribution of class interaction on the forum appears significantly different than it actually is;
- (c) these trends persist systematically across the majority of students rather than being skewed only by a small number of particularly active students;
- (d) as a result of these trends, there are existing interactions that miss the opportunity to combat the very stereotypes that lead to anonymous posting in the first place.

In this work, we evaluate these hypotheses using a dataset drawn from six semesters of interactions in a course forum associated with a CS1 class at an American university that requires one CS class for all students regardless of major. We then discuss the ramifications of these findings and pose ideas for future developments that might stop this cycle while preserving the benefits of anonymous posting.

2 Related Work

Significant research exists examining instances where women prefer to be anonymous across disciplines, media, and eras. Birch 2019, for example, examines the use of anonymity by women contributors to the long-running British magazine *Punch* starting in the 1840s to circumvent gender-based social limitations of the time. Birch goes on to note, however, that this use of anonymity both “imprisoned and emancipated” them, as in addition to allowing them to circumvent limitations, it also “prevented these writers from receiving recognition for their work” and missed an opportunity “to combat the societal prejudice” [4]. This effect identified in women’s essays in the 1800s is the same dichotomy we explore here; anonymity brings comfort and freedom but may miss an opportunity to accomplish a greater good. In popular culture, Terry Pratchett’s *Monstrous Regiment* deals with similar issues; there, the pervading impression that a regiment is exclusively men is discovered to be false when it is revealed that, unbeknownst to one another, every individual is actually a woman “in disguise” [37]. Such a potential interaction between personal anonymity and general perception is well-recognized.

Further research has more specifically examined anonymity and gender in online educational forums. Early findings were optimistic that computer-mediated communication (CMC) and the anonymity it allows may remove negative gender effects from

online discourse [13]; this was soon observed to be premature, however, as significant later research showed gender differences persisted in CMC [2, 17, 27, 40, 44, 46, 48]. Researchers then examined if anonymity can help individual women feel comfortable online. Research found women elect to contribute anonymously more often than men [11, 18, 19, 33, 43], and with good reason: negative gender effects emerge when anonymity is removed [11, 25, 30, 34]. Some research suggests more complex mechanisms for this trend, such as that anonymity mediates between contribution patterns and an underlying social identity model [36].

In our work, we are particularly interested in how this trend intersects with representation of women in CS. That women are underrepresented in computing fields is well-documented [12, 24, 39], and negative stereotypes play a significant part [3, 26, 28]. It is similarly well-established that access to role models [1, 8, 16, 22], mentors [32, 41], media representations [7, 35], and friends [5, 6, 29, 47] in computing fields helps increase belongingness among women and underrepresented minorities in such fields. Finding new friends in CS classes may be important given evidence that men and women seek different outcomes in computing [10, 15, 38]. It is reasonable to suggest that one mechanism to improving women’s belongingness and rebutting negative stereotypes is to make women’s contributions visible [14, 15]. Anonymity, however, may hide exactly what needs to be shown to realize this progress: as Birch noted for women writers in the 1800s, anonymity in a computer science forum may deprive women of credit for their contributions and perpetuate a negative stereotype of the gender split in the field.

3 Context

In this work we analyze an online CS1 course taught at a major research university in the United States. The course functions as the first computer science course for incoming CS majors, as well as one of three ways to satisfy the CS requirement for all university majors. In the dataset for this study, 6% are computer science majors; most others come from an engineering major (35%), a science major (18%), or a business major (14%). 43% of students are in their first year of college; 30% are in their second year, and 23% are in their third year or later. 4% enrolled before officially beginning their college career as part of a dual enrollment or pre-college summer program. Prior research on this course has found performance in the online course comparable to that in an in-person course [20, 23], and that students with limited or negative prior computing experience perform particularly well [21, 31].

This analysis covers six semesters of course enrollment. Terms 1, 3, 4, and 6 are full 17-week semesters; Terms 2 and 5 are shortened 12-week semesters. Each semester, students are given a survey on which they are asked to self-report their gender identity; this is also the survey where they opt into allowing their data to be analyzed for research purposes. The results of this survey question per term are presented in Table 1. “Other” here includes students self-reporting an alternate gender identity (1) and students electing not to disclose their gender identity (5). These six students comprised less than a dozen forum posts in the

dataset, and as such are excluded from this analysis as no general trends can be observed regarding their likelihood to remain anonymous when posting based on such a small number of forum contributions. Students that did not complete the survey are similarly excluded from this analysis as they also did not opt into the course's research study.

