

# When and how do peers stimulate engaging in desirable difficulties

*Student perspectives on the effectiveness of supplemental instruction*

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# **When and How do Peers Stimulate Engaging in Desirable Difficulties: Student Perspectives on the Effectiveness of Supplemental Instruction**

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## **Abstract**

Supplemental instruction, also known as Peer Assisted Study Sessions (SI-PASS), is a well-established form of peer learning that has been implemented in higher education institutions across the globe and that coincides with learning gains for participants. While the effects on learning gains have been extensively studied with quasi-experiments, the underlying mechanisms that make SI-PASS effective are less well understood. This study explored what benefits students thought SI-PASS offered and through which mechanisms. We studied this by interviewing 14 students who participated in SI-PASS during a field experiment that reliably found a significant impact of SI-PASS on performance. The students were asked to expand on if and why they thought SI-PASS was effective. Thematic analysis and independent coding indicated an interplay of three main drivers. SI-PASS was experienced as effective because it stimulated the use of effective study techniques and social learning. These drivers were facilitated and enhanced by a pedagogical climate that lowered the threshold to engage in collaborative learning and effective study techniques. These findings could help pinpoint what elements should be highlighted during the preparation of SI-leaders and what aspects should be monitored and tested when implementing or studying SI-PASS.

## Introduction

Supplemental instruction or peer assisted study sessions (SI-PASS), are structured peer-led study groups attached to high-risk courses (Arendale, 1993). The peer student who prepares and supervises these sessions, called the ‘SI-leader’, has passed the course to which SI-PASS is attached and is trained to design active sessions with collaborative learning techniques and in guiding students to find answers together and independently. Supplemental instruction was introduced in the ‘70s in the United States at the university of Missouri Kansas by Deanna Martin in order to provide small-scale but cost-effective education for a larger inflow of students. The supplemental nature of SI-PASS ensured that SI-leaders would not be used as cheaper replacement for faculty, and would simultaneously match with calls for more active and participatory forms of learning in higher education.

Since its introduction in the ‘70s, SI-PASS has spread out across universities all over the world. Compared to the often fuzzily defined variations of peer learning, SI-PASS stands out as a practice that is relatively uniform across different contexts (Dawson et al., 2014). This is likely due to the supervisor courses, SI-leader manuals, and the accreditation structure that the international centers provide (Dawson et al., 2014). The SI-PASS literature contains a vast amount of quasi-experimental studies that compare students who participate with those who do not, while controlling for variables such as previous performance or motivation (e.g., Musah & Ford, 2017). In their systematic literature review into the effectiveness of SI-PASS, Dawson et al. (2014) conclude that they found a diverse range of effects, which all support the claim that SI-PASS improves grades and retention. They also found support for several non-cognitive effects such as well-being, and social relationships. They continued by describing two important caveats: “importantly, however, none [of the claims] is supported by a gold standard study involving random assignment to groups and sufficient detail about

methodology [...] Also missing from the reviewed articles was a rigorous qualitative study employing a clear methodology that is well grounded in learning theory” (p. 635).

The present study is part of a larger project in which we first checked whether these caveats were still present and in which we tried to address both. By conducting a field experiment in which we randomly allocated 493 students to receive access to SI-PASS during either the third or fourth term we could reliably estimate the intention-to-treat effect (Gupta, 2011) of SI-PASS. Because this experiment yielded a reliable estimate of the effectiveness (Authors, 2023), it also granted the possibility to qualitatively explore the mechanisms of an effective SI-PASS program. Understanding working mechanisms in addition to direct effectiveness, can help make educational interventions more transferable across contexts (Dekker & Meeter, 2022).

Therefore, we performed a qualitative study based on active learning theories to get a better understanding of why and how SI-PASS might work and towards what end. In the next section we will first describe which learning theories are likely candidates for understanding SI-PASS’s effectiveness.

