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A Review of U.S. Engineering Cooperative Education Programs: Institutional Characteristics and Pathways to the First Co-op

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Abstract

Cooperative education (co-op) is a well-established high-impact practice in engineering education, yet U.S. institutions vary widely in how co-ops are structured, required, and integrated into curricula. Despite its prevalence, little is known about how students access their first co-op opportunity or the institutional models that shape these pathways. This study investigated engineering co-op structures through a review of co-op programs at the top 224 U.S. institutions awarding bachelor's degrees in engineering. Using structured content analysis of publicly available online catalogs, program handbooks, and career services webpages, this study documented (a) the prevalence of co-op offerings, (b) the proportion of programs requiring co-op participation, and (c) the curricular pathways and timing leading to students' first co-op experience. Results indicated that most engineering institutions offered co-op opportunities, though requirement status, sequencing, and access pathways vary. Two dominant models emerged, required and elective, with notable variations among required programs in the timing of students' initial co-op placements. This national mapping of co-op structures, with the focused analysis of 12 institutions requiring co-ops, provides a foundation for comparative research on access, timing, and curricular integrations in experiential learning and contributes to understanding how co-op design influences engineering students' professional formation and workforce readiness.

1. Introduction

1.1. Co-op in Engineering Formation

Experiential learning has long been recognized as a critical mechanism for supporting engineering students' professional formation by connecting academic knowledge to authentic practice. Rooted in foundational learning theories, such as Dewey's philosophy of experience and Kolb's Experiential Learning Theory (ELT) [1], [2], experiential learning emphasizes learning through action, reflection, and meaning-making across real-world contexts. In engineering education, career-based experiential learning opportunities, such as internships, cooperative education, and broader forms of work-integrated learning, serve as primary vehicles for operationalizing these theoretical commitments [3], [4].

Work-integrated learning (WIL) is considered an umbrella framework encompassing educational approaches that intentionally connect academic learning with workplace experience, including internships, cooperative education, industry projects, and service learning [5]. Unlike general employment, WIL is defined by explicit pedagogical intent, with structured experiences aligned to learning outcomes and often supported by reflective practice to promote professional and identity development [6], [7]. Internships, as a subset of WIL, are typically short-term, time-bound experiences occurring during academic terms or summers. Although internships can provide meaningful exposure to professional environments, they vary widely in structure and curricular integration, and are often optional and lightly scaffolded, which may limit opportunities for systematic reflection and deeper learning [8], [9].

In contrast, cooperative education (co-op) represents a more formalized and theory-aligned model of experiential learning. First established by Herman Schneider in 1906 at the University of Cincinnati (UC), co-op programs are characterized by alternating periods of full-time academic study and full-time, discipline-related employment [10], [11]. Co-op relies on a triadic partnership among students, employers, and academic institutions, with clearly articulated learning objectives, institutional oversight, and structured reflection [12]. As a result, co-op has been associated with both short-term learning gains and long-term outcomes, including higher academic performance, improved retention and graduation rates, stronger employment outcomes, and higher post-graduation entry-level salaries [10], [13], [14], [15]. However, despite the well-documented benefits of co-ops, a national-level mapping of co-op structures and first co-op pathways is lacking in the literature.

1.2. Purpose of the Study

This study aimed to reveal the current landscape of co-op structures in engineering education by conducting a review of co-op programs at the top U.S. institutions awarding bachelor's degrees in engineering [16]. The goal is to document how co-op opportunities are embedded within engineering curricula and to identify the primary pathways through which students enter their first co-op experience. Three research questions guided this study: (1) What proportion of the top U.S. engineering programs offer co-ops, and how do the characteristics of these institutions differ from institutions which do not offer co-ops? (2) Of the top U.S. engineering programs offering co-ops, what proportion require co-op participation for graduation, and what are the characteristics of these institutions? and (3) What curricular pathways lead students to their first co-op experience, and how do timing and sequencing vary across institutions with required co-ops?

2. Literature Review

Since the inception of cooperative education (co-op), its implementation has varied widely across engineering institutions in the U.S. Despite this variation, a substantial body of literature documents broadly consistent academic and professional outcomes associated with co-op participation. Prior studies show that co-op experiences support the development of professional skills, such as communication, collaboration, teamwork, and initiative [4], [7]. Early exposure to workplace environments also enables students to build professional confidence and develop a clearer understanding of engineering practice [17]. Beyond short-term skill development, co-op participation has been linked to long-term academic outcomes, including increased likelihood of graduation and persistence [10], [13].