Table 1: Total enrollment, response rate, and gender breakdown for each semester under analysis. Note that not all students actually post in the course forum.

Sem.	Enrollment	Responses	Women	Men	Other
1	211	204	90 (44%)	113 (55%)	2 (1%)
2	108	105	53 (50%)	51 (49%)	1 (1%)
3	225	219	114 (52%)	104 (47%)	2 (1%)
4	284	263	136 (52%)	127 (48%)	1 (0%)
5	163	148	89 (60%)	59 (40%)	0 (0%)
6	266	249	123 (49%)	126 (51%)	0 (0%)
Total	1,257	1,188	605 (51%)	580 (49%)	6 (<1%)

The gender difference is statistically significant at $\alpha = 0.05$ for only one term (Term 5, $z = 2.40$, $p < 0.05$); in all others there is no statistically significant difference. In our subsequent analyses, we will generally operate under the assumption that the gender breakdown is relatively even given the lack of significant difference in five of six terms. In our course surveys, we also ask students to report their prior programming experience; a greater fraction of men report some prior programming experience (58% of men compared to 40% of women). This difference may explain some later trends in contribution types and likelihood to contribute anonymously, although in this work we are less concerned with an explanation of the existing trends than we are quantifying the trends and their potential ramifications.

4 Dataset

For all six semesters, this class used the Piazza web forum for official class discussion and Q&A. Discussion in Piazza takes place in threads. At the top level, each thread can be either a Question or a Note, either of which may be edited after the initial post¹. Both thread types allow Follow-Ups; Follow-Ups can receive their own Replies. Questions further allow a particular kind of response called Student Answer; each Question has a single area for Student Answer (separate from the area for an Instructor answer), where multiple classmates may collaborate on an answer to the original poster's question. Thus, each student contribution to a Piazza forum can have one of eight types: Start Question, Update

Question, Start Answer, Update Answer, Start Note, Update Note, Post Followup, and Reply to Followup.

We assembled the dataset by exporting forum history for each semester, anonymizing personally identifiable information, removing private posts, connecting contribution history to results of the survey, and removing students for whom a survey response was unavailable. The resulting dataset contains 6,239 unique student contributions. Table 2 provides a count of total contributions across all semesters.

Table 2: Total count of each contribution type in the dataset.

Contribution Type	#
Start Question	2700
Update Question	331
Start Answer	847
Update Answer	174
Start Note	86
Update Note	73
Post Followup	1110
Reply to Followup	918

The large majority of updates come from the same student as the original contribution, so we exclude Update Question and Update Answer from analysis for brevity. We also exclude notes given their rarity in the course forum and the often-unpredictable manner in which they are used—notes are sometimes miscategorized questions, but also are used to promote events outside of class, network socially, and seek advice unrelated to the class, separating them from domain-specific discussion. So, our analysis focuses on four contribution types: Start Question, Start Answer, Post Followup, and Reply to Followup.

5 Analysis

To evaluate our hypotheses, we analyzed this dataset in four ways. First, we examined the distribution of contributions by type, gender, and anonymity. Second, we compared the perceived gender divide based on non-anonymous contributions alone with the actual breakdown present in the dataset. Third, we examined whether the differences observed previously were systematic across students or biased by a small number of students exhibiting extreme behaviors (such as a single super-poster always electing to remain anonymous). Finally, we examined individual question-answer interactions to find the frequency of each type of interaction based on gender and anonymity. Note that whenever comparing ratios, we employed a two-tailed difference of population proportions z-test; all reported z-scores and p-values come from this test.

¹ Polls are also possible, but no students in our dataset created a poll.

5.1 Overall Distribution

Table 3 provides the overall breakdown of contributions in the dataset by gender, anonymity, and contribution type. Women are more likely to contribute anonymously in every post category. 69% of questions asked by women are asked anonymously, compared to only 50% of questions asked by men ($z = 9.67$, $p < 0.001$). For each of the other three posts categories, 63% of contributions from women are anonymous, compared to 37% (Start Answer) ($z = 7.38$, $p < 0.01$), 41% (Post Followup) ($z = 7.06$, $p < 0.01$), and 40% (Reply to Followup) ($z = 6.86$, $p < 0.01$) from men. This analysis thus supports hypothesis (a): women elect to post anonymously more often across all contribution types.

