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Distributed Practice and Interleaved Practice: Undergraduate Students' Strategies, Experiences, and Beliefs

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ABSTRACT

Do undergraduate students know and use *distributed practice*, the strategy of spacing apart learning opportunities over time, and *interleaved practice*, the strategy of alternating between topics during learning? What beliefs do students hold about how learning should be scheduled, and how are common learning activities—such as using flashcards and completing problem sets—actually scheduled? To explore these questions, we surveyed students at two major universities in North America and Southeast Asia, respectively. We found that distributed practice is unfamiliar to many students, whereas interleaved practice is virtually unknown. Both strategies are often underutilized and perceived with mixed effectiveness. Instructors, meanwhile, reportedly use various scheduling approaches in lectures and assignments. Additionally, distributed practice was associated with better academic performance. These findings, which showed relative consistency across culturally diverse samples, underscore significant gaps in student awareness and adoption of distributed and interleaved practice, highlighting the need to improve their integration into educational settings.

1 | Introduction

The *scheduling* of learning activities—that is, when one engages in learning activities and the order with which those activities occur—can affect knowledge acquisition, retention, and transfer in profound ways. Whereas some scheduling strategies yield rapid forgetting and limited learning, others produce better outcomes. Two strategies, *distributed practice* and *interleaved practice*, stand out for their capacity to enhance learning. These strategies are emblematic of what R. Bjork (1994) (see also E. L. Bjork and Bjork 2011) called "desirable difficulties"—that is, methods of learning that are usually more effortful or challenging to implement, yet yield better outcomes over the long term.

Distributed practice involves spreading learning activities out over time, as opposed to *massing*, where learning is concentrated into a single session. For instance, a student might review a topic over several days rather than intensively in one sitting. In another example, they might perform retrieval practice (i.e., self-testing) on a topic over several days rather than on just 1 day. Engaging in distributed practice often yields better learning than massing, a phenomenon called the *spacing effect*. Over 300 studies have shown the spacing effect across diverse learners, content types, activities, and outcomes, from recall to problem-solving (for reviews see Carpenter et al. 2022; Carpenter and Pan 2024; Cepeda et al. 2006; Donovan and Radosevich 1999; Janiszewski et al. 2003; cf. Rodriguez et al. 2021; Ruiz-Martín et al. 2024). Accordingly, many researchers now urge students and instructors to use distributed practice (e.g., Carpenter et al. 2012; Kang 2016; Rohrer 2015; Wiseheart et al. 2019).

Interleaved practice involves alternating between a series of topics as they are learned. For example, rather than studying three physics topics in three separate sessions, one might switch between these topics within every session. This approach includes an element of distributed practice, as exposures to each topic are spread out in time. Relative to *blocking*, where one focuses on only one topic at a time, interleaved practice improves learning from studying or completing problem sets in such domains as visual category induction (e.g., Kornell and Bjork 2008) and mathematics instruction (e.g., Rohrer et al. 2015). This phenomenon, called the *interleaving effect*, appears strongest when the topics being learned are similar in some way (Brunmair and Richter 2019; Firth et al. 2021; Kang 2017). Although more investigation of interleaved practice in real-world settings is needed (Dunlosky et al. 2013), some researchers already endorse its use in certain learning contexts, such as learning to distinguish between perceptually similar categories (e.g., Firth et al. 2021; Rohrer 2012; Weinstein et al. 2018).

In contrast with the growing evidence showing pedagogical benefits of distributed and interleaved practice, far less is known about how undergraduates engage with these strategies on their own or in activities that instructors prepare for them. Measuring such behaviors and experiences can be challenging due to the variability of student experiences and the dynamic, context-dependent nature of self-regulated learning (Rovers et al. 2019). In the broader context of learning research, researchers have used offline measures where participants report their thoughts and activities after learning (e.g., surveys and interviews), as well as online measures that capture behaviors in real time (e.g., trace data and think-aloud protocols). Some approaches blend both methods, such as having participants respond to research-generated scenarios. Each approach has its strengths and weaknesses: Offline measures can be used widely but rely on respondent reports (Rovers et al. 2019; Schellings and Van Hout-Wolters 2011), which can be unreliable, whereas online measures offer direct insights but can be impractical and miss underlying motivations. Although some of these approaches have been used to address the scheduling of learning activities among undergraduates, most have yet to be applied specifically to investigate the issue.

1.1 | How Learning Activities Are Commonly Scheduled

To date, insights into undergraduates' scheduling behaviors have come from studies where participants select from possible study sequences or plan out imaginary study schedules (e.g., Hartwig et al. 2022; Tauber et al. 2013; Wissman et al. 2012). In such studies, learners tend to choose massing or blocking rather than distributed or interleaved practice. Although these studies provide useful information, they primarily simulate learning practices rather than directly measure them. Further insights come from studies of study behaviors in psychology and other undergraduate courses, where students often resort to massing their study sessions before high-stakes exams (Blasiman et al. 2017; Carvalho et al. 2016; Hartwig and Malain 2022; Taraban et al. 1999). Such studies have commonly used learning analytics to measure student activities, and their findings are usually specific to the course or subject under investigation.

Additionally, some surveys of student study habits have included questions about study schedules, revealing trends toward massing and blocking (Bartoszewski and Gurung 2015; Hartwig and Dunlosky 2012; Kornell and Bjork 2007; Morehead et al. 2016; Susser and McCabe 2013), although few have focused exclusively on distributed and/or interleaved practice. These studies generally support claims that students default to massing and blocking when scheduling learning activities (e.g., Carvalho and Goldstone 2019; Rohrer 2012). Yet, how widespread these patterns are across different learning environments remains unclear.

The ways in which instructors schedule learning activities for their students are also largely unexplored. Instructors' use of effective scheduling approaches is debatable; for instance, Rohrer (2015) argued that students seldom encounter massing in classrooms, as instruction on any given topic is typically spread across multiple days, and Samani and Pan (2021) reported college science instructors' claims that they revisit material periodically (a practice that could foster distributed learning) and avoid exclusive focus on single topics (which might reduce blocking). A survey of university instructors by Morehead et al. (2016), meanwhile, found that the vast majority encourage and incorporate spacing into their instructional practices. Yet analyses of mathematics and language learning textbooks suggest that massing and blocking of lessons and practice exercises are common (Pan, Tajran, et al. 2019; Rohrer, Dedrick, and Hartwig (2020)). Further research is needed to reconcile these contrasting findings.

1.2 | What Students Know and Believe About Scheduling Strategies

Students may be more likely to use distributed and interleaved practice if they are aware of both strategies and believe in their effectiveness (for related theorizing, see McDaniel and Einstein 2020; Pan and Rivers 2023). Survey research offers relevant insights, but as in the case of their scheduling behaviors and experiences, most of this research has relied on hypothetical scenarios or domain-specific tasks (e.g., Feenstra et al. 2024; Kornell et al. 2010; Kornell and Bjork 2008; Onan et al. 2022; Van Etten et al. 1997; Yan et al. 2017). Susser and McCabe (2013) (see also Blasiman et al. 2017), for example, surveyed undergraduate students and found that most preferred distributed practice over massing after reading hypothetical scenarios, whereas McCabe (2011) found that most survey respondents favored blocking after reading a description of a study comparing interleaved practice and blocking. Hartwig et al. (2022) had undergraduates rate example schedules for learning mathematics, resulting in high ratings for distributed practice, moderate ratings for massing, and lukewarm ratings for interleaved practice.

Collectively, findings to date suggest that whereas undergraduates may recognize the effectiveness of distributed practice (e.g., Susser and McCabe 2013), they are less aware of the benefits of interleaved practice (e.g., McCabe 2011). Yet undergraduates' beliefs and practices pertaining to these strategies in the context of common learning activities—such as flashcard study and completing problem sets—have yet to be investigated. As examples, the extent to which students space out flashcard learning and interleave between problem types when completing problem sets remains to be established (although see Zung et al. 2022). Moreover, undergraduates' views of distributed and interleaved practice in the absence of researcher-provided information, beyond specific scenarios, and outside of specific domains have yet to be addressed.