While these studies establish the value of co-op participation, comparatively little attention has been paid to the institutional structures and guidelines that precede and shape students' access to co-op opportunities, such as degree requirements, eligibility criteria, and curricular sequencing. Reporting institutional differences in co-op programs is therefore necessary to understand the range of pathways through which students encounter co-op experiences [9]. Because co-op functions as a bridge between academic preparation and professional practice, institutional design choices play a critical role in determining which students can cross that bridge, when, and under what conditions [12].

2.1. Access, Pathways, and "Gatekeeping" into Early Co-op Opportunities

Although co-op is often framed as broadly beneficial, existing research highlights that access to co-op is structured and selective. Entry into co-op programs frequently requires minimum GPA thresholds, prerequisite coursework, and administrative screening processes. In describing pathways into voluntary co-op programs, Main [13] noted that students commonly applied during their second year after completing foundational coursework, and that GPA requirements and institutional pre-screening "inevitably functioned as gatekeeping" mechanisms that regulated early access to desirable positions and sustained employer relationships.

This gatekeeping function has important implications. If co-op participation shapes access to early professional networks, engineering identity development, and post-graduation employment opportunities, then late access to co-op can have downstream consequences for participation and persistence in the engineering workforce [13], [17]. Importantly, this literature suggests that co-op should not be understood as a single intervention, but rather as a pathway characterized by decision points, eligibility rules, and sequencing structures that can either expand or constrain opportunity. Some students may opt out of co-op due to extended time-to-degree, while others may choose internships for greater flexibility [9]. These dynamics underscore the importance of examining how institutions design first co-op access, the point at which students first transition from academic coursework into professional engineering work through the curriculum

2.2. The Need for National Mapping of Co-op Structures and First-Access Pathways

Several themes converge across the literature on engineering co-op. First, co-op and internships are widely valued as forms of work-integrated learning (WIL) that support employability, professional identity development, and, in some cases, improved academic and salary outcomes [4], [10]. Second, deeper outcomes such as persistence and self-efficacy have gained increasing attention, particularly for women and other underrepresented populations, suggesting that co-op experiences can meaningfully influence identity and confidence development and persistence decisions [17]. Third, there is growing recognition that co-op access is shaped by institutional eligibility rules, screening practices, and curricular sequencing that operate as gatekeeping mechanisms, making program design highly consequential [13].

What remains underdeveloped in the literature is a national baseline of (a) how co-op is structurally embedded within engineering curricula across institutions and (b) the specific curricular pathways that lead students to their first co-op experience, particularly in institutions where co-op participation is required. Although prior work provides valuable insight into outcomes and mechanisms, it is less explicit about comparative institutional models and how first-access pathways are organized at scale.

Addressing this gap through a review of institutional and publicly available curricular documents can clarify dominant co-op models (e.g., required versus elective), characterize variation in timing and sequencing, and provide a foundation for future comparative analyses of access, curricular integration, and student outcomes in engineering work-based learning pathways.

3. Method

3.1. Selection Criteria

The institutions included in this structured content analysis were selected from the 2026 versions of the "Best Undergraduate Engineering Programs Rankings (Doctorate)" list and the "Best Undergraduate Engineering Programs Rankings (No Doctorate)" list published by U.S. News [16]. All institutions from both lists with a rank of #100 or better were selected. In cases where several institutions were tied for a rank (e.g., many universities tied for rank #96), all the institutions were included, resulting in a total of 224 universities used.

3.2. Content Analysis

The first two authors conducted content analysis using standard search engines. Only publicly available institutional materials were used, including undergraduate catalogs, program handbooks, and career services webpages. No webpages requiring login or passwords were accessed, and no faculty or staff members from any of the institutions were contacted for more information.

