"It's Not You, It's the Room"—Are the High-Tech, Active Learning Classrooms Worth It?

By Sehoya Cotner, Jessica Loper, J. D. Walker, and D. Christopher Brooks

Several institutions have redesigned traditional learning spaces to better realize the potential of active, experiential learning. We compare student performance in traditional and active learning classrooms in a large, introductory biology course using the same syllabus, course goals, exams, and instructor. Using ACT scores as predictive, we found that students in the active learning classroom outperformed expectations, whereas those in the traditional classroom did not. By replicating initial work, our results provide empirical confirmation that new, technology-enhanced learning environments positively and independently affect student learning. Our data suggest that creating space for active learning can improve student performance in science courses. However, we recognize that such a commitment of resources is impractical for many institutions, and we offer recommendations for applying what we have learned to more traditional spaces.

Among active learning strategies, team-based learning (or cooperative learning) has perhaps the longest history and the richest evidentiary basis (Michael, 2006; Prince, 2004; Springer, Stanne, & Donovan, 1999). Yet architecturally, traditional classrooms with rows of students facing a single focal point—the instructor or a central screen or board—are not necessarily conducive to peer interaction (Milne, 2006; Oblinger, 2006). In response to this perceived barrier to the implementation of active learning strategies, a few institutions have pioneered the reconfiguration of entire classrooms (e.g., North Carolina State University's SCALE-UP classrooms [Beichner et al., 2007] and the TEAL project at MIT [Dori, 2007]). These rooms are designed to encourage student interaction and facilitate active or team-based collaborative learning by including features such as round tables, movable chairs, student laptop connections for sharing work on overhead projectors, and tableside whiteboards.

Some work has been done to assess the effectiveness of these rooms in contributing to meaningful student interactions and in increasing student understanding of course material (Dori & Belcher, 2005; Gaffney, Richards, Kustusch, Ding, & Beichner, 2008). At both North Carolina State University and MIT, students in the modified classrooms had lower failure rates and increased levels of conceptual understanding compared with students taking the course in a traditional classroom using a lecture-based approach. However, the interpretation of these early results is constrained because of methodological limitations; specifically, the previous work lacks sufficient controls to make a case for the physical space as opposed to the instructor (or pedagogical approach) in contributing to student gains.

After a pilot study of two active learning classrooms (or ALCs), the University of Minnesota constructed the new Science Teaching and Student Services (STSS) building with 10 ALCs (Whiteside, Brooks, & Walker, 2010). These classrooms, modeled in part on North Carolina State University's SCALE-UP classrooms, consist of a centralized teaching station with technological controls and from 3 to 14 nine-person round tables, each of which has several laptop connections, a dedicated large overhead LCD screen, whiteboard space, several microphones, and visual access to large projection screens (Figure 1). Constructing these rooms required a significant up-front and long-term commitment of scarce resources, expenditures that are especially onerous for a public institution facing budget constraints and increased tuition costs in a strapped economy. Was the investment worth it?