The extent to which undergraduates' beliefs and practices about learning schedules might vary across different cultures also remains unclear. Nearly all studies on scheduling strategies in undergraduates to date have relied on North American samples. It is presently unknown whether their findings will generalize to other populations (for a relevant discussion, see Agarwal et al. 2021). Relatedly, some studies have shown differences in learning behaviors between undergraduates of Asian and European origin, including in the amount of time devoted to studying (Helmke and Tuyet 1999) and the degree of test preparedness (Schommer-Aikins and Easter 2008), both of which might influence scheduling approaches. These differences may stem from cultural influences and the pressure to perform academically (Helmke and Tuyet 1999).

1.3 | The Present Study

The present study focused on two primary areas: undergraduate students' awareness, use, and beliefs regarding distributed and interleaved practice, as well as the scheduling of learning activities in both self-regulated and instructor-led contexts. As secondary areas of interest, the relationships between these strategies, GPA, and self-regulated learning measures were explored, and patterns across two culturally distinct student samples were compared. The four primary research questions were:

1. To what extent are undergraduates aware of distributed and interleaved practice?
2. How frequently do students use or experience these strategies, including during such learning activities as retrieval practice, flashcard learning, and completing problem sets?
3. How frequently do students use related, alternative, or overlapping approaches such as massing and revisiting materials?
4. What beliefs do students hold about how learning should be scheduled, including the effectiveness and feasibility of implementing distributed and interleaved practice?

In addition, we addressed three secondary research questions:

1. Does undergraduates' use of distributed or interleaved practice correlate with academic performance?
2. Does undergraduates' use of distributed or interleaved practice correlate with established measures of self-regulated learning behaviors and beliefs, namely the metacognitive self-regulation and time management scales of the motivated strategies for learning questionnaire (MSLQ; Pintrich et al. 1991)?
3. Are there geographic or sociocultural differences in undergraduates' experiences, beliefs, and practices pertaining to the scheduling of learning activities?

To address these issues, we employed a survey approach that has commonly been used to investigate such topics as collaborative learning, feedback, online learning, and retrieval practice (e.g., Dirkx et al. 2019; Pan et al. 2020; Zepeda et al. 2023; Zung et al. 2022). It incorporated varied questions to probe in a more thorough manner while acknowledging the inherent limitations of survey methods. The survey involved undergraduates from two large research universities in North America and Southeast Asia, respectively.

By exploring students' personal beliefs and self-reported behaviors in real-world contexts, we sought to build upon prior laboratory-focused research and develop insights into the use of effective strategies in day-to-day academic practices. Moreover, by asking students about how their instructors arrange learning activities, we aimed to extend prior work that examined instructors' self-reported teaching practices (e.g., Morehead et al. 2016). Notably, instructors' use of learning strategies may not fully align with their intentions, and student reports could shed light on any such discrepancies.

The cross-cultural approach (Rad et al. 2018) was intended to provide converging evidence when patterns aligned and highlight meaningful contrasts when they differed. We sought insights into whether awareness and use of effective learning strategies are potentially shaped by differences in educational systems, cultural attitudes toward learning, and metacognitive beliefs. Given prior evidence of cultural differences in learning behaviors (e.g., Helmke and Tuyet 1999; Schommer-Aikins and Easter 2008), it was important to assess whether students from different backgrounds differ in their perceptions and application of distributed and interleaved practice.

Based on prior research, we considered it likely that students would report using massing often yet endorse the effectiveness of distributed practice (cf. Blasiman et al. 2017; McCabe 2011). We also expected that students would favor blocking over interleaving (Kornell and Bjork 2008) and that using distributed practice would be positively correlated with academic performance (Hartwig and Malain 2022). In addition, given the variety of scheduling approaches possible in different learning contexts, we anticipated that students would report that their instructors use a range of scheduling strategies.

2 | Methods

2.1 | Participants

The survey was administered online from March to May 2023 to undergraduates enrolled at the National University of Singapore and the University of California, San Diego—henceforth abbreviated as Uni1 and Uni2, respectively—with voluntary participation and informed consent under ethical approvals from Uni1 (#2023-02-05) and Uni2 (#806722). Participants were treated in accordance with principles in the Declaration of Helsinki. Demographic details, including ethnic background and academic major, are presented in Table 1.

Students at both universities were recruited through psychology courses, ensuring comparability in academic background. At Uni2, additional respondents were recruited from biology courses to increase the sample size. Given that discipline-specific factors may influence study strategies (e.g., structured vs. flexible study schedules), we conducted subgroup analyses comparing psychology vs. biology students (see Supporting Information). No major differences emerged, reducing concern about this sampling variation.

At Uni1, 424 students completed the survey via the psychology department's participation site or university recruitment channels for partial course credit or a $3SGD payment. At Uni2, 669 students completed the survey, of which 221 students were recruited through the psychology department's participation site and 448 students were recruited via two large-enrollment biology courses, BIPN 100 (Human Physiology) and BIPN 134 (Human Reproduction), with credit incentives provided.

2.2 | Materials

The survey, which was programmed in Qualtrics, included 17 questions addressing the aforementioned four primary research issues, along with demographic and academic profile questions and supplementary items (i.e., questions about experience with learning materials that have commonly been used as stimuli in research on interleaved practice), plus a question about grade point average (GPA), and two scales from the MSLQ (the metacognitive self-regulation [MSR] and metacognitive time management [MTM] scales; Pintrich et al. 1991). The MSLQ measures students' learning processes, focusing on cognitive, metacognitive, and motivational factors; the MSR addresses how students plan and monitor their learning activities (Example item: "When I study for this class, I set goals for myself…"), whereas the MTM addresses how students plan and allocate their time for learning activities (Example item: "I make good use of my study time…").

Nearly all survey questions used a multiple-choice format, except for two short-answer questions. Most multiple-choice questions had standardized Likert scale options. Frequency questions had five choices ("often," "sometimes," "not very often," "never," and "not applicable" for unfamiliarity or irrelevance), whereas difficulty and effectiveness questions had seven choices (i.e., "very easy," "easy," "somewhat easy," "neutral," "somewhat difficult," "difficult," and "very difficult" in the case of difficulty questions; analogous choices in the case of effectiveness except for "effective" and "ineffective" in place of "easy" and "difficult"). Some questions involved multiple steps, for instance, beginning with an overall question and requiring a follow-up response. For questions that asked students to describe how learning is arranged by instructors, respondents were asked to respond specifically for courses taken in each of eight subject domains, where applicable (business, computing, engineering, foreign languages, humanities, mathematics, physical sciences, and social sciences).

A glossary defining key terms, such as "class," "topic," "new topic," and "old topic," was provided to aid comprehension. These definitions were repeated alongside any question that specifically used the terms. Wording aimed to be neutral to avoid bias. Specifically, none of the survey language stated or implied that distributed practice (or interleaved practice) is more effective than massing (or blocking); all answer options were written without any language suggesting a preferred or best answer, and the instructions stressed that all answer options were potentially valid.

Following Krosnick and Presser (2010), questions progressed from general to specific. Behavior- and experience-focused items appeared before metacognitive beliefs and judgments (as in Pan et al. 2020). Several questions were couched using terminology and/or descriptions drawn from the research literature on distributed or interleaved practice, for instance, in the context of related vs. unrelated topics (Brunmair and Richter 2019). All questions were designed in consultation with prior research (e.g., McCabe 2011; Susser and McCabe 2013) and following discussions with undergraduate research assistants. These consultations helped us better address the nuances and complexities of students' beliefs about learning schedules, plus refined our approach to capturing students' perceptions of how instructors structure learning activities. Before administration, we worked to maximize clarity and employed multiple questions addressing overlapping issues to obtain more comprehensive perspectives. All questions were pilot tested with a separate group of undergraduates beforehand.

The survey instrument and the glossary of definitions that were presented to participants is available at Open Science Framework and accessible at: https://osf.io/3wq9v/?view_only=45cf4accdfaa490caf5175ed5adda93b.