Characteristics of each institution were identified, including institution ownership (private/public), degree levels offered, undergraduate enrollment, location, and whether the institution offered co-ops for its engineering students. An institution was coded as "co-ops offered" if one of the following criteria was met: (a) the institution had an engineering program webpage indicating that undergraduate engineering students can participate in co-ops, or (b) the institution had a career services webpage indicating that undergraduate students can participate in co-ops, with the assumption that engineering students are included. Institutions that only mentioned "internships" were not coded as "co-ops offered." For universities that offered co-ops, further information regarding the co-op was also identified, including whether the co-op is required, what pathways are available for the co-ops, and the number of rotations of co-ops. An institution was coded as "co-ops required" if at least one engineering major required the completion of co-ops before graduating from the program.

The first two authors started by randomly selecting 10 institutions from the list together. Next, they independently coded these same 10 institutions. They then met together to compare their coding and address discrepancies. Afterwards, the remaining 214 institutions were divided evenly between the first two authors and coded independently.

4. Results

4.1. Differences Between Institutions Offering and Not Offering Co-ops

Table 1 shows a comparison of institutional characteristics between institutions offering and not offering co-ops. Co-ops were offered at 129 (57.6%) of the 224 institutions examined. Compared to the overall selection of institutions examined, institutions with co-ops have a greater proportion that are public, offer doctoral degrees, and have a large undergraduate enrollment. Meanwhile, institutions without co-ops have a greater proportion that are private, non-doctoral, and have a small or medium-sized undergraduate enrollment.

Table 1. Comparison of Characteristics Between Institutions Offering and Not Offering Co-ops

Characteristic	Category	Co-ops Offered		Co-ops Not Offered		All Institutions	
		N	%	*n*	%	*n*	%
Institution Ownership	Public	91	70.5	42	44.2	133	59.4
	Private	38	29.5	53	55.8	91	40.6
Degree levels offered	Doctoral	79	61.2	32	33.7	111	49.6
	Non-Doctoral	50	38.8	63	66.3	113	50.4
Undergraduate Enrollment	Small (<5,000)	22	17.1	38	40.0	60	26.8
	Medium (000-15,000)	35	27.1	39	41.1	74	33.0
	Large (>15,000)	72	55.8	18	18.9	90	40.2
Total		129	100.0	95	100.0	224	100.0

4.2. Differences Between Institutions with Required and Optional Co-ops

Of 129 institutions offering co-ops, only 12 (9.3%) required co-ops for some or all engineering majors. Table 2 shows the characteristics compared between institutions with required co-ops and institutions with optional co-ops. Overall, institutions with co-ops were mostly large, public, and doctoral. However, institutions where co-ops are required had a larger proportion that were non-doctoral and a larger proportion with a small undergraduate enrollment. A U.S. map of the institutions with co-ops can be found in Figure 1.

Table 2. Comparison of Characteristics Between Institutions with Required and Optional Co-ops

Characteristic	Category	Co-ops Required		Co-ops Optional		All Institutions with Co-ops	
		N	%	*N*	%	*n*	%
Institution Ownership	Public	7	58.3	84	71.8	91	70.5
	Private	5	41.7	33	28.2	38	29.5
Degree levels offered	Doctoral	3	25.0	76	65.0	79	61.2
	Non-Doctoral	9	75.0	41	35.0	50	38.8
Undergraduate Enrollment	Small (<5000)	6	50.0	16	13.7	22	17.1
	Medium (5000-15000)	4	33.3	31	26.5	35	27.1
	Large (>15000)	2	16.7	70	59.8	72	55.8
Total		12	100.0	117	100.0	129	100.0

Figure 1. Map of institutions offering co-ops.