Table 3: Total number of contributions of each type by gender and by decision to contribute anonymously.

Contrib. Type	Total by Women	By Anon. Women	Total by Men	By Anon. Men
Start Question	1742	1204	948	476
Start Answer	328	207	515	191
Post Followup	705	445	403	166
Reply to Followup	525	328	387	153

There are also differences in underlying posting patterns: while men contribute 57% more answers than women, women contribute 83% more questions, 75% more follow-ups, and 35% more replies. It is important to note that, as acknowledged previously, a greater fraction of men (58%) than women (40%) have prior computing experience; as part of the anonymization process, the link between individual posts and prior experience was severed, and so we cannot establish to what extent prior experience and gender separately predict post volume and likelihood to post anonymously. However, our interest is whether the perceived fraction of contributions from women differs from the actual fraction due to anonymity, regardless of why that actual fraction arises in the first place.

These trends could be explained if a small number of super-posters drastically sway the overall dataset. The third part of this analysis, Individual Patterns, examines this, but we also break the data down by term to observe that for five of the six semesters in the dataset, these trends hold. The only anomaly was Term 3, wherein we see a greater fraction of anonymous questions, follow-ups, and replies from men than women; a greater fraction of women's answers are still anonymous.

5.2 Actual, Visible, and Perceived Distributions

Based on those observed trends, we set out to compare the apparent gender distribution of forum interaction for each semester with its actual gender distribution. We perform this analysis per semester because we are interested in how a student in the class may perceive the distribution based on contributions

they can see, which includes only those in their own term. It is worth noting that this assumes that the identifiers associated with identified contributions—in Piazza, a name and an optional avatar—are sufficient to reveal the underlying contributor's gender. Further research is necessary to investigate whether this is the case, in particular whether students' reported impressions of the gender distribution mirror the actual distribution, the perceived distribution, or something else entirely.

Table 4 displays the actual, visible, and perceived gender distribution for contributions in our dataset per semester: actual reflects the actual distribution of contributions by gender; visible shows what percentage are posted by a non-anonymous woman, non-anonymous man, or anonymous contributor; and perceived extrapolates the perceived gender divide based only on those non-anonymous contributions.

Table 4: Actual and perceived distribution of contributions based on gender and anonymity across all six terms. %W = Percentage women; %M = Percentage men; %A = Percentage anonymous

Sem.	Actual Distribution (% W / % M)	Visible Distribution (%W / %M / %A)	Perceived Distribution (%W / %M)
1	41.9% / 57.3%	16.7% / 36.8% / 46.4%	31.2% / 68.8%
2	63.6% / 36.3%	19.2% / 19.9% / 60.8%	49.1% / 50.9%
3	56.9% / 41.6%	33.8% / 21.4% / 44.9%	61.2% / 38.8%
4	60.9% / 39.1%	17.0% / 20.6% / 62.4%	45.2% / 54.8%
5	77.3% / 22.7%	14.9% / 10.0% / 75.4%	59.8% / 40.2%
6	52.6% / 47.4%	17.8% / 27.6% / 54.6%	39.2% / 60.8%

In five of the six semesters, forum contributions from women outnumber those from men. In three of those five semesters, though, the perceived distribution based only on identified posts would suggest men are the more frequent contributors; in all six semesters, the perceived distribution based only on identified posts is skewed toward men compared to the actual distribution.

We may delve further into different contribution types as well. Space constraints prevent us from reporting this breakdown for all terms, so we select the highest-enrollment term to report in detail in Table 5, and note other semesters follow similar patterns. Among questions receiving student answers in Term 4, women contribute 42.3% of those answers, but are identifiable as contributing only 8.5%: 33.8% of questions are answered by anonymous women. Men, by contrast, answer 57.7% of these questions, but only 12.3% are answered by anonymous men, leading to a disproportionately high identifiable rate of men answering compared to the actual underlying distribution: if a reader judges the gender distribution of the class by the perceived gender of non-anonymous posts alone, all fractions change radically.

Table 5: Actual, visible, and perceived distribution of contributions in Term 4 based on gender, anonymity, and contribution type. SQ = Start Question; SA = Start Answer; PF = Post Followup; RF = Reply to Followup.