2.3 | Scoring and Data Analysis

Responses for multiple-choice questions were automatically tabulated within Qualtrics, yielding descriptive statistics that comprise most of the results to follow. For questions about how instructors arrange learning, we calculated the total number of responses for each answer option across all subject domains and reported these totals as percentages. Two short-answer questions where respondents provided a definition were independently scored by two research assistants against standard correct definitions (cf. Pan et al. 2023; see also McHugh 2012), with a high interrater agreement of 95.3%; discrepancies were resolved through discussion.

2.4 | Procedure

The survey was administered online and typically took 20 min to complete. Respondents began by reading instructions that emphasized answering honestly based on their undergraduate experiences and noted that each question did not necessarily have a correct answer. They were reassured of their anonymity, which

TABLE 1 | Participant demographics, grade point average, and motivated strategies for learning questionnaire (MSLQ) scores.

Demographic category	Characteristics	Uni1	Uni2
Sample size			
	Total (n)	424	669
Gender			
	Female	66%	73%
	Male	32%	26%
	Other	0%	< 1%
	Decline to state	< 2%	< 2%
Age			
	Mean, in years	21.6	20.8
	SD, in years	2.2	2.3
Ethnic background			
	African American or Black	—	< 3%
	Asian or Pacific Islander	—	49%
	Caucasian or White	—	20%
	Latino, Latina, or Hispanic	—	18%
	Chinese	81%	—
	Malay	< 4%	—
	Indian	< 8%	—
	Others	< 7%	< 8%
	Decline to state	< 1%	< 2%
Academic major			
	Business or finance	17%	< 3%
	Clinical sciences	7%	11%
	Engineering	13%	< 2%
	Foreign languages	< 1%	0%
	Humanities or liberal arts	< 7%	< 2%
	Mathematics or computing	12%	< 2%
	Physical or natural sciences	12%	61%
	Social sciences	29%	18%
	Undeclared	< 1%	< 1%
	Decline to state	< 3%	< 3%
Grade point average (GPA), out of 5.0 at Uni1 and 4.0 at Uni2	Mean GPA	4.2	3.5
	SD of GPA	1.5	0.4
MSLQ metacognitive self-regulation (MSR) scale composite score, out of 7	Mean composite score	4.3	4.6
	SD of composite score	0.8	0.9

(Continues)

TABLE 1 | (Continued)

Demographic category	Characteristics	Uni1	Uni2
MSLQ metacognitive time management (MTM) scale composite score, out of 7	Mean composite score	4.6	4.9
	SD of composite score	0.9	1.0

Note: MSLQ and GPA data were calculated out of 398 (Uni1) and 661 (Uni2) participants who answered that portion of the survey and provided GPA information. Independent-samples *t*-tests revealed significantly higher GPA (with Uni1 data rescaled to a 4.0 scale), MSR, and MTM scores among Uni2 students (p values < 0.001).

was upheld throughout the process. After agreeing to participate, respondents answered demographic questions before the remaining survey items. For all multiple-choice questions, they were required to select the single best-fitting option. The survey concluded with a short debriefing paragraph and a thank-you message.

3 | Results

The results are presented in the following order: first, data regarding undergraduates' awareness, use, and beliefs pertaining to distributed and interleaved practice; second, findings concerning scheduling strategies more generally and in the context of retrieval practice and completing problem sets; and third, students' experiences with learning schedules as defined by their instructors and within instructional materials. In these analyses, data from the entire sample ($n = 1093$) are considered. We conclude with two sets of secondary analyses: (a) correlations between scheduling strategies, academic performance, and MSLQ data; and (b) differences between the two university samples.

The Supporting Information, which are available online and on OSF, contain three additional sets of extended data, including (a) measures of central tendency (mean, standard deviation) for individual survey responses separated by university source (Uni1 vs. Uni2) and (b) Uni2 survey results separated by respondent source (participants drawn from psychology vs. biology courses). The results were roughly similar between sources in both cases. Further, (c) MSLQ subscale data separated by individual questions are also presented.

In discussing the results, data from both university samples are presented side-by-side for comparison. When two results are reported together as percentages, the first value corresponds to the Uni1 sample, whereas the second value pertains to the Uni2 sample. Additionally, in the results tables, the most relevant scheduling strategy is noted after each question (e.g., *distributed practice*) to aid interpretation.

3.1 | Student Awareness, Use, and Beliefs About Distributed and Interleaved Practice

As depicted in Figure 1, most undergraduates are unfamiliar with "distributed practice" "spacing," or "spaced practice" (have not heard before: 78% and 69%). Similarly, "interleaved practice" and "interleaving" are nearly unknown (have not heard before: 96% and 97%). Thus, in the absence of researcher-provided information, awareness of these strategies by name is remarkably low. Among students who recognized distributed practice, most could accurately define it; among the few students who recognized interleaved practice, most Uni1 students defined it correctly, whereas most Uni2 students did not.

After receiving definitions of both practices, students reported differing usage rates. As illustrated in the top panels of Figure 2, a minority indicated they often use distributed practice (common: 10% and 17%; very common: ~3% and ~5%), whereas even fewer reported often using interleaved practice (common: ~8% and 10%; very common: ~1% and ~2%). Well over half of the respondents do not regularly utilize either strategy. Regarding the effectiveness of distributed practice, the most common rating was "effective" (38% and 41%), whereas for interleaved practice, the most frequent rating was "somewhat effective" (36% and 29%). Hence, although many students perceive distributed and interleaved practice as effective, usage rates remain relatively low. That pattern, which is depicted across the top and bottom panels of Figure 2, implies a disconnect between understanding and application, plus heightens the possibility that students may benefit from targeted instructional support to deepen their understanding of these strategies' practical benefits.

When asked about the difficulty of incorporating distributed practice into their learning activities, the most common rating was "somewhat difficult" (32% and 29%). Similar numbers rated interleaved practice as "somewhat difficult" (31% and 22%), which implies potential barriers for use. When queried about their future likelihood of using distributed practice, the most common response was "likely" (33% and 27%), with a smaller proportion feeling similarly about interleaved practice (26% and 16%). These results are further detailed in Table 2.

3.2 | Student Scheduling of Learning Activities in Various Contexts

As illustrated in Figure 3, students commonly endorse various scheduling strategies that may not fit strict definitions of distributed practice (we incorporated questions targeting these broadly defined strategies—*massing* as in Hartwig and Dunlosky 2012; *revisiting materials* as in Carpenter 2020; and *spreading out studying* as in Rodriguez et al. 2021—to better capture the range of student scheduling behaviors). A sizable proportion engage in massing all their study for a single class into one session before a test (sometimes: 38% and 36%; often: 32% and 33%). Yet even more students indicate that they revisit previously covered topics (sometimes: 53% and 55%; often: 22% and 31%) and spread studying over multiple days or weeks (sometimes: 44% and 41%; often: 39% and 42%). The latter two strategies could facilitate distributed practice if specific materials are revisited or spread

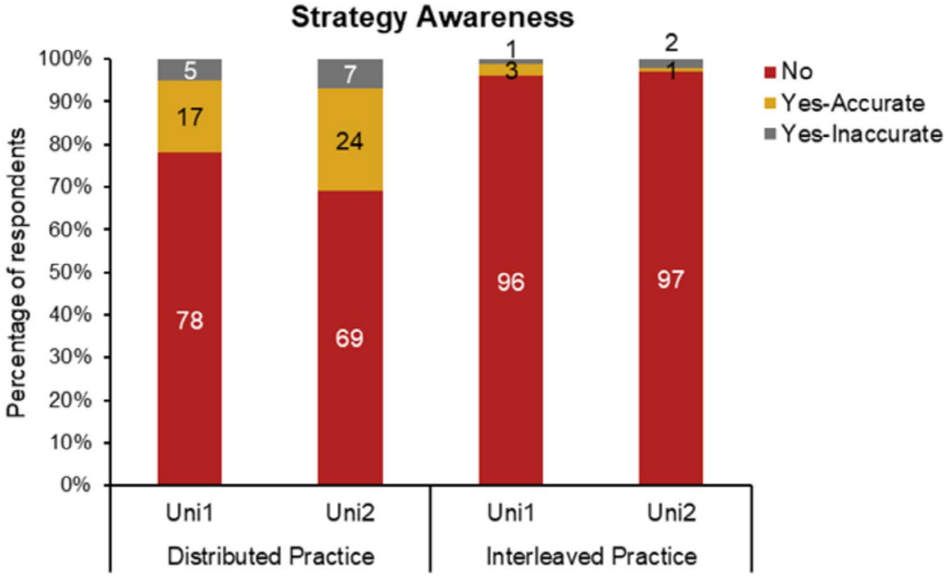

FIGURE 1 | Awareness of distributed and interleaved practice. *Note:* Percentage of students who are familiar with, and can accurately define, the terms "distributed practice," "spacing," "spaced practice," "interleaved practice," and "interleaving."