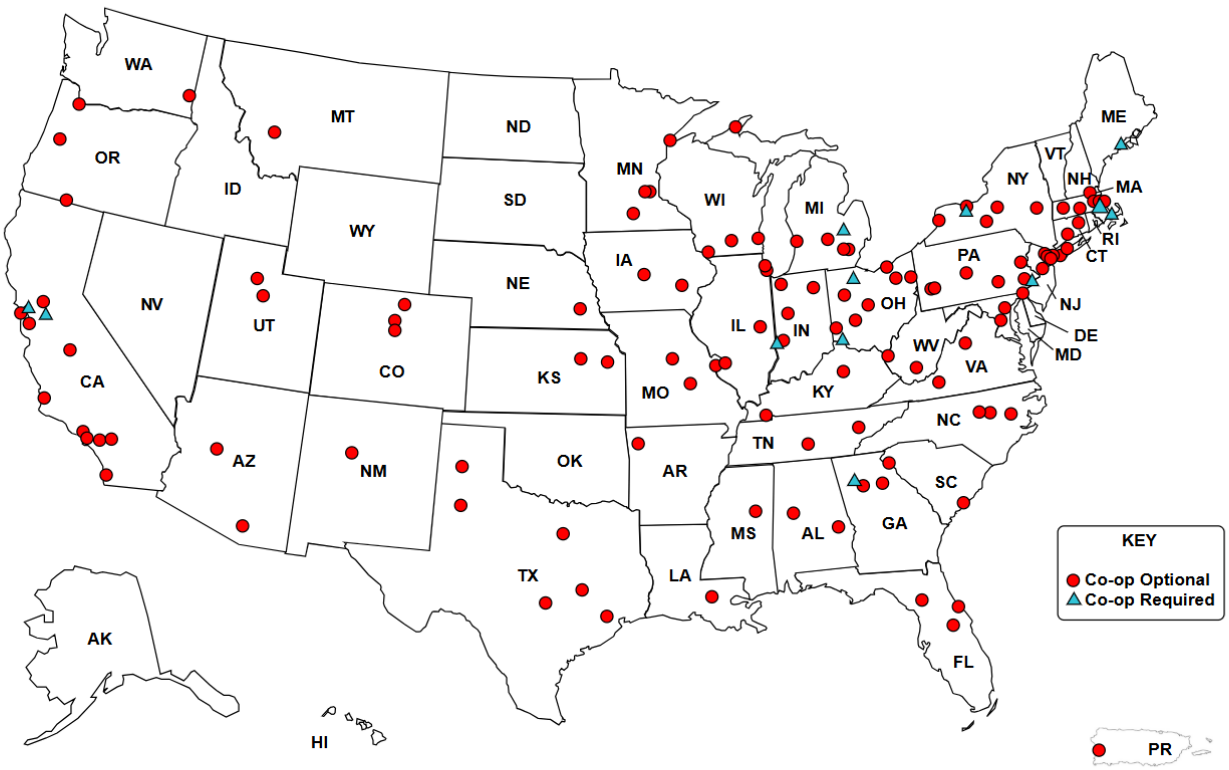

Figure 1 shows a geographic distribution of co-op institutions across the four regions of the U.S. [18]. As shown in Table 3, 39 (30.2%) out of 129 institutions with co-ops were located in the Midwest. The Midwest also has the largest number of co-op optional institutions at 35 (29.9%). However, of the institutions with required co-op programs, most (*n* = 5, 41.7%) were located in the Northeast.

Table 3. Summary of the geographic distribution of co-op institutions in the US

Region	Description	Co-ops Required		Co-ops Optional		All Institutions with Co-ops	
		N	%	*N*	%	*n*	%
Northeast	New England, North Atlantic	5	41.7	26	22.2	31	24.0
Midwest	East North Central, West North Central	4	33.3	35	29.9	39	30.2
South	South Atlantic, East South Central, West South Central	1	8.3	33	28.2	34	26.4
West	Mountain, Pacific	2	16.7	23	19.7	25	19.4
Total		12	100.0	117	100.0	129	100.0

4.3. Paths to the First Co-op

Several common paths to the first co-op are shown in Table 4. Some institutions had unique paths to the first co-op, which are not shown in this table. 52 (40.3%) of the 129 institutions offering co-ops did not have public information about the timing of the first co-op.

Table 4. Common Paths to the First Co-op.

Path	Description	Timing of the first co-op	# of Institutions
Path 1	Students can engage in their first co-op immediately after their first-year engineering experience.	Fall semester of the second year	22
Path 2	Students can engage in their first co-op after ONE semester of courses in their engineering major, after their first year.	Spring semester of the second year	12
Path 3	Students can engage in their first co-op after TWO semesters of courses in their engineering major, after their first year.	Summer semester of the second year *or* Fall semester of the third year	25

Note. # of institutions counted out of the 129 institutions offering co-ops.

4.4. Specifics of the 12 Institutions Requiring Co-ops

Bowling Green State University. Bowling Green State University is a medium-sized public non-doctoral institution. The university follows a two-semester system with an optional summer semester. Engineering students at Bowling Green State University are required to complete one to three co-ops, depending on their major. Students are asked to work with their academic advisors to plan their co-op schedules. Program duration is four to five years.