## **Theory**

From the learning literature focused on active and student-centered forms of learning, we derived three theories that potentially help explain what makes SI-PASS effective. First, since its introduction, SI-PASS has aspired to help students to achieve learning goals (the 'what' of learning) as well as to help them to better understand learning itself (the 'how' of learning) (Arendale, 1994). The latter aspiration supposes that the program addresses deeper instead of surface types of learning, also known as desirable difficulties and effective study techniques (De Bruin et al., 2023). Therefore, one of the explanations for the effectiveness of SI-PASS

could be that its attention to active study techniques rather than surface learning impacts students learning positively (e.g., Ning and Downing, 2010). Second, the SI-PASS training guide and method explicitly uses collaborative learning strategies (Arendale, 1994). The rationale behind collaborative learning strategies might also help explain why and how SI-PASS is effective. Third, a unique feature of SI-PASS is that the teacher is a peer. From the literature on the Peer Assisted Learning (PAL) model we know there is a specific pedagogical impact of having a peer as teacher, which may also help to explain SI-PASS's effectiveness (Lockspeiser et al., 2008). We will describe these three possible explanations in more detail below.

### ***Desirable Difficulty and Effective Study Techniques***

In their review study, De Bruin et al. (2023) summarize that the most effective study techniques are deeper and active forms of learning that involve ‘desirable difficulties’. There is rigorous evidence for a high effect of deliberate and effortful techniques such as practice-testing and distributed practice (spreading study sessions over time) (De Bruin et al., 2023; Dunlosky et al., 2013; Yang et al., 2021). Both require students to actively retrieve what they have learned. Retrieval effort increases how long the learned content is retained. Dunlosky et al. (2013) found moderate effects for varying subjects within study sessions (interleaving), elaborative interrogation and self-explanation. The effects of less effortful forms of learning such as rereading, highlighting, mnemonics, (copy paste) summarization, and imagery use, were low. Important to note is that the evidence of effectiveness does not always correspond with day to day experiences. Carpenter et al. (2020) describe that the effective techniques cost more effort, while ineffective techniques might feel more natural and fluid. The fluid

feeling can be misinterpreted as effective, which creates ‘illusions of learning’, leading students preferring the less effective techniques.

If the activating didactical approach of SI-PASS helps students to change their study techniques from less to more effortful and difficult, this could partially explain SI-PASS’s effectiveness both for the attached course and potentially also for other courses (e.g., Malm et al., 2012; 2018).

### ***Social Interdependence Theory of Collaborative Learning***

Collaborative learning strategies are a didactic application of collaborative or cooperative learning. Collaborative learning can broadly be defined as “active engagement and interaction among group members to achieve a common goal” (Nokes-Malach et al., 2015, p. 646). Cooperative learning is defined similarly but with the addition of competitive elements: “classroom techniques in which students work on learning activities in small groups and receive rewards or recognition based on their group's performance” (Slavin, 1980, p. 315). Both concepts can be seen as a specification of social interdependence theory. Social interdependence occurs when the outcomes of individuals are affected both by their own and others’ actions (Johnson & Johnson, 2009). Overviews and meta-analyses show that collaborative learning can increase cognitive (performance), and non-cognitive outcomes (motivation, quality of relationships, psychological health) if the right conditions are met (Johnson & Johnson, 2009; Lou et al., 2001; Nokes-Malach et al., 2015). Common goals, interpersonal relations, social skills, and complementarity of team members can increase positive interdependence. This leads to the motivating feeling that everyone is pulling their weight and the promotive interaction that increases effort and performance (Johnson & Johnson, 2009). Nokes-Malach et al. (2015) summarize how both cognitive and social

models help explain when collaborative learning is effective for learning. Cognitive conditions for success include relearning through retrieval practice, cross-cuing, complementary knowledge, and error correction. Social conditions include joint management of attention and increased engagement. When collaboration involves coordination costs (time loss due to poor coordination), social loafing and fear of evaluation, it is more likely to lead to failure. As might be noticed, there is some overlap between the cognitive conditions for success and effective study techniques: both contain relearning through retrieval practice (Nokes-Malach et al., 2015) and cross-cuing and error-correction can be seen as aspects of practice-testing. The social processes involved in collaborative learning can induce or hinder effective retrieval effort and desirable difficulty.