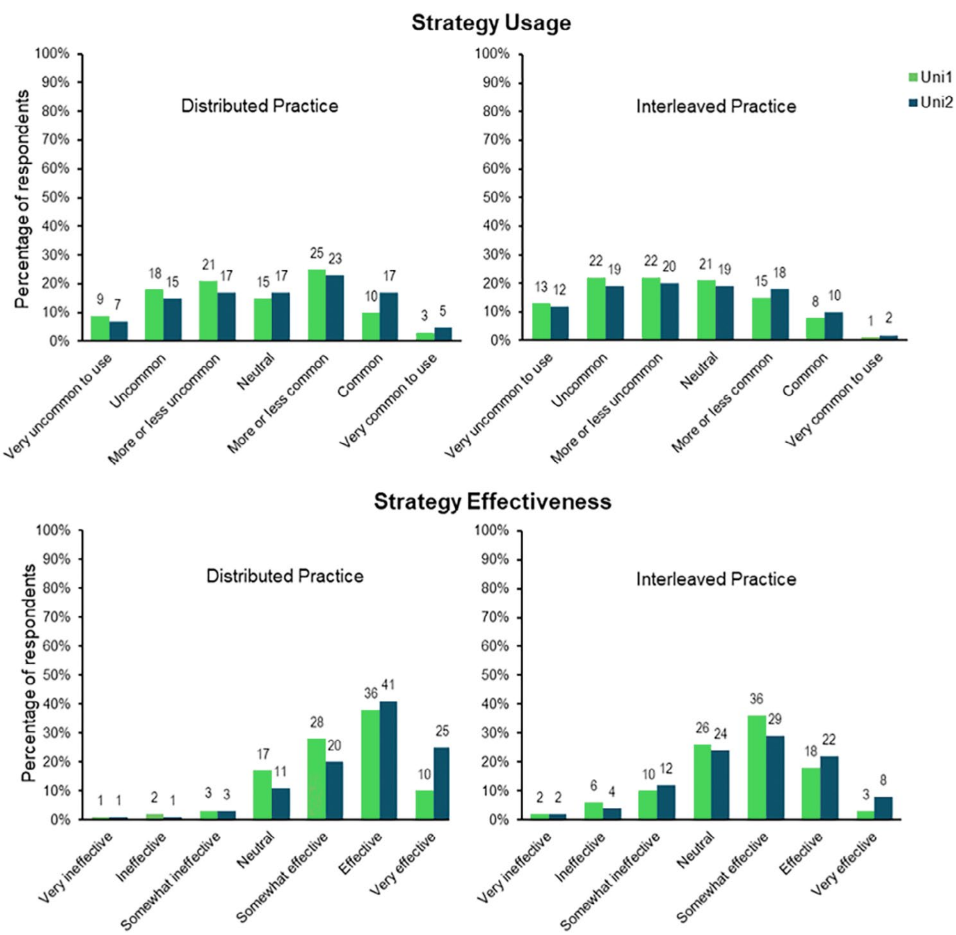

FIGURE 2 | Usage and effectiveness ratings of distributed and interleaved practice. *Note:* Top panels: Reported usage rates of distributed practice and interleaved practice among undergraduates. Bottom panels: Effectiveness ratings for both strategies.

over time, but not if materials are viewed only once. Thus, students employ multiple scheduling strategies, including massing and approaches that might allow for some amount of distributed practice.

For further insights, we asked students about the scheduling strategies they use when engaging in two common learning activities, namely, retrieval practice and completing problem sets, during self-regulated learning. When engaging in retrieval

TABLE 2 | Ease and likelihood of using distributed and interleaved practice.

			Distributed practice		Interleaved practice	
No.	**Question**	**Choices**	**Uni1**	**Uni2**	**Uni1**	**Uni2**
1.	How easy or difficult is it/would it be for you to incorporate distributed practice/interleaved practice into your study activities?					
		Very easy	< 3%	< 5%	< 2%	< 3%
		Easy	10%	11%	< 7%	11%
		Somewhat easy	21%	24%	21%	21%
		Neutral	18%	22%	24%	26%
		Somewhat difficult	32%	29%	31%	22%
		Difficult	13%	< 9%	13%	13%
		Very difficult	< 4%	< 2%	< 4%	< 5%
2.	How likely are you to use distributed practice/interleaved practice in your future learning activities?					
		Very unlikely to use	< 3%	< 1%	< 8%	< 5%
		Unlikely	< 8%	< 5%	17%	16%
		More or less unlikely	12%	< 9%	16%	15%
		Neutral	19%	17%	21%	22%
		More or less likely	19%	27%	12%	22%
		Likely	33%	27%	26%	16%
		Very likely to use	< 8%	15%	< 3%	< 5%

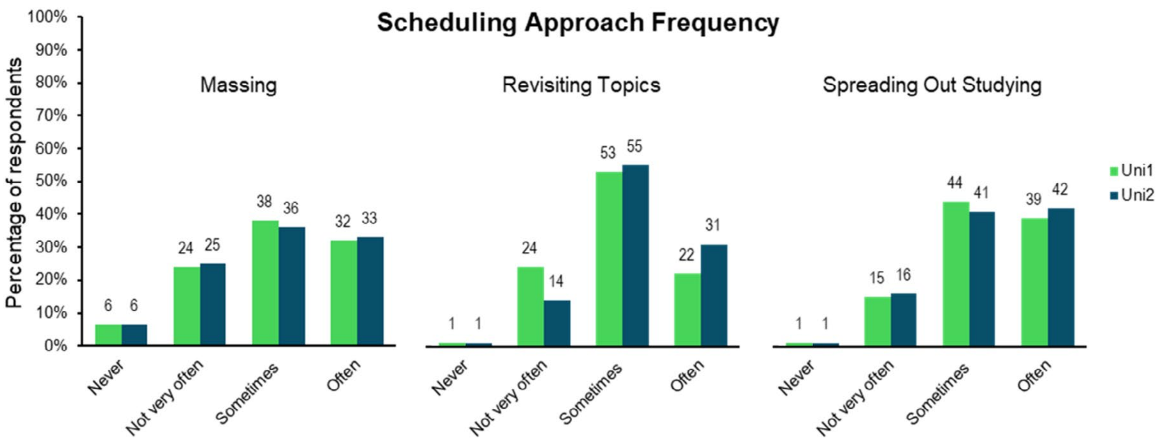

FIGURE 3 | Usage ratings for various scheduling approaches. *Note:* Frequency with which students report using various general scheduling approaches.

practice, such as testing one's memory with flashcards, students often focus on a mix of old and new topics (63% and 77%), which could allow for distributed practice (if materials are revisited) and interleaved practice (if one alternates between those topics). Many students perform retrieval practice on multiple topics from a single class but do so one topic at a time (35% and 39%), which reflects the use of blocking. When presented with hypothetical scenarios involving flashcard practice with three related topics, most respondents initially chose to practice each set separately (blocking) before mixing the cards (interleaved practice). In contrast, when faced with three unrelated topics, the predominant choice was to study each set separately (blocking). These findings are detailed in Table 3.