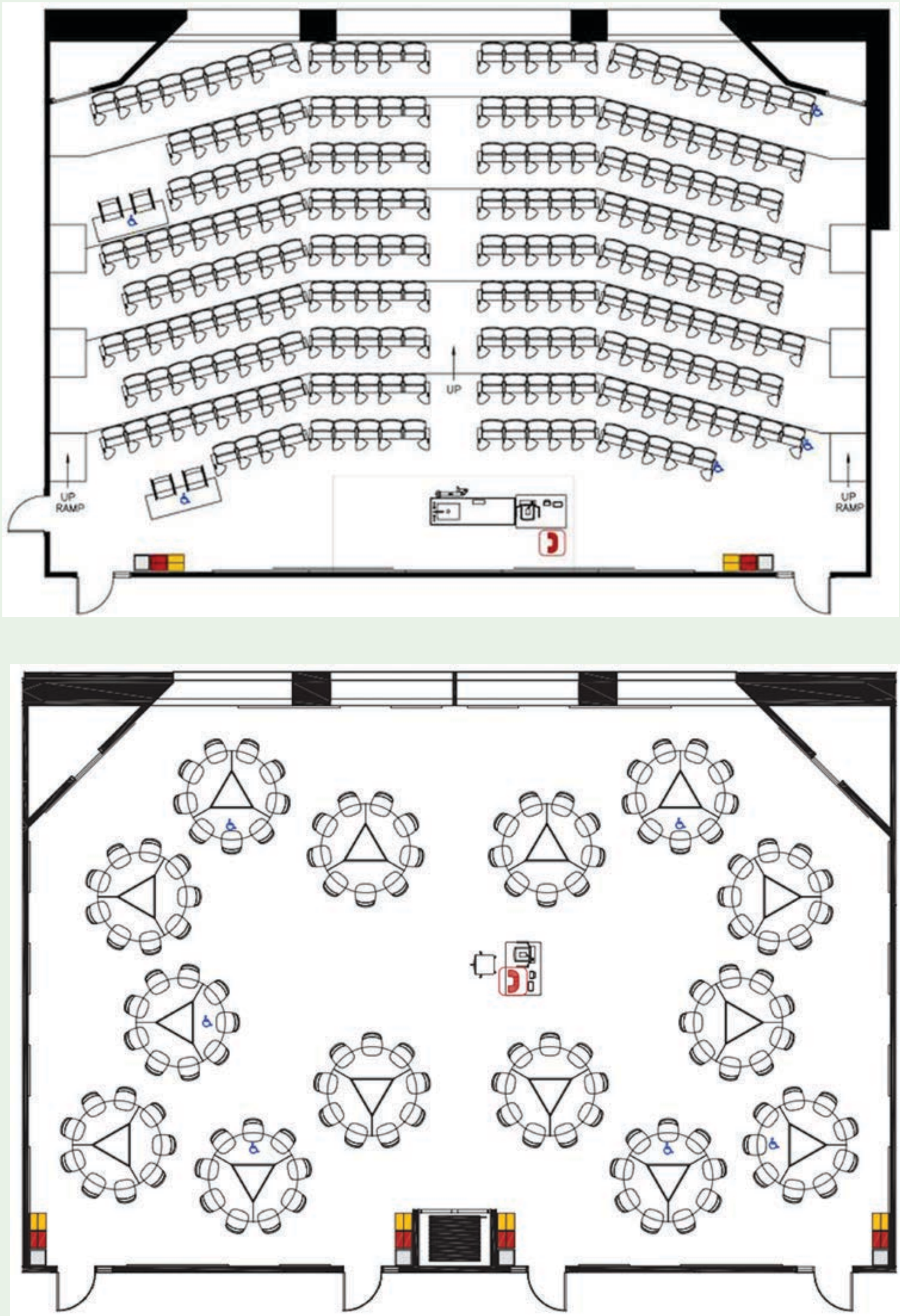
Learning gains in active learning classrooms

To determine whether the investment has had the desired effects, researchers at the University of Minnesota have engaged in a longitudinal investigation of the ALCs' impact on how instructors teach and how students learn.

Early work on the ALCs (Whiteside et al., 2010) focused on student and faculty attitudes, expectations, and perceptions of the rooms. Faculty members had high expectations when they began teaching in the ALCs and strongly positive attitudes toward the spaces at the end of the term; many noted that their role changed in the ALCs, shifting to the role of a learning coach or facilitator. Students also had strongly positive attitudes toward the ALCs, particularly regarding the rooms' facilitation of teamwork and collaboration with their classmates and the ability of ALCs to appeal to a variety of learning styles. Both faculty and students noted the importance of the round-table design in altering the classroom dynamic in important ways. However, some differences emerged: Freshmen and sophomores rated the rooms more highly than

FIGURE 1

Top: Layout of traditional classroom (STSS 220). Bottom: Layout of active learning classroom (STSS 330). More details available at http://www.classroom.umn.edu/.



did upperclassmen, and metropolitan students perceived the rooms as more useful than did students from rural backgrounds.