### ***Students as Teachers***

A third explanation for the effectiveness of SI-PASS for both cognitive and non-cognitive outcomes stems from the literature on peer assisted learning (PAL): the pedagogical impact of a near-peer teacher. PAL is a type of peer learning that can be similar to SI-PASS but differs in a few aspects. PAL is less uniform because it is not coordinated by international centers and is often used for practical education within the medical domain and for chemistry or other courses that require lab-work. Several studies in the PAL literature compare education provided by faculty with that provided by near-peers (e.g., Cameron et al., 2015; Dickman et al., 2017). These comparisons yielded insights into the specific added pedagogical benefits of peers compared to faculty: relationships with peers are more informal, which lowers the threshold to ask questions (Cameron et al., 2015) or feedback (Zamberlan & Wilson, 2017) and makes it easier to experience interpersonal relationships (Lockspeiser et al., 2008). Peers speak ‘the language of the learner’ and are also less



susceptible to the curse of knowledge: having difficulties to empathize with someone who does not understand the subject matter one teaches (Lockspeiser et al., 2008). These advantages can induce cognitive outcomes (better understanding of the content matter) and yield additional non-cognitive outcomes such as better interpersonal relationships (Lockspeiser et al., 2008).

### ***Present Study***

To sum up: effective learning techniques, collaborative learning, and having a peer as teacher are hallmarks of SI-PASS that may help explain its effectiveness for cognitive and non-cognitive outcomes. What is understudied is whether students in SI-PASS actually experience these hallmarks as effective towards those ends, and whether there are other traits of the program that students deem effective as well. Therefore, our research question is: What do students who participated in SI-PASS consider its cognitive and non-cognitive benefits and mechanisms? By answering this question this study aims to propose a preliminary model based on which hypotheses can be formulated that can be tested with inferential studies.

## **Methods and Materials**

### ***Design***

The present study was part of a larger project in which we conducted a pre-registered randomized field experiment into the effects of SI-PASS (Authors, 2023). All materials that were used to train and supervise SI leaders and the data that was gathered during this experiment (outcomes as well as participation rates, specified per course) are publicly available ([blinded link](#)). The overarching project and the current sub-project were approved by the internal review board of the university (registration number 2021-151439). The current

study explored mechanisms that make SI-PASS effective by interviewing students who had been as part of the experiment, allocated to receive access to SI-PASS and had participated four times or more during one term. Because the field experiment showed a significant (intention to treat) treatment effect on grades, we may assume that SI-PASS, was indeed effective in this case (Authors, 2023).

For the present study we chose to conduct semi-structured interviews, as such an interview approach maximizes the possibility that all relevant topics are addressed while maintaining the possibility for each interview to have its own flow, as is advised when recall is involved (Salgado & Moscoso, 2002). To minimize colorization of students' recollections over time, the interviews were scheduled within two months after the final SI-PASS session.

### *Sample*

This study was conducted at five different types of courses of the education faculty of a large urban university in The Netherlands. The university is large (more than 40.000 students) but the students followed classes together in small groups within their courses (ranging from 8-30 students per classroom). Participation in the SI-PASS sessions was voluntary. Because we were interested in the working mechanisms and previous studies indicate that students likely need to participate at least four times for the treatment to be effective (Malm et al., 2011), we randomly selected twenty students who had attended at least four SI-PASS sessions. These students were sent an email that stated the purpose of the study and asked them if they would volunteer to be interviewed. Fourteen students agreed to be interviewed. The relatively high participation rate is most likely related to their high voluntary participation rate in the sessions. Table 1 shows the spread of the sample across the types of courses involved.

**Table 1***Sample spread*

<b>Course</b>	<b>Participants</b>	<b>Sample</b>
Pedagogy	169	3
Elementary school	48	0
Languages	123	3
Social sciences	102	5
STEM	51	3
Total	493	14

### ***Instruments***

Five researchers discussed and prepared an interview guideline. The requisites for this guideline were that it should be open enough to allow the students to independently explain what cognitive and non-cognitive benefits they might have gained from SI-PASS, if any, and why. Only a few open questions directed at cognitive and non-cognitive processes were used as starting questions, with room for follow-up questions targeting the mechanism whenever a student would mention a potential benefit. The first question that was posed was how the student had experienced the SI-PASS sessions in general. Next, the students were asked to describe in detail their actions, behavior, and feelings during the SI-PASS sessions. Furthermore, students were asked to describe their experiences with interpersonal interactions during the sessions. As a closing question, the students were asked what, if anything, they had learned during/from participating in SI-PASS.