When completing problem sets, students often choose to work with a mix of old and new problem types (69% and 76%), which could facilitate distributed practice and possibly interleaved practice. Many students also focus on multiple problem types from a single class, tackling one type at a time (34% and 44%), which reflects a blocked approach rather than using interleaved practice. These patterns, which are detailed in Table 3, mirror those observed for retrieval practice.

TABLE 3 | Students' scheduling of learning activities.

No.	Question	Choices	Uni1	Uni2
1.	When you study, if you use quizzes, tests, or flashcards to test your memory...			
	a. ...which best represents the types of materials that you practice on? (*distributed* or *interleaved practice*)			
		All new topics	<7%	13%
		All old topics	<7%	<4%
		A mix of old and new topics	63%	77%
		Not applicable	24%	<8%
	b. ...which best represents the manner in which you do so? (*interleaved practice*)			
		I test my knowledge of a specific topic within an individual class	17%	13%
		I test my knowledge of multiple topics within an individual class, one topic at a time	35%	39%
		I test my knowledge of multiple topics within an individual class, with those topics mixed together (e.g., in random order)	13%	32%
		I test my knowledge of multiple topics across multiple classes, one class at a time	<7%	<8%
		I test my knowledge of multiple topics across multiple classes, with the classes and or topics mixed together (e.g., in random order)	<4%	<2%
		Not applicable	24%	<8%
2.	If I was given a set of flashcards for each of...			
	a. ...three *different but related topics* (e.g., in biology, three related topics could be circulatory, digestive, and respiratory systems), I would prefer to: (*interleaved practice*)			
		Learn using each set separately	21%	19%
		Learn using the cards from all three sets mixed together	16%	17%
		First learn using each set separately, then learn using the cards from all three sets mixed together	59%	61%
		First learn using the cards from all three sets mixed together, then learning using each set separately	<4%	<3%
		Other	0%	0%
	b. ...three *different and unrelated topics* (e.g., in biology, three unrelated topics could be immunology, DNA replication, and photosynthesis), I would prefer to: (*interleaved practice*)			
		Learn using each set separately	52%	54%
		Learn using the cards from all three sets mixed together	13%	<9%
		First learn using each set separately, then learn using the cards from all three sets mixed together	33%	36%
		First learn using the cards from all three sets mixed together, then learn using each set separately	<2%	<2%
		Other	0%	0%
3.	When you study, if you practice solving problems...			
	a. ...which best represents the types of materials that you practice on? (*distributed practice*)			
		All new topics	<9%	16%
		All old topics	<8%	<5%
		A mix of old and new topics	69%	76%
		Not applicable	15%	<5%

(Continues)

TABLE 3 | (Continued)

No.	Question	Choices	Uni1	Uni2
	b. ...which best represents the manner in which you do so? (*interleaved practice*)			
		I practice a specific problem type within an individual class	13%	13%
		I practice multiple problem types within an individual class, one type at a time	34%	44%
		I practice multiple problem types within an individual class, with those problem types mixed together (e.g., in random order)	25%	30%
		I practice multiple problem types across multiple classes, one class at a time	< 9%	< 8%
		I practice multiple problem types across multiple classes, with the classes and/or problem types mixed together (e.g., in random order)	< 4%	< 2%
		I do not practice solving problems	16%	< 5%

Overall, despite minimal formal awareness of distributed and interleaved practice, it appears that some students naturally engage in behaviors that might align with those strategies, such as mixing old and new topics. Those patterns imply that, if properly instructed, students may be willing to embrace those strategies on a wider scale.

3.3 | Instructors' Scheduling of Learning Activities

Table 4 details students' responses to survey questions addressing how their instructors arrange learning activities. Undergraduates perceive course syllabi as typically including a mix of old and new content in each lesson (39% and 42%) or emphasizing new topics while occasionally revisiting old ones (40% and 39%). Both arrangements may involve opportunities for distributed practice if old topics are revisited more than once. Further, according to students, instructors sometimes review previously taught materials during lectures (38%, 42%), indicating additional potential for distributed practice through temporally distanced review. Conversely, massing is also prevalent during lectures, with a sizeable amount of repeated presentations of a single topic (sometimes: 46%, 41%; often: 17%, 29%). Additionally, when multiple topics are covered within the same lecture, students report that instructors sometimes alternate between related topics (48% and 43%), whereas alternating between unrelated topics occurs less frequently (not very often: 41% and 43%). Such alternation may provide opportunities for interleaved practice.

Homework assignments focusing solely on one topic are also reportedly common (sometimes: 38% and 38%; often: 32% and 33%), exemplifying blocking. Assignments containing a mix of questions from different topics, however, are also frequently assigned (sometimes: 43% and 42%; often: 20% and 27%). When such mixtures exist, it is common for the topics to be mixed together (61% and 51%), which could facilitate interleaved practice.

Table 5 presents data from an additional survey question asking respondents about the prevalence of learning materials—that is, those used in research on interleaved practice (Brunmair and Richter 2019)—in their courses. The results show that artists' painting styles, which are the most investigated stimulus type and yield the largest effects in the interleaving literature, are by far the least commonly learned. On the other hand, computational problem-solving skills, physical sciences categories, and foreign language materials are more frequently learned.

3.4 | Supplementary Analyses

3.4.1 | Correlational Analyses Involving Scheduling Strategies, GPA, and MSLQ Scores

Before conducting the survey, we preregistered hypotheses pertaining to scheduling strategies, metacognitive skills, and/or academic achievement as indexed by GPA data (at https://aspredicted.org/WM1_8N1). Specifically, we predicted that the use of distributed practice, but not interleaved practice, would be positively correlated with GPA, aligning with prior observations for distributed practice and academic success (e.g., Hartwig and Malain 2022) and our expectation that interleaved practice would be too rarely used to be predictive of academic performance; MTM scores would be positively correlated with the use of distributed practice but not interleaved practice, drawing on the practical necessity of time management to plan out a multi-day or multi-week distributed practice schedule; and MTM and MSR scores would be positively correlated with GPA, drawing on research into the association between the MSLQ and academic performance (Credé and Phillips 2011).

Descriptive statistics for GPA and MSLQ sub-scale scores are presented in Table 1. Analyses were conducted separately for Uni1 and Uni2 using Spearman's correlation in all cases, as the strategy usage data did not strictly meet the assumptions of interval measurement and Shapiro–Wilk tests accompanied by inspection of histograms revealed that scores deviated from a normal distribution in the case of GPA and measures of distributed practice usage. We opted for nonparametric tests for all group comparisons to maintain consistency across analyses. In interpreting the strength of the correlations, Cohen's (1988) traditional guidelines (where correlations of 0.10, 0.30, and 0.50 are considered "small," "medium," and "large" effect sizes, respectively) can be considered (although see Kraft 2020).

3.4.1.1 | Distributed Practice, Interleaved Practice, and GPA. Correlations between the use of distributed practice and GPA were calculated using data for each of the following

TABLE 4 | Instructors' scheduling of learning activities.