Preliminary study

Following initial work on perceptions and attitudes, researchers worked with a faculty member to design a quasi-experimental study in an effort to isolate the impact of the room itself on student learning. The instructor taught the same section of an introductory biology course (Postsecondary Teaching and Learning 1131), but in two different rooms—an ALC and a traditional classroom. The two sections were taught at the same time of day, yet on different days of the week. Course materials, assignments, exams, and pedagogical approaches were controlled across sections; the only factor that varied systematically was the room itself. Researchers were unable to assign students randomly to the treatment and experimental sections; however, students were unaware of the room differences during course registration, allowing for post hoc demographic equivalency to be established. The only anomaly that emerged between the sections was that students in the traditional classroom had, on average, significantly higher ACT scores than did students in the ALC (22.54 vs. 20.52; $p < .05$). Given the predictive nature of ACT scores (e.g., ACT, 2007; Marsh, Vandehey, & Diekhoff, 2008; Stumpf & Stanley, 2002), we expected students in the traditional classroom to earn higher grades than their peers in the ALC. However, at the end of the term, there was no significant difference in class performance, on identical metrics, between the two sections (Brooks, 2011). This finding suggested that the ALCs positively affected student learning.

TABLE 1

Students in the traditional classroom had significantly higher ACT scores (yet did not perform significantly better in the course).

	Traditional classroom	ALC	Difference
Age	19.78 (0.18) 161	20.43 (0.32) 102	0.65
Sex (female = 1)	0.76 (0.03) 161	0.65 (0.05) 102	0.11
Caucasian	0.82 (0.03) 164	0.78 (0.04) 102	0.04
Year (senior = 4; first year = 1)	2.03 (0.08) 162	2.19 (0.11) 101	0.16
Metropolitan	0.75 (0.04) 107	0.66 (0.06) 74	0.09
ACT score	26.36 (0.31) 139	25.32 (0.37) 81	1.04*
Grade (% of total)	77.77 (0.69) 161	76.69 (0.84) 102	1.28

Note: Cell entries for each classroom are means, standard errors (in parentheses), and the number of cases for two-group, mean-comparison tests. ALC = active learning classroom.
*$p < .05$.

Methods and data collection

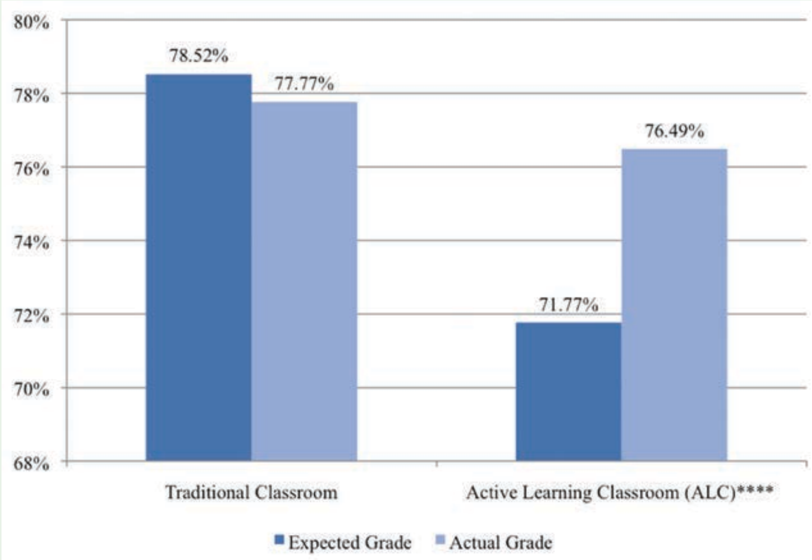
In spring 2011, we sought to replicate these initial results using a similar quasi-experimental design with a different course, different instructor, and groups of students that were both larger and more representative of our general student population than the students involved in the initial study. Specifically, one instructor worked with two groups of students enrolled in an introductory biology course for nonscience majors (Biology 1003). One group met in a traditional classroom, the other in an ALC. In addition to controlling for instructor, every attempt was made to keep course material and designed activities the same across the two sections. Laboratory exercises were identical, as were quizzes, homework assignments, and all three major exams.

Biology 1003 is a large introductory class ($N = 161$ and 102 for the traditional and active sections, respectively). Survey data were collected via surveys administered in class on the last day of the term. The University of Minnesota's Institutional Review Board approved the protocol, and we obtained informed consent for all subjects. Demographic and grade data were supplied by the University Office of Institutional Research and the instructor, respectively.