Type	Actual Distribution (% W / % M)	Visible Distribution (%W / %M / %A)	Perceived Distribution (%W / %M)
SQ	66.0% / 34.0%	19.2% / 12.3% / 68.4%	39.0% / 61.0%
SA	42.3% / 57.7%	8.5% / 45.4% / 46.1%	15.8% / 84.2%
PF	60.3% / 39.7%	21.2% / 21.8% / 57.0%	49.3% / 50.7%
RF	50.0% / 50.0%	10.2% / 32.2% / 57.6%	24.1% / 75.9%

These patterns support the acceptance of hypothesis (b): there is a notable difference between the actual distribution of contributions to the forum based on gender and the perceived distribution due to the increased frequency with which women elect to contribute anonymously compared to men; further, while this discrepancy is present throughout, it is most dramatic in terms of answering classmates' questions..

5.3 Individual Patterns

One possible explanation for these trends is that isolated individuals systematically skew the data (rather than systematic differences in overall behavior between women and men). Forums are unique in that they give individual students a large platform, and it is mathematically plausible that every term, a highly active male contributor who never elects to remain anonymous may skew the observed results. Our third analysis attempts to control for this possibility. For each student, we compute the fraction of contributions submitted anonymously, then group and compare the gender breakdown. Each student represents only a single data point regardless of their total number of contributions, thus controlling for the possibility of super-posters.

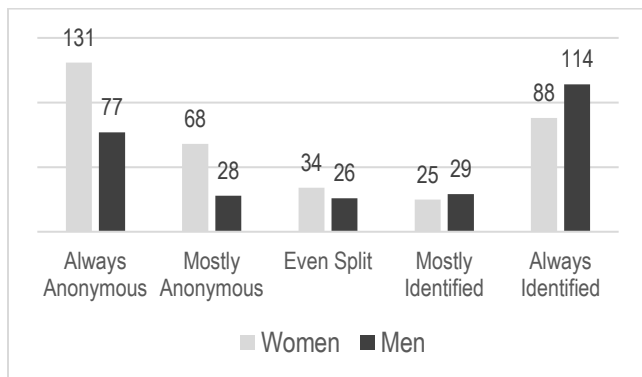


Figure 1: Number of students in the dataset by gender who always post anonymously, always post identified, or somewhere in between.

For summarization, we label each student with one of five categories, from “Always Anonymous” (anonymous in more than

90% of their contributions) to “Always Identified” (anonymous in less than 10% of their contributions). Students who are anonymous in between 35% and 65% of their contributions are labeled “Even Split”, while the remainder are labeled “Mostly Anonymous” (65% to 90% anonymous) or “Mostly Identified” (10% to 35% anonymous). Figure 1 shows the resultant split². Women are more likely to be Always Anonymous ($z = 2.56$, $p < 0.05$) and Mostly Anonymous ($z = 3.22$, $p < 0.01$) than men, while men are significantly more likely to be Always Identified ($z = 4.27$, $p < 0.01$). Thus, even when controlling for number of posts per student, we find that women are more likely to contribute anonymously all or most of the time. Note that these numbers also reveal that a greater fraction of women participate in the course forum overall: 57% of women in the study contribute compared to 47% of the men in the study.

These data support accepting hypothesis (c): the trend toward women contributing anonymously more often is not due to a small number of super-posters skewing the data set; instead, women systematically elect to post anonymously more often.

5.4 Q&A Interactions

While our prior analyses focus on broad trends, our last analysis instead targets specific interactions. We assume based on the previously referenced literature it can be considered beneficial for women to receive answers from other women, and to know they have received answers from other women, in order to combat the stereotype that computer science is a male-oriented field.

Although our dataset cannot be used to investigate whether such interactions are valuable, it can identify whether such interactions are occurring unbeknownst to the individuals participating in the interaction. For this, we examine questions that received student answers (excluding those that received only an instructor answer). Each question and answer is tagged with the gender and anonymity of the contributor. We remove any pair where the gender of either the asker or answerer is unknown, as well as pairs where students answer their own questions; in these cases, either no interaction occurs between different individuals, or we do not know which type of interaction is occurring. The resulting subset of the data contains 608 question-answer pairs, each characterized by the gender and anonymity of the asker and the answerer. Table 6 illustrates these relationships.

Several interesting trends can be observed in these data. First and most directly, we may observe examples of our hypothesized missed opportunities for beneficial interactions. 68 times an anonymous woman answered an anonymous woman's question, missing the opportunity for either to potentially improve their sense of belongingness; in only 9 interactions were both women identified. Further, 16 times an anonymous woman answered an identified woman's question, and 43 times an identified woman answered an anonymous woman's question. In each of these 59 interactions, the perception is asymmetrical: the negative stereotype may be diminished in the anonymous poster, but not the identified one³. Taken together, 93% of all Q&A interactions

² We also performed this same analysis with only students who contributed at least five times and found essentially the same distribution shape.