No.	Question	Choices	Uni1	Uni2
1.	Think of the way in which instruction is scheduled in your courses (as is outlined in the course syllabus). Which of the following best represents how the topics in your courses are arranged? (*distributed practice, interleaved practice*)			
		New topics only during each lesson	22%	19%
		Mix of old and new topics covered during each lesson	39%	42%
		New topics covered for most lessons; old topics revisited occasionally during some lessons	40%	39%
2.	How often do your instructors spend class time going over (i.e., reviewing) materials that were previously covered in an earlier lesson? (*distributed practice*)			
		Often	12%	16%
		Sometimes	38%	42%
		Not very often	39%	33%
		Never	11%	10%
3.	Think about the lectures that you attend:			
	a. How often do your instructors *repeatedly present the same information on a specific topic*, over and over at one time? e.g., showing an example of DNA transcription, then another example of DNA transcription, and then another example of DNA transcription.) (*blocking*)			
		Often	17%	29%
		Sometimes	46%	41%
		Not very often	31%	25%
		Never	5%	5%
	b. How often do your instructors present information in a manner that *alternates between a series of related topics*? (e.g., showing an example of DNA transcription, then an example of RNA translation, and then an example of DNA replication.) (*interleaved practice*)			
		Often	21%	31%
		Sometimes	48%	43%
		Not very often	25%	22%
		Never	6%	4%
	c. How often do your instructors present information in a manner that *alternates between a series of unrelated topics*? (e.g., showing an example from biology, then an example from psychology, and then an example from sociology.) (*interleaved practice*)			
		Often	7%	7%
		Sometimes	27%	27%
		Not very often	41%	43%
		Never	25%	23%
4.	Think about the homework assignments in your courses:			
	a. How often are you tasked to complete homework assignments that focus on only one topic, with multiple questions on the same topic? (e.g., a biology homework assignment on the topic of DNA replication with questions only related to DNA replication.) (*blocking*)			
		Often	32%	33%
		Sometimes	38%	38%

(Continues)

TABLE 4 | (Continued)

No.	Question	Choices	Uni1	Uni2
		Not very often	22%	22%
		Never	8%	7%
b.	How often do you encounter homework assignments that focus on many topics with a mixture of questions involving these topics? (e.g., a biology homework assignment on a mix of topics such as immunology, DNA replication, and photosynthesis with questions related to these topics.) (*interleaved practice*)			
		Often	20%	27%
		Sometimes	43%	42%
		Not very often	28%	24%
		Never	9%	7%
No.	**Question**	**Choices**	**Uni1**	**Uni2**
c.	If you do encounter homework assignments that focus on many topics with a mixture of questions involving these topics, are those topics typically grouped together or mixed together? (e.g., given topics A, B, and C, where A = homeostasis, B = metabolism, and C = respiration; grouped together would be a pattern such as AAABBBCCC, where each letter represents a question, whereas mixed together would be a pattern such as ABCBACABC or ABCACBCAB, where each letter represents a question. (*interleaved practice*)			
		Grouped together (e.g., AAABBCCC)	39%	49%
		Mixed together (e.g., ABCBACABC or ABCACBCAB)	61%	51%

TABLE 5 | Student-reported prevalence of topics in undergraduate courses.

Topics	Uni1	Uni2
Artist painting styles (e.g., the characteristics of Monet and Seurat)	< 2%	< 3%
Biology categories that are identified by appearance (e.g., animal features)	10%	17%
Chemistry categories identified by structure (e.g., organic chemicals and molecule families)	< 8%	17%
Computation-based problem-solving skills (e.g., how to calculate area or volume, solve questions, and calculate velocity)	23%	14%
Faces (e.g., of human beings)	< 8%	< 7%
Foreign language grammar, vocabulary, or speech	13%	< 9%
Geology categories identified by appearance (e.g., type of rocks)	< 2%	< 2%
Psychological disorders (e.g., borderline personality disorder)	19%	14%
Vocabulary or technical words	17%	15%
Tastes (e.g., different flavors)	< 3%	< 5%

Note: Participants were presented with all 10 options and asked to select all that they had learned in their courses.

three questions about distributed practice: "How commonly do you use distributed practice in your current learning activities?," "How often do you spread out studying for your classes over multiple days or weeks?," and "How often do you go back and revisit old topics that were previously covered?." In the Uni1 data, spreading out studying over days or weeks was significantly and positively correlated with GPA ($\rho = 0.13$, $p = 0.009$), although this correlation was "small" in magnitude. Revisiting materials or endorsing the specific use of distributed practice was not significantly correlated with GPA (p values ≥ 0.607). In the Uni2 data, the use of distributed practice ($\rho = 0.17$, $p < 0.001$), spreading out studying over days or weeks ($\rho = 0.17$, $p < 0.001$), and revisiting materials ($\rho = 0.10$, $p < 0.001$) were all significantly and positively correlated with GPA, although again these correlations were "small" in magnitude. Together, these results suggest that there is at least some positive association of distributed practice with academic performance, which is in line with predictions (note: a graph of these results is presented in the Supporting Information).

Correlations between responses to the question, "How commonly do you use interleaved practice in your current learning activities?" and GPA were also calculated. There was no significant correlation between the use of interleaved practice and GPA in either the Uni1 ($\rho = -0.090$, $p = 0.073$) or Uni2 data ($\rho = 0.021$, $p = 0.589$), as predicted. That result suggests no close relationship between interleaved practice and academic outcomes.

3.4.1.2 | Distributed Practice, Interleaved Practice, and MSLQ Scores. In both the Uni1 and Uni2 data, MSR composite scores were significantly and positively correlated with all three of the aforementioned questions addressing the use of distributed practice, including when mentioned by name ($\rho = 0.22$, $p < 0.001$; $\rho = 0.29$, $p < 0.001$), in terms of spreading out studying over days or weeks ($\rho = 0.23$, $p < 0.001$; $\rho = 0.31$, $p < 0.001$), and with respect to revisiting materials ($\rho = 0.22$, $p < 0.001$; $\rho = 0.24$, $p < 0.001$). Further, MSR scores were weakly but significantly and positively correlated with the use of interleaved practice ($\rho = 0.14$, $p = 0.005$; $\rho = 0.091$, $p = 0.019$). Hence, learners with higher scores on the MSR also tended to make greater use of both effective scheduling strategies.

In both the Uni1 and Uni2 data, MTM composite scores were significantly and positively correlated with all three of the aforementioned questions addressing the use of distributed practice, including when mentioned by name ($\rho = 0.13$, $p = 0.011$; $\rho = 0.35$, $p < 0.001$), in terms of spreading out studying over days or weeks ($\rho = 0.30$, $p < 0.001$; $\rho = 0.42$, $p < 0.001$), and with respect to revisiting materials ($\rho = 0.27$, $p < 0.001$; $\rho = 0.28$, $p < 0.001$). In contrast, MTM composite scores were not significantly correlated with the use of interleaved practice in either the Uni1 or Uni2 data (p values ≥ 0.056). These results indicate a correspondence between MTM items and the use of distributed practice but not interleaved practice.

3.4.1.3 | MSR Scores, MTM Scores, and GPA. In both the Uni1 and Uni2 data, MSR composite scores were significantly and positively correlated with GPA ($\rho = 0.19$, $p < 0.001$; $\rho = 0.20$, $p < 0.001$). Similar patterns were observed for MTM composite scores and GPA ($\rho = 0.25$, $p < 0.001$; $\rho = 0.21$, $p < 0.001$). These results, which mirror those reported by McCabe (2011) and Susser and McCabe (2013) for the case of MSR data and align with predictions, are consistent with the conclusion that effective MSR and time management are associated with better academic performance.

3.4.2 | Comparison of Universities' Results

To assess differences in self-regulated learning behaviors and beliefs between Uni1 and Uni2, we conducted Mann–Whitney U-tests and calculated rank-biserial correlation coefficients, as the data did not meet the normality assumptions required for independent-samples t-tests and could not be strictly considered interval-level. The rank-biserial correlation (r_{rb}) quantifies the degree of separation between the two groups, with values closer to ±1 indicating a stronger difference. A positive r_{rb} value indicates higher scores among Uni1 students, whereas a negative value reflects higher scores among Uni2 students (Mangiafico 2023). More intuitively, the rank-biserial correlation represents the difference in the proportion of favorable vs. unfavorable pairwise comparisons between the two groups (e.g., an r_{rb} value of 0 indicates perfect balance, with 50% of comparisons favoring Uni1 and 50% favoring Uni2; an r_{rb} value of −0.20 means 20% more comparisons favor Uni2, with Uni1 scores higher in 40% of the comparisons and Uni2 scores higher in 60%). Although Cohen (1988) did not define thresholds specifically for the rank-biserial correlation, its mathematical similarity to other correlation-based measures (such as Spearman's correlation) supports the use of conventional benchmarks, where values of approximately 0.10, 0.30, and 0.50 are typically interpreted as "small," "medium," and "large" effects, respectively.