A project PI and a trained student researcher collected observational data on 50% of randomly selected class periods for both sections. An observer recorded the levels at which students appeared to be "on task," as well as specific characteristic behaviors of the instructor (e.g., lecturing, consulting individuals or groups, and working problems with the document scanner) and the students (e.g., consulting in a group, asking questions, and working on a group activity). And finally, students were surveyed about their experiences and perceptions in their respective classrooms on the last day of class. The design was intentionally quasi-experimental in that we used principles of experimental design, but we were unable to randomly assign subjects to control and experimental groups. However, we worked with the same instructor, same syllabus, and same test items, and the sections were offered back-to-back in the late morning on the same days (Tuesdays and Thursdays); only the space was allowed to vary systematically. Although the random assignment of students into sections that would have afforded a fully experimental design was not possible, the enrollment process (e.g., registering for a specific lab section), coupled with post hoc equivalency tests, essentially approximates randomization. We suspect dialogue between the sections was minimal to nonexistent: Students enrolled from a variety of majors within a very large university, lab sections were specific to each class section, and the sections—although offered back-to-back—were on different floors of the classroom building with only 15 minutes separating them.

FIGURE 2

Expected versus actual grades (BIOL 1003). Students in the ALC earned significantly higher final grades than their ACT scores predicted (***p* < .0001).**



All instruments used in this research have been tested for scale reliability and validity and are available online at http://z.umn.edu/lsr.

Results

Like our earlier study, students in the traditional classroom had, on average, significantly higher ACT scores and were thus expected to outperform students in the ALC. And, like our earlier study, final scores—on identical metrics—were not significantly different across sections (Table 1). Given what we know about the predictive capacity of the ACT scores for grades, this finding is surprising. Using a point estimation regression model, we expected students in the ALC to earn approximately 6 percentage points lower on their final grades than their peers in the traditional classroom; instead, students in the ALC earned half of a letter grade more than expected ($p < .0001$; Figure 2). However, just as we observed in the first experiment (Brooks, 2011), the altered environment did not undermine the ACT's predictive power. In both classrooms, the ACT score served as a reliable predictor of performance, predicting 20% and 23% of variation in student grades in the traditional and ALC spaces, respectively (Table 2, Model 1). Even when we control for a host of demographic variables, ACT composite scores continued to be the only significant predictor of student grades with little explanatory improvement over the initial model (Table 2, Models 2 and 3). Thus, the patterns of evidence in support of our initial findings—that ALCs have a significant and independent impact on student performance—are identical.

In the ALC, the same instructor, teaching the same material, spent more time consulting and leading group activities and less time at the podium (Figure 3). Furthermore, tetrachoric correlational analysis (rho) reveals significant and positive relationships between ALCs and group activities ($p < .05$) and consultation ($p < .01$), and negative relationships with location in the room ($p < .05$).

Several significant differences emerged in student perceptions of the learning spaces (Figure 4): Students in the ALC reported a higher level of engagement than did their peers in the traditional classroom ($p < .0001$); also, ALC students reported higher room flexibility in regard to in-class activities ($p < .001$); finally, students in the ALC perceived a higher alignment between the room and the course ($p < .01$).

Discussion

Our findings show that students in the ALC outperformed their counterparts in the traditional classroom, everything else being equal (gender, race, year in school, etc.). By replicating initial work, our results provide empirical confirmation that new and technology-enhanced learning environments positively and independently affect student learning.

We are doubly intrigued by the fact that these effects were noted in the courses of two very different, but skilled and experienced, instructors—one a faculty member using a hybrid lecture problem-solving approach in both classrooms and one a faculty member using active-lecturing techniques with both groups (the present study).

TABLE 2

Ordinary least squares (OLS) regression of ACT score on course grade, by section.