### ***Procedures***

We first conducted a test-interview, and then calibrated the procedures. The fourteen interviewees were contacted and interviewed by the five different researchers. As some of the researchers were also teachers, we made sure that no student was interviewed by a researcher who was affiliated with that student's course, to minimize the risk of socially desirable answers. The researchers began each interview by explaining the purpose of the study, stating their independence as researchers, how data would be handled, and by asking for permission to record the interview. After this introduction, and a cup of tea, the first question was posed. Without the introduction, recorded interviews averaged 15:52 minutes, ranging between 7:09 and 25:37 minutes. All interviews were transcribed verbatim.

### *Data Analysis*

The data analysis was conducted in five steps. First, all transcripts were read in their entirety by two researchers, to check whether each contained recall relating to either cognitive or non-cognitive outcomes. Second, each transcript was segmented into cognitive or non-cognitive outcomes and processes. Both researchers first segmented the same interview independently, and then recalibrated. Segmentation was done in large ‘chunks’ that ended when a different topic was introduced. Third, within each segment passages were coded for causal relationships, when such a relationship was indicated by the student’s wording, for instance in utterances as ‘because of’, or ‘this led to’. All 85 coded passages together amounted to 33.9% of the total amount of words (31.053) over all transcripts. Fourth, two researchers summarized each coded passage as a mechanism. For example, “I do not remember exactly, but first it was scheduled at 9:00 and later at 10:30. The later it was scheduled, the more people that showed up. At 9 o clock some people just refuse to attend” was summarized as “The scheduled time for SI influenced attendance rates”. Fifth, the first author read all 85 summaries and clustered these under 15 different labels. For instance, “The pedagogical climate felt safe and open because the SI leader ensured us that there were no stupid questions, ask anything you want” and “so if you had questions from the class then you could raise them during SI” were labeled as ‘room for questions’. The second author then independently tested whether the labels were clearly applicable to the coded passages by applying the 15 labels to the 85 coded fragments. They then checked whether they had applied the same labels and discussed the differences, and organized the labels within 4 categories. All categories, labels, example summaries, and example fragments are presented in table 2. Fragments that led to discussion were marked and evaluated in an additional round to see whether they might indicate interplay or overlap between categories.

**Table 2**

*Examples of segments and summaries for each category and label*

<b>Category</b>	<b>Label</b>	<b>Summary</b>	<b>Example segment</b>
Pedagogical climate	Small-scale	The small-scale of SI helped me get to know people I would otherwise not have approached.	All my life I had trouble to make the first move and talk to people, but because of the small setting I felt more comfortable to engage with others.
	Room for questions	SI allowed students to raise questions they had during or after class.	I thought it was really helpful and also because it was after classes. Not the same day necessarily, but then you could dive into the subject matter after the class, so if you had questions from the class then you could raise them during SI.
	SI leader	It is easier to talk with an SI leader than with a teacher, this positively influence the pedagogical climate.	Its easier to talk with a fellow student I think, they know what you are dealing with. ... This mostly impacts the pedagogical atmosphere in the class I think.
	Community	The students who attended SI became a team that keeps studying together and helps and motivates each other.	Because of SI we kind of became a team. [...] so now we preceded with our team for the next course. And we try to motivate each other. We try to help each other.
	More motivating than at home	At home there are more distractions compared to working in a group at SI.	And at home of course it is easier to get distracted of course, right? You can go to youtube, facebook, netflix, listen to music, while here you are really in a group and actively engaged.
	Attention for personal situation	I also learned to use check-in and check-out questions from the SI-leaders. These questions allow the group to understand and adapt to everyone's personal situation and needs	What I have also learned because of SI, was to use a check-in and check-out. To ask people at the start of a session how they feel and what they want to achieve. And at the end, this is how I feel now, this is what I have learned. I am now applying this in my side-job. I noticed how it has a positive effect both in SI and in my side-job. It allows people to be seen and allows others to take it into consideration.
Effective study techniques	Practice testing	In SI I learned to make flashcards which was helpful for retaining information.	Before, for me I thought the best way to learn is to make summaries. But for some courses like analyzing the English language this did not always work. I learned to make and use flashcards and this allowed me to retain the information.