California State University – Maritime Academy. California State University, Maritime Academy is a small public non-doctoral institution. The university follows a three-semester system. Mechanical engineering students at this institution are required to complete two co-op rotations, the first during the summer semester of their second year (Path 3), and the second during the summer semester of their third year. Students graduate in four years.

Drexel University. Drexel University is a medium-sized private doctoral institution. The university operates on a four-period system, with fall, winter, spring, and summer semesters. The co-op program at Drexel University has two main co-op pathways for engineering students. The more popular pathway is the five-year degree option, in which students start their first co-op in the fall semester of their second year (Path 1). Students complete three co-op rotations, each lasting 6 months, alternating between two semesters of co-op and two semesters of coursework. The other pathway is the four-year degree option, in which students complete only one co-op, starting in the fall semester of their third year (Path 3). Depending on the chosen degree option, students graduate in four or five years.

Grand Valley State University. Grand Valley State University is a large public non-doctoral institution. The university follows a three-semester system. The institution has one main co-op pathway, which requires 3 co-op rotations. Students start their first co-op in the summer semester of their second year (Path 3) and alternate between one semester of co-op and one semester of coursework. Some students may choose to start their first co-op a semester earlier or follow a more flexible schedule, though deviating from the standard pathway requires permission from the co-op coordinator. Students graduate after four years.

Indiana State University. Indiana State University is a medium-sized public non-doctoral institution. The university follows a two-semester system with an optional summer semester. Some engineering majors at the institution are required to complete co-ops, including manufacturing engineering technology and mechanical engineering technology. Students in these engineering majors start their first co-op after completing their first year (Path 1). Students graduate after four years.

Kettering University. Kettering University is a small private non-doctoral institution. The university uses a quarter system, consisting of four semesters. At Kettering University, there is one main co-op pathway for engineering students. Students can start their co-op during their first year, and complete two three-month rotations each year, alternating between three months of coursework and three months of co-op. The engineering program's duration is between 4.5 and 5 years.

Maine Maritime Academy. Maine Maritime Academy is a small public non-doctoral institution. This institution follows a three-semester system. At Maine Maritime Academy, students in some engineering majors are required to complete co-ops. Marine systems engineering students can choose from two co-op pathways. In the four-year track, students complete two co-ops, with the first co-op starting in the third semester of their second year (Path 3), and their second co-op occurring in the third semester of the following year. Power engineering technology majors also follow this track. In the five-year track, students complete one co-op in the third semester of their fourth year. Depending on the chosen degree option, students graduate in four or five years.

Massachusetts Maritime Academy. Massachusetts Maritime Academy is a small public non-doctoral institution. The university follows a two-semester system with optional winter and summer semesters. Students in several engineering programs at Massachusetts Maritime Academy, including energy systems engineering and facilities engineering, are required to complete three co-op rotations. These co-ops are typically completed in the summer or winter semesters. Students graduate in four years.

Rochester Institute of Technology. The Rochester Institute of Technology is a medium-sized private doctoral institution. The university uses a three-semester system, with fall, spring, and summer semesters. The institution has two sets of co-op requirements, one for software engineering and packaging science majors, and one for all other engineering majors. For most engineering majors, students complete four rotations of co-ops, with their first co-op starting in the fall semester of their third year (Path 3) and alternating between a semester of co-op and a semester of courses. For software engineering and packaging engineering majors, their co-op pathway starts in the summer of the second year (Path 3). Software engineering majors complete three co-op rotations, while packaging science majors complete two co-op rotations. Both these majors only take co-ops during the summer semester. All engineering degree programs have a 5-year duration.

University of Cincinnati. The University of Cincinnati is a large public doctoral institution. The university uses a three-semester system, with fall, spring, and summer semesters. The institution offers two main co-op pathways for engineering students, depending on major. In one pathway, students start their first co-op during the fall semester of their second year (Path 1). In the other pathway, students start their first co-op in the spring semester of their second year (Path 2). Students complete five co-op rotations, alternating between one semester of co-op and one semester of coursework. Although most students complete the undergraduate degree in five years using one of the two main co-op pathways, a small number of students may choose to opt into a four-year curriculum, in which students still start their first co-op during the fall semester of their second year, but only complete a total of four co-ops instead of the usual five.