	Traditional classroom			ALC		
	Model 1	Model 2	Model 3	Model 1	Model 2	Model 3
ACT composite score	1.06*** (0.18)	0.97*** (0.19)	0.97*** (0.21)	1.25*** (0.25)	1.23*** (0.28)	1.06** (0.35)
Age		–0.08 (0.45)	–0.10 (0.45)		–0.03 (0.77)	–1.64 (1.28)
Sex		2.63 (1.62)	2.34 (1.98)		1.32 (1.89)	0.85 (2.36)
Caucasian		3.32 (2.06)	0.70 (2.53)		2.77 (2.33)	1.21 (2.85)
Year		–1.23 (0.82)	–1.17 (0.92)		–0.80 (1.19)	0.75 (1.78)
Metro			–2.61 (1.72)			–3.38 (2.26)
Constant	50.58*** (4.74)	51.75*** (10.97)	57.03*** (12.13)	44.93*** (6.31)	44.35* (17.56)	81.32** (27.45)
Adjusted R^2	0.20	0.24	0.26	0.23	0.23	0.22
N	139	139	97	81	81	58

Note: Cell entries are unstandardized OLS regression coefficients with standard errors in parentheses. ALC = active learning classroom.
*$p < .05$. **$p < .01$. ***$p < .001$.

How can a classroom positively affect student learning?

Work on learning spaces encourages us to reevaluate the role of a physical space in facilitating or hindering the construction of knowledge (Whiteside et al., 2010). Specifically, traditional classrooms, especially those with chairs bolted in place, emphasize the instructor over the student and make group formation seem awkward and contrived. Round tables allow students "face time" with other students, deemphasize the role of the instructor, and permit groups to form naturally. We tested these predictions via a systematic analysis of student and instructor behaviors, throughout the course of a class session, in 15 randomly selected sessions during the semester.

Our analysis of classroom behaviors highlights some possible causes for the room effect (Figure 3). Specifically, in spite of concerted effects to maintain equivalency across the two sections, the space itself appears to have exacted behavioral differences in course delivery. Student survey responses reinforce this notion (Figure 4). We acknowledge that positive student perceptions of the impact of the room are not the same as saying the room actually has an impact. Regardless, these data are consistent with the behavioral differences and performance gains documented previously.

Was the investment worth it?

We believe that the investment in ALCs at the University of Minnesota was worth it. Documented increases in student engagement and confirmed average gains of nearly 5 percentage points in final grades are improvements in the student academic experience that few educational interventions could aspire to. However, whether these improvements warrant the capital investment in ALCs is a judgment each educational institution must make for itself, drawing on local priorities and resources.

Instructors may need to think seriously and creatively about changing the manner in which they deliver their courses in spaces such as these—not only for the sake of navigating the challenges of teaching in a decentered space, but also to take advantage of the features of the room that allow us to better realize the benefits of active learning. The classroom architecture is bound to frustrate the efforts of faculty who don't yield to the rooms' novel demands. There is no well-identified "stage" from which to deliver a traditional lecture. Half of the students in the class may be facing away from the instructor at any given time. Teachers who view silence as engagement will need to adjust their perceptions, as one goal of decentralized classrooms is increased small-group interaction and this activity can be noisy and difficult to monitor. And, in the case of the ALCs at our institution, there is a learning curve with respect to the technological capabilities of the rooms.

Considering these hurdles, a substantial commitment to the ALC is required from instructional staff. As evidence of this commitment, a variety of institutional resources exist at the University of Minnesota to aid faculty in the transition to these novel learning spaces. Resources range from technology training courses, to month-long workshops, to 18-month faculty development programs—all designed to support technology-enhanced learning. A faculty-development program explicitly focused on ALCs would be a welcome addition to this arsenal.

Given the resources expended in making this transformation, faculty should require evidence of the ALCs' effectiveness. In addition to the existing work on student engagement via active learning, the results described herein document the positive impacts of designing spaces for active learning.