	Distributed learning	Because of SI I learned to start studying earlier in the term and to repeat the content weekly in order to remember it better.	Start on time. That's it really. You really saw, when you start on time. If you attend classes on Monday and then repeated the content in SI on Thursday. Then you remember much more.
	Questions about learning	Because of SI I learned that support is available and that you can ask questions about learning.	For first-year students I think this should really be a standard part of the program. I came from a community college and it was a pretty big step. At the start I thought "shit how am I gonna do this all by myself". But when we were offered SI then I realized that there is support and that there is a possibility to ask questions about learning.
Social learning	Promotive interaction	You needed to prepare for the session. When I did not prepare for the SI class I noticed that I did not contribute to the group and lesson and felt bad. I did not slip up afterwards.	SI gave me an extra push to prepare. I have trouble planning. But you really have to do it, because I clearly noticed that it was not nice for the group and for me. Then you are attending but not learning as much, because I did not do my part. Then you don't help each other. I did not slip up afterwards.
	Collaborative learning strategies	We could complement each other as attendants because the SI leader asked us for our perspectives and stimulated us to engage with each other.	We often complemented each other. For example, when they asked us something then we could complement each other. Ok try and solve this together. What do you guys think is the answer, how do you think this should go. They gave us lots of opportunities to engage with each other about the subject, which was very nice.
	Peer feedback	Giving each other feedback helped me pass the course.	I think SI helped me pass the course because I remembered more words and because we had provided each other peer feedback on our letters.
	Jigsaw	Jigsaw allowed me to learn the topic from the perspective of the student instead of the teacher.	Everyone chose one topic. In this case there were five topics. And then we had to search information about our chosen topic and afterwards explain it to each other. That was very helpful because it provided insights in how others learn. Not from the teacher perspective but from the students themselves.
	Presenting to each other	Explaining subject matter to peers improved my understanding.	Well explaining to others. When you explain it to others, I think, you will understand it better yourself.
Schedule and attendance	Schedule and attendance	The scheduled time for SI influenced attendance rates.	I do not remember exactly, but first it was scheduled at 9 and later at 10:30. The later is was scheduled, the more people that showed up. At 9 o'clock some people just refuse to attend.

### ***Reliability***

The two researchers who conducted the analysis monitored consistency of the analytic process by comparing and discussing their results after each step in the analysis. Whenever they did not agree, for instance about how to determine the length of a passage to code, they consulted a third researcher.

After the passages were coded, the first two researchers asked the third researcher to independently select which 45 passages from the interviews (40 that were coded for causal relationships and 5 that were not) belonged to which of the 5 categories. The original and independent coders agreed in 82,5% of the cases. Cohen's kappa's were then calculated per category to test the inter coder reliability in line with the guidelines from O'Connor and Joffe (2020). The kappa's ranged from substantial to perfect inter-coder reliability for the used clustering (Table 3). All fragments that led to discussion were separately discussed and analyzed in order to find out whether there might be conceptual overlap or interaction between categories.



**Table 3***Inter-coder reliability for each individual category*

<b>Cluster</b>	<b>Kappa</b>	<b><i>p</i></b>	<b><i>n</i></b>
Pedagogical climate	0.83	< 0.001	45
Effective study techniques	0.74	< 0.001	45
Social learning	0.86	< 0.001	45
Attendance and schedule	1.00	< 0.001	45

**Results**

All interviewed students mentioned at least one and often several potential mechanisms behind SI-PASS's effectiveness, leading to a total of 85 occurrences. These can be distinguished into pedagogical climate (32 times by 10 different students), effective study techniques (30 times by nine different students), collaborative learning (20 times by nine different students), and attendance and schedule (3 times by three different students). Below we describe the findings within each category, using quotes from the interviews.

***Pedagogical Climate***

Within the category pedagogical climate students mentioned six aspects of the pedagogical climate that made SI-PASS effective: the small scale of SI-PASS sessions (7 students, 12 times), the relationship with the SI-leader (5 students, 7 times), community (4

students, 5 times), more motivating than studying alone at home (3 students, 4 times), room for questions (2 students, 2 times), and attention for personal situation (2 students, 2 times).