³ This assumes that students are equally likely to assume an anonymous individual is a woman or man; this, too, may need further research.

between women involve at least one anonymous party. This supports hypothesis (d), that within existing interactions there exist significant missed opportunities to diminish the perception that CS is male-dominated.

Table 6: Each question-and-answer pair coded for whether the asker and answer are a woman or a man, and whether they are anonymous (anon) or identified (iden).

		Answerer				
		Women		Men		
		Anon	Iden	Anon	Iden	
Asker	Women	Anon	68	43	85	120
		Iden	16	9	19	45
	Men	Anon	26	13	21	78
		Iden	14	8	22	31

Other interesting trends may be found in these data as well. Within this dataset, a greater fraction of men choose to remain anonymous when answering an identified man (42%) or an anonymous classmate (36%) than when answering an identified woman (30%), although these differences are not statistically significant at $\alpha = 0.05$. By comparison, women choose to answer anonymously 64% of the time regardless of whether the asker is an identified woman, identified man, or anonymous.

6 Discussion

It has been previously observed that when anonymity is supported in an online course forum, women are more likely to elect to contribute anonymously than men. This reflects one of the purposes of allowing anonymous contributions: to make people more comfortable contributing who might otherwise be reluctant to do so due to a lack of confidence or perceived belongingness. However, one of the effective ways to address a lack of perceived belongingness is to better surface an individual's similarity to many of their peers; visible representation can help combat these negative stereotypes. If anonymity is used disproportionately by those who do not feel like they belong, then it risks perpetuating those negative stereotypes.

In this work, we have explored whether that may be occurring in a CS1 course forum over six semesters. We have found, in line with prior literature, that women choose to remain anonymous more frequently across all contribution types (hypothesis (a)). As a result, the perceived gender distribution based only on identified contributions skews more male than the actual underlying distribution (hypothesis (b)); this, we hypothesize, may perpetuate the stereotype of computer science as male-dominated even while the actual distribution rebuts that stereotype. We further find that this trend is distributed across students as a whole rather than arising from a small number of contributors acting at the extremes (hypothesis (c)), and that as a result, there already exist numerous interactions that, if persisted without anonymity, may help counter those negative stereotypes (hypothesis (d)).

7 Future Work

Significant future work is necessary to fully examine the reality and repercussions of the findings of this study. First, we generally have assumed that students' perception of the gender split in a particular class's forum is derived solely from the visible volume without preconceived notions. This is likely untrue; we hypothesize that even in instances where identified forum contributions are evenly divided by gender, perceptions differ. This may break down by gender as well; women may perceive the forum as more male-dominated due to this stereotype, while men may perceive it was more female-dominated given research that shows men generally perceive women as talking more than they do [9]. Future work ought to examine students' actual self-reported perceptions of the volume of contributions by gender.

Second, we similarly assume that students make no inference as to the gender of an anonymous contributor; research noting women are more likely to contribute anonymously, however, may be publicized enough that students are likely to infer an anonymous contributor is a woman. Alternatively, students may infer that any contributor without an identified gender is a man, given the existing stereotypes of gender and CS. Some research has found students are relatively accurate at guessing gender based on contributions themselves [25]. Further research should investigate how anonymous contributions factor into students' calculus in estimating the gender split in class contributions.

Third, when we describe missed opportunities already present in forum interactions, we assume that students would not vary any other aspect of their behavior if the ability to contribute anonymously was removed. This is certainly not the case: without a doubt, there exist questions and answers that students would not contribute if not allowed to do so anonymously to their classmates [34]. Careful investigation into the short-term and long-term ramifications of removing anonymity is necessary before risking losing the benefits it brings.

Finally, it is too simplistic to assume the only options are to allow or disallow anonymity; anonymous posting has many goals beyond helping women specifically feel more comfortable. Future work may also focus on other design alternatives to combat these negative stereotypes while preserving the benefits of anonymous contributions. For example, interfaces may be redesigned to only present certain identity information when it may have a positive secondary effect. Or, specific efforts may be taken to have teaching assistants from underrepresented groups play particularly visible roles on the course forum so that the perceptions are not drawn solely from classmates.

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