University of the Pacific. The University of the Pacific is a small private non-doctoral institution. The university follows a two-semester system, with an optional summer semester. At the University of the Pacific, co-op is required for all engineering students except those in computer science and bioengineering. Students typically complete their co-op in their third or fourth year, beginning either in the spring semester of their third year or in the summer before their fourth year. The co-op usually takes place over the combination of one semester and one summer. Students can complete their degree in four years, but some may take five.

Wentworth Institute of Technology. Wentworth Institute of Technology is a small private non-doctoral institution. The university follows a two-semester system, with an optional summer semester. The institution has one main co-op pathway. Students complete two co-op rotations, each one semester long, with their first co-op in the spring semester of their third year, and their second co-op in the fall semester of their fourth year. Students graduate in four years.

5. Discussion

This study examined the prevalence, requirement status, and curricular pathways of cooperative education (co-op) in the top 224 U.S. undergraduate engineering programs. The discussion is organized around the three research questions.

5.1. Prevalence of Co-op Offerings and Institutional Characteristics

Most U.S. engineering programs offer co-op opportunities in some form, with offering institutions tending to be larger and more often doctoral-granting. A possible explanation is that larger and doctoral-granting universities may have extensive industry connections, in part due to a larger alumni network.

5.2. Required Co-op Participation and Institutional Characteristics

Only a small subset of institutions requires co-op participation for graduation. These institutions are more often smaller and non-doctoral. These characteristics could imply that institutional mission and curricular priorities play a key role in positioning co-op as a core requirement. Notably, maritime academies are overrepresented among required co-op institutions, indicating that disciplines with strong applied or regulated professional contexts may place greater emphasis on mandatory workplace experience.

5.3. Pathways to the First Co-op Experience

Among institutions requiring co-ops, substantial variation exists in the timing, number, and duration of co-op rotations. First co-op experiences occur anywhere from the first year to the third year, with one to five required rotations lasting three to six months. This variation suggests that there is no single dominant model for structuring co-op pathways. Instead, institutions tailor co-op integration to their curricular sequencing and institutional context.

5.4. Incomplete Co-op Information on Institutional Websites

Throughout the process of conducting content analysis of publicly available institutional materials, we noticed that many institutional websites were unclear or provided incomplete information when describing co-op opportunities and programs. While this was not an intended research focus initially, this finding has important implications. Especially for institutions where co-op participation is optional, publicly available information about co-op pathways is frequently limited. Websites typically highlight the benefits of co-op but provide little detail on eligibility, timing, or curricular integration, instead directing students to academic advisors. This reliance on informal advising may disadvantage prospective or early-career students seeking clear information about experiential learning opportunities. The insufficient clarity and completeness of co-op information on institutional websites can create a barrier for engineering students to enter their co-op participation.

5.5. Significance

The findings serve as a foundation for comparative analysis of access, timing, and curricular integration in co-op offerings. By identifying patterns and institutional co-op models, this research contributes to a broader understanding of how co-op pathways shape engineering students' professional formation and workforce preparedness.

5.6. Limitations and Future Research

Although we tried to be as thorough as possible in the search and coding of the institutions, it is possible that some information about co-ops was missed due to convoluted websites and unclear information.

Co-op pathways in institutions where co-op is optional, but most students participate, can also be examined. For example, at Purdue University and Northeastern University, engineering students are not required to participate in co-ops. However, most students choose to participate, making co-ops a large focus in these institutions. Looking into these institutions can be beneficial for providing a more thorough overview of the pathways to first co-ops at the U.S. institutions. In addition, while this study used only publicly available institutional materials, future studies can involve reaching out to co-op offices for more details, focusing on institutions where co-ops are popular.

Other information that can be analyzed includes the types of co-ops that students engage in (e.g. industry-based or research-based), the mode of the co-ops (e.g. in-person, remote, or hybrid), as well as second and subsequent co-ops.

5.7. Conclusion

Together, these findings underscore the importance of institutional design in shaping students' opportunities to engage in co-op experiences. Clarifying co-op pathways, particularly entry points into the first co-op, represents a critical step toward improving transparency and intentionality in engineering work-integrated learning.

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