### ***Small Scale***

The small-scale of the SI-PASS sessions created a stimulating setting for interaction and active learning. In the words of one student (Alyssa<sup>1</sup>, Pedagogy):

Because of the small size of the group, there was time and attention for everyone. It activated me. In a normal class you are listening and taking notes, but now you had the time to really ask questions, you could really go deep and dive into the subject matter.

Or as another student formulated it: “being with less students created time to talk and also to think really” (Salima, Pedagogy). The small scale was also experienced as safe and informal “It was very much a safe space [...] Many of the students who attended would normally not pass for this course, so there is stress and anxiety which could be talked about, which was really helpful” (Hamza, Pedagogy). It also made students more comfortable with social interaction with peers “Normally I do not feel like contacting other people [...] but in a small group I am more comfortable with approaching others” (Otis, English).

### ***SI Leader***

Important for the pedagogical climate was the SI-leader. Being students themselves made them approachable: “The SI-leaders are people you run into often [...] they made it more accessible” (Dylan, Geography). The SI-leader also helped to decrease barriers for asking questions “The mood was very nice because of the SI-leader [...] They emphasized that we could ask anything” (Alyssa, Pedagogy).

### *Community*

The pedagogical climate may contribute to SI-PASS's effectiveness through the feeling of being part of a community, which led students to help each other during SI and thereafter. As Hannah (Pedagogy) put it: “We kind of became a team. [...] so now we continued meeting with our team for the next course. And we try to motivate each other.”

### *More Motivating Than at Home*

The pedagogical climate was seen as less distractive than the home environment, which may contribute to SI-PASS success because less distraction can make one more productive:

It is not that I seek distraction, but I get distracted really quick. Even though I put my phone on airplane mode at home, I still just stare out the window for a half hour, at nothing. And so I started coming to school, and with peers. And even when we did not really work together, I came in an environment where I started studying sooner and kept studying longer.

Less distracting, or framed positively, by Gul (Economics), making learning pleasurable:

SI provided me the pleasure of learning. If there was no SI, I would have had a lot of trouble with learning at home, and I would not have done it with the right feeling. Not feeling like learning, or procrastinating.

### *Safe to Ask Questions*

Three students mentioned it felt safe to ask questions during SI : “we could always ask our questions. It did not matter which questions you wanted to ask, it was always okay.” (Alyssa, Pedagogy).

### ***Attention for Personal Situation***

Two students mentioned they appreciated that they received attention for their personal situation from the SI-leader at the beginning and end of each session and that this helped them to study during the SI sessions: “Hey, how do you feel? This way they could take that into account. When it went better or worse, or whether I had a lot of energy or not” (Celina, Geography).

### ***Effective Study Techniques***

We used the term effective study techniques to cluster mechanisms that drew on self-testing, spacing, planning, and interleaving (Dunlosky et al., 2013). These mechanisms were mentioned by nine different students 29 times. Eight different students mentioned the effectiveness of types of practice testing 18 times. Six different students mentioned distributed practice and planning a total of 11 times, and one student mentioned interleaving. One student -more generally- mentioned that SI-PASS allowed for reflection and questions about effective study techniques.

### ***Practice-Testing***

The students who mentioned that SI-PASS was effective because of the encouragement of practice testing named several forms in which this mechanism operated. It could take place with the use of flash-cards, which helped to retain knowledge. Other practice

test forms mimicked the format that was used in the exam “We tested our knowledge with propositions, which is handy because these are also often used in the exam” (Salima, Pedagogy). This knowledge can increase the effectiveness of the study time and save time spend on resits “Normally I do not know what to expect from the exam because its new. I expect to fail the first time and use that information for the resit. This time I knew what to expect beforehand” (Hannah, Pedagogy). Practice testing also made students less anxious about what to expect during the exams and improved their confidence in mastering the subject matter.

The feedback from practice testing allowed students to monitor where they stood in order to increase their effort when needed “I realized I had to work on this because my classmates did understand it and I did not. Which made me increase the self-study time I spent on this course” (Gul, Economics).