3.4.2.1 | Awareness and Use of Distributed Practice and Interleaved Practice. Uni2 students reported greater awareness of distributed practice than Uni1 students, $U = 128{,}506$, $p < 0.001$, $r_{rb} = -0.09$. Among students who indicated awareness of the term, however, there were no significant university differences in the accuracy with which they defined it ($p = 0.820$). There were no university differences in reported awareness of interleaved practice ($p = 0.160$), although among those who reported awareness, students from Uni1 were more accurate than students from Uni2 ($U = 252$, $p = 0.001$, $r_{rb} = 0.56$). When the strategies were specifically defined, Uni2 students reported higher usage of distributed practice ($U = 127{,}185$, $p = 0.003$, $r_{rb} = -0.10$) and interleaved practice ($U = 129{,}034$, $p = 0.011$, $r_{rb} = -0.09$) than Uni1 students, as well as greater ease incorporating these techniques (distributed practice: $U = 125{,}214$, $p < 0.001$, $r_{rb} = -0.12$; interleaved practice: $U = 131{,}413$, $p = 0.036$, $r_{rb} = -0.07$).

Uni2 students were more likely to endorse future use of both scheduling strategies (distributed practice: $U = 115{,}250$, $p < 0.001$, $r_{rb} = -0.19$; interleaved practice: $U = 131{,}002$, $p = 0.030$, $r_{rb} = -0.08$). Effectiveness ratings for distributed practice were also higher among Uni2 students ($U = 110{,}050$, $p < 0.001$, $r_{rb} = -0.22$), whereas ratings for interleaved practice were similar between universities ($p = 0.065$). It should be noted, however, that although significant differences between universities were observed, these differences were relatively "small" in effect size terms.

3.4.2.2 | Other Scheduling Strategies, Learning Activities, and Instructor Approaches. No significant differences were found between universities in spreading out studying ($p = 0.715$), although Uni2 students were more likely to revisit topics previously taught in class ($U = 119{,}426$, $p < 0.001$, $r_{rb} = -0.16$). When engaging in retrieval practice, Uni2 students tended to mix multiple topics more often ($U = 89{,}080$, $p = 0.008$, $r_{rb} = -0.10$). Yet, there were no significant differences between universities with respect to other questions involving retrieval practice, flashcard practice, or completing problem sets (p values ≥ 0.370).

As the data for instructors' scheduling of learning activities were collected separately for eight academic subjects, we conducted multilevel logistic regression analyses considering both academic subject and universities as factors, and accounting for the multilevel structure of the data, as many students gave responses for multiple subjects. Although variations in responses were observed across different subjects, the main effect of university was significant only for blocking by topic during lectures, which Uni2 instructors employed more frequently (coefficient = 0.33, SE = 0.12, $Z = 2.88$, $p = 0.004$). For survey items addressing other scheduling choices, the overall patterns did not significantly differ across universities (p values ≥ 0.051).

4 | Discussion

The present study investigated undergraduate students' practices, instructional experiences, and metacognitive beliefs pertaining to the scheduling of learning activities. It focused on distributed and interleaved practice, two strategies supported by learning science research, plus considered alternative and potentially related approaches. The extent to which undergraduates incorporate scheduling strategies into common learning activities was investigated, as well as the relationship between effective scheduling strategies and academic performance. Further, geographically and culturally distinct samples were obtained, facilitating cross-cultural comparisons. As outlined next, insights emerged regarding students' knowledge and beliefs about scheduling strategies, the approaches that they use or encounter, factors influencing their scheduling choices, and related issues.

4.1 | Student Awareness and Use of Scheduling Strategies

The vast majority of undergraduates had never even heard of "distributed practice," "spacing," "interleaving," or other synonyms. More than 95% of respondents were unaware of interleaved practice. These results imply a large gap in awareness of effective scheduling practices, which is all the more remarkable considering that distributed practice ranks among the most effective of all known learning strategies, and interleaved practice is regarded as having at least moderate utility (Carpenter et al. 2022; Dunlosky et al. 2013). Even when both strategies were described, which bypass the need for name recognition, more than half of the respondents stated that they did not use either. Overall, these results align with research indicating that students, in general, lack awareness of optimal learning strategies unless explicitly taught (e.g., McCabe 2011; Pan et al. 2020). Accordingly, there is considerable room for improvement in increasing awareness and encouraging the use of both distributed and interleaved practice.

As for alternative and potentially related approaches, our results reveal that students often engage in multiple approaches. Massing (i.e., cramming) before exams is common, yet so is spreading out learning across multiple sessions, revisiting materials, and mixing old and new materials during learning. That seemingly contradictory pattern may reflect varying strategies across courses or a mix of strategies within a single course, where students spread learning throughout the term yet cram before major exams. Crucially, the findings for spreading out learning, revisiting materials, and mixing old and new materials suggest that many students already engage in some scheduling strategies that have the potential to enable, but do not guarantee, the use of distributed practice. In fact, students who engage in such strategies may inadvertently benefit from a distributed practice effect.

With respect to interleaved practice vs. blocking, on the other hand, the data reveal a strong bias towards blocking in many instances, including when engaging in retrieval practice and completing problem sets (e.g., focusing on one problem type at a time). These patterns contrast strongly with recent evidence suggesting that performing retrieval practice and completing problem sets in an interleaved manner—that is, alternating between related concepts or problem types during practice testing or on homework assignments—is beneficial for learning (e.g., Rohrer, Dedrick, Hartwig, et al. 2020; Sana and Yan 2021). Undergraduates' preference for blocking and their minimal awareness of interleaved practice are barriers to efforts aimed at encouraging the adoption of this effective learning strategy.

Our findings also indicate that, similar to previous research, massing and blocking are prevalent choices (e.g., Hartwig et al. 2022; Carvalho et al. 2016; Hartwig and Dunlosky 2012). Yet the finding that students engage in multiple scheduling approaches suggests more nuanced patterns—in particular, many students use both massing *and* scheduling approaches that could allow for distributed practice. Nevertheless, less than half of the respondents stated that they were likely to specifically use distributed or interleaved practice in the future, which underscores the room for growth in encouraging the use of both strategies.

4.2 | Student Beliefs About Scheduling Strategies

Undergraduates expressed greater belief in the effectiveness of distributed practice compared to interleaved practice, which aligns with patterns observable across prior surveys (e.g., McCabe 2011; Susser and McCabe 2013). Nevertheless, appreciation for both strategies could be improved: At least a quarter of respondents did not consider distributed practice to be effective, and roughly one-third held the same view of interleaved practice. Hence, many students may benefit from learning about (or perhaps experiencing demonstrations of) the pedagogical benefits of both techniques (e.g., Onan et al. 2024).

A large proportion of respondents—at least 40% in each sample—perceived that using distributed or interleaved practice would be at least somewhat challenging. This finding implies that practical challenges and barriers hinder the adoption of either strategy. Moreover, they align with the counterintuitive nature of "desirable difficulties" (R. Bjork 1994; see also Pan and Bjork 2020) wherein such strategies are less fluent and can yield more errors, at least initially, yet are ultimately better for learning. Although we did not specifically examine the nature of these challenges, possibilities include the need to plan study schedules, selecting and organizing learning materials, the discipline needed to commit to multiple learning sessions, and even the extra effort that distributed or interleaved learning requires (Abel et al. 2024; Onan et al. 2024; Rea et al. 2022). Some of these obstacles, such as time and effort required, may not be specific to scheduling strategies per se but a variety of effective learning strategies more generally (Rea et al. 2022). Addressing these obstacles could, in turn, enhance students' willingness to adopt distributed and interleaved practice.