Recognizing that such a commitment of resources is impractical for many institutions, we offer recommendations for applying what we've learned to more traditional spaces. Figures 3 and 4 suggest that the benefits of these rooms may hinge on their flexibility and their explicit emphasis on small-group interaction (e.g., the round, nine-person tables). Namely, any efforts to decentralize the room, with an overt focus on group dialogue, are likely to increase the individual student's sense of accountability and lead to the learning gains that result from peer interaction. Decentralization can be accomplished several ways, from something as simple as movable chairs, to small tables with whiteboards for impromptu problem-solving or presentation, to full-blown ALCs as documented previously. When a student enters one of our ALCs for the first time, he or she gets a clear message that this class will not be "business as usual." However, we are confident that this message, and the gains we associate with ALCs, can be achieved in numerous ways by inspired faculty seeking the best for their students. ■

Acknowledgments

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FIGURE 3

Interval frequency of observed classroom activity and instructor behavior (BIOL 1003): traditional vs. ALC. Data are percentages of 5-minute intervals in which the activity or behavior was observed. Given that more than one activity or behavior was possible in any given interval, totals do not sum to 100%. *$p < .05$. **$p < .01$. ***$p < .001$.

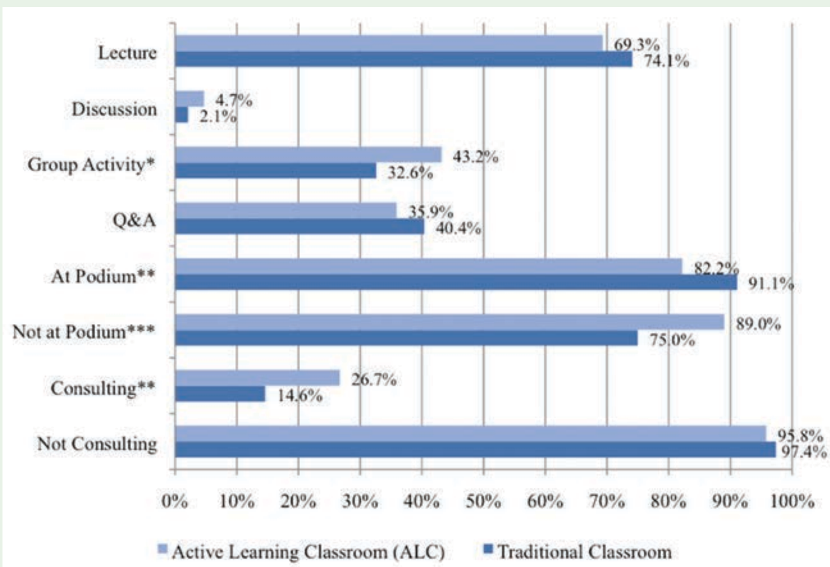

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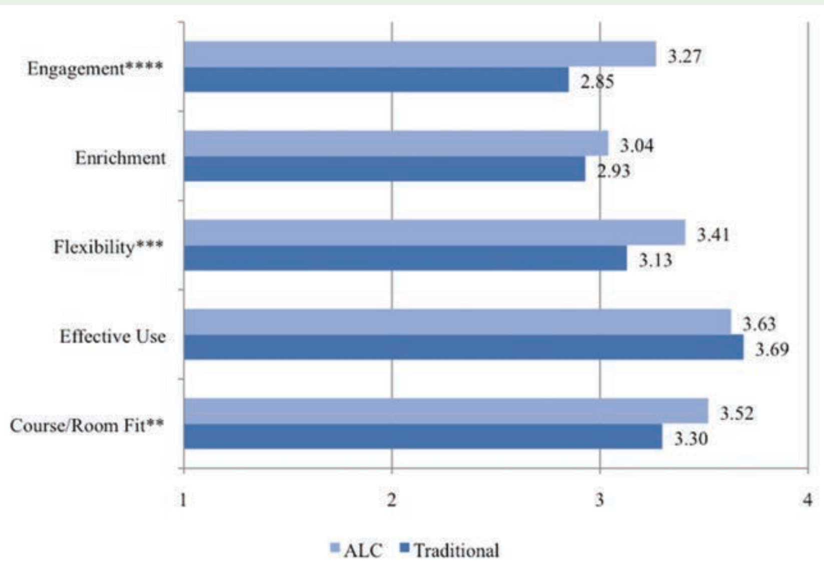
FIGURE 4

Student perceptions of classroom impact (BIOL 1003), traditional vs. ALC. Students in the ALC agreed significantly more than their peers in the traditional classroom that the room engaged them in the learning process, was flexible with regards to classroom activities and approaches to learning, and was an appropriate space in which to hold the course. **$p < .01$. ***$p < .001$. ****$p < .0001$.



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