A method related to practice testing was composing test-questions. “As a group we composed test-questions. Because of this we had a document with questions that we could use to test ourselves at home” (Salima, Pedagogy). Some mentioned that it helped that the SI-Leader had already succesfully completed the course. “Because of this they could help us check whether our questions and answers were correct” (Hannah, Pedagogy). This can be seen as a combination of practice testing and error correction. They emphasized that SI-PASS not only triggered practice testing but also forced the students to find out whether their answers were actually correct, a process which was monitored by the SI-leader.

Practice testing was also done in more informal ways, as a type of formative feedback. For instance by asking students to craft several landscapes they needed to know in miniature sandboxes for a geography course. A student mentioned that the concepts from the lectures “were rather abstract in my head but by doing all types of different exercises and by having to

show the differences between a fjord and a riacoast in the SI-PASS session I was able to test if I really grasped it” (Celina, Geography).

### ***Distributed Learning***

Six students mentioned that SI-PASS helped them to plan and distribute the time they spent on their study. Most of the students mentioned that SI-PASS stimulated them to start earlier. “Normally I start studying one week or a few days before the exam. With SI, I was studying and rehearsing throughout the term, that really helps” (Dylan, Geography). One student (Otis, English) also mentioned that he learned to plan and manage time more effectively because this was explicitly discussed during the sessions.

SI-PASS made me improve my time-management when studying. [...] Most of the people in our class said they would just study in one sit, learn untill exhaustion. She [SI leader] said that’s not good, and then she would give us advice. For example break it up into study sessions[...] mix sessions of working on literature, with working on your essay, and spread it out.

### ***Social Learning***

Nine students mentioned aspects of social learning as effective mechanism behind SI-PASS. All nine students also described specific collaborative learning strategies, while four students mentioned more general aspects of collaborative learning and three students mentioned more general types of promotive interaction.

Presenting to others was mentioned seven times by four different students. “It works well, because it makes you think actively about the subject matter” (Celina, Geography), and it “is a good method to test whether you really understand” (Gul, Economics). Jigsaw

methods in which members of the group divided content, studied it and combined it to grasp the complete picture were also experienced as useful. “I learned from checking others. It made me more aware of alternative approaches.” (Maarten, Mathematics)

More general aspects of social learning consisted, among others, of the added value of collaboration when members had complementary knowledge “We often complemented each other” (Maarten, Mathematics) or between students with different levels of understanding.

The students who understood it really well also helped us [in addition to the SI leader], which meant that we had three people who were helping us, which opened up the SI leader to help others and to help everyone go through every step. I really understood it better because of this. (Melissa, Mathematics)

One student mentioned that she learned that talking about the subject matter with others was way more effective for her: “I really internalized that I remember the content better by talking about it with others than when I am just rereading it”. Another student stated that he learned to also listen to peers when he did not understand the teacher “When the teacher has simply one way, you can listen to other students, to also learn about other ways to get to the solution” (Gino, Mathematics).

Three students described how working in groups stimulated them to pull their weight or participate more actively, as Celina (Geography) formulated it:

SI gave me an extra push to prepare. I have trouble planning. But you really have to do it, because I clearly noticed that it was not nice for the group and for me. Then you are attending but not learning as much, because I did not do my part. Then you don't help each other. I did not slip up afterwards.

### ***Schedule and Attendance***

The schedule was mentioned by three students as a necessary condition for SI-PASS to be attended well “At 9 am, some people are impossible to reach” (Dylan, Geography). It was perceived as ideal when sessions were scheduled directly after the attached course. “Our SI-PASS sessions were right after the lecture. I really liked to go straight to SI-PASS after the lecture and practice the stuff with the SI-leader.” (Hamza, Pedagogy).

### **Discussion**

The present study sheds light on what students who participated in SI-PASS think about what made the program work for them. We distinguish four mechanisms: the pedagogical climate, effective study strategies, social learning and schedule/attendance. In this paragraph we will interpret the findings through the lenses of the social interdependence theory of collaborative learning and the desirable difficulty framework and propose an integrated preliminary model that could be used to further explore and test the underlying mechanisms that make SI-PASS effective.

### ***Active Learning Theories***

The findings from this study align well with both the framework of desirable difficulties and effective study techniques and the social interdependence theory of collaborative learning. The results from the interviews indicate that students experienced SI-PASS as effective when it drew on different cognitive and social drivers for collaborative success. Students mentioned that the collaborative learning strategies encouraged them to actively retrieve the