When asked about learning related topics using flashcards, over half of the respondents preferred using blocking before transitioning to interleaved practice. That pattern reflects a "hybrid scheduling" approach, which some researchers theorize may benefit learning (Pan, Lovelett, et al. 2019). Prior research has also shown that undergraduates sometimes gravitate towards hybrid schedules in hypothetical flashcard learning scenarios (Yan et al. 2017). In research to date, however, hybrid scheduling has not had a clear advantage over purely interleaved schedules (e.g., Mielicki and Wiley 2022). Student openness to using interleaved practice was also greater when the to-be-learned topics were related, which aligns with the finding that the interleaving effect is greater for related materials (Brunmair and Richter 2019).

4.3 | Instructors' Use of Scheduling Strategies

Mirroring their students, instructors of undergraduate courses reportedly use multiple scheduling strategies. For instance, during lectures, it is apparently common for instructors to employ massed instruction on a single topic, reviews of prior topics, and mixing between multiple topics, perhaps depending on the circumstances. According to students, however, instructors' rate of revisiting earlier materials in class is not as high as that of instructors surveyed at a university in the Western US state they do (80% according to Morehead et al. 2016). Various strategies were also reported during homework assignments. These patterns contradict prior suggestions that massing and blocking of instruction are uncommon (e.g., Rohrer 2015; Samani and Pan 2021). It is also notable that instructors are reported tending to alternate between topics only when they are somehow related, which aligns with the finding that the interleaving effect is larger for related materials. On a separate note, it is interesting that most students have never encountered the most common stimulus type used in studies of interleaved practice, artists' painting styles, whereas mathematical problem-solving materials and physical sciences categories, for which interleaving effects have also been observed, are more commonly encountered.

4.4 | Scheduling Strategies and Academic Performance Across Universities and Cultural Settings

Consistent with prior research (e.g., Hartwig and Malain 2022), both university samples showed that distributed practice was linked to higher academic performance. This association was strongest in the Uni2 sample, where both direct and indirect measures of distributed practice were positively correlated with GPA. In the Uni1 sample, the indirect measure of studying over days or weeks was similarly positively associated with GPA. The absence of similar findings for interleaved practice might be attributed to its more infrequent use among respondents and/or its reduced effectiveness or applicability for improving learning outcomes (cf. Brunmair and Richter 2019). It is also notable that the use of either scheduling strategy was positively associated with MSR scores, and the use of distributed practice was positively associated with MTM scores. These findings suggest that students with better self-regulation and time management skills tend to make greater use of effective scheduling strategies.

Besides similar relations between scheduling strategies and academic performance, students' response patterns were generally consistent across universities—ranging from awareness of effective scheduling strategies to experiences in the classroom. These patterns suggest that the current findings may be relevant across North American and Southeast Asian educational contexts and may extend to students from different ethnic and cultural backgrounds. A notable divergence, however, emerged in responses to several related survey questions: Students at Uni2 reported more frequent use of both distributed and interleaved practice, rated distributed practice as more effective, experienced less difficulty integrating both strategies, and were more likely to endorse their future use. Such patterns are plausible given that greater confidence in a strategy's effectiveness and less difficulty with its application are likely to correlate with higher current and anticipated usage.

The underlying causes of these sample differences are unclear, but cultural differences in learning environments and approaches could influence how students adopt and use learning strategies, including distributed and interleaved practice. In Eastern countries such as China, for example, there is a preference for small-group learning, with a strong emphasis on consolidating and reviewing material, including heavy use of repetition (Jin and Cortazzi 1998; Mitchell et al. 2009). Academic staff are viewed as high-authority figures who should not be questioned, which might result in heavy use of teacher-directed strategies (Levinsohn 2007). In contrast, some Western cultures, where understanding is often believed to arise from sudden insights and academic success is attributed to intrinsic ability, promote questioning and exploration during and after class (Mitchell et al. 2009; Watkins and Biggs 2001). This approach might encourage greater experimentation with self-regulated learning strategies.

It is important to emphasize that Uni1 is located in Singapore, where education often emphasizes rote learning, memorization, and highly structured, teacher-directed approaches. In contrast, the US cultural context of Uni2 encourages more independent learning, with students taking a less instructor-defined approach. This difference likely contributes to Uni2 students' greater propensity to experiment with diverse learning strategies, such as distributed practice, of which there were some indications. Nevertheless, the relatively strong consistency in results across the two sampling sites suggests that cultural differences—at least those separating the United States and Singapore—do not completely override widespread patterns in learning scheduling behaviors, beliefs, and experiences.

4.5 | Limitations and Future Directions

Although surveys are widely used to assess self-regulated learning, they have limitations in accurately capturing actual behaviors. Students may misremember their study habits (Blasiman et al. 2017) or overestimate their use of effective strategies due to metacognitive misjudgments (Rea et al. 2022). Despite efforts to ensure the comprehensibility and neutrality of the questions, a degree of imprecision is likely to remain. Future research could improve accuracy by combining self-reports with real-time tracking of students' actual scheduling behaviors (e.g., Blaisman et al. 2017; Carvalho et al. 2016; Taraban et al. 1999). Mixed-methods research might employ experimental designs that directly observe students' study behaviors or test interventions that explicitly teach distributed and interleaved practice (Yüksel et al. 2024), followed by assessments of their impact on academic performance.

In addition, it is important to note that the Uni1 sample was recruited entirely from a psychology participant pool, which consisted of students enrolled in psychology courses, whereas the Uni2 sample was divided between students recruited through the same method and from biology courses. A comparison of Uni2 results by source showed similar overall patterns (see Supporting Information), excepting somewhat greater awareness of distributed practice by name among psychology students (37% vs. 28%). The inclusion of students from different majors in Uni2 may still have influenced findings; however, particularly in strategy perception and use, affecting generalizability. Individual differences, such as motivation (Rea et al. 2022) or cognitive abilities (e.g., Pan et al. 2025), may also have shaped perceptions and responses to different scheduling strategies.

Nuances in how the strategies were described may have also been influential. For instance, an alternate interpretation of the definition of interleaved practice that was used could encompass multitasking. To avoid that misconception, future studies could specify that different topics being mixed together during interleaved practice are not being learned all at once. Further, we used differently worded survey questions to avoid relying on the wording of any one particular question, but future work could adopt even more refined wording and open-ended questions to verify understanding (relatedly, logistical constraints reduced our ability to ask many open-ended questions about why students prefer certain scheduling strategies). Similarly, future studies could ask instructors directly about their scheduling approaches. A persistent challenge in all such work, however, is that capturing scheduling patterns is complex due to nuanced behaviors and the multidimensional nature of learning activities (Rovers et al. 2019).

5 | Concluding Remarks

The present study sheds light on the gap between undergraduates' awareness and use of distributed and interleaved practice, two strategies that a growing literature has shown foster effective learning. Despite their demonstrated benefits, these strategies remain underutilized and largely misunderstood among students, suggesting opportunities for targeted educational initiatives to improve strategy awareness, understanding, and application. By integrating structured scheduling strategies into curricula, educators could empower students to adopt more effective study habits, ultimately enhancing long-term knowledge retention and transfer. Future research should therefore continue exploring practical approaches to bridging this knowledge gap, potentially examining interventions that directly engage students in these methods. Such efforts stand to play a pivotal role in improving academic outcomes and promoting lifelong learning strategies that extend beyond the classroom.

Author Contributions

Steven C. Pan: conceptualization, methodology, investigation, formal analysis, supervision, funding acquisition, visualization, project administration, resources, writing – original draft, writing – review and editing. **Eduardo González-Cabañes:** methodology, data curation, investigation, validation, formal analysis, writing – review and editing. **Andy Z. J. Teo:** conceptualization, methodology, software, data curation, investigation, validation, formal analysis. **Inez Zung:** conceptualization, methodology, data curation, validation, formal analysis, investigation, supervision, resources, writing – review and editing. **Faria Sana:** resources, writing – review and editing. **James E. Cooke:** resources, writing – review and editing.

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Ethics Statement

This work was conducted with ethical approvals from NUS (Psych-DERC #2023-02-05) and UCSD (IRB #806722).

Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability Statement

Data and materials are archived and available on request at the Open Science Framework: https://osf.io/3wq9v/?view_only=45cf4accdfaa490caf5175ed5adda93b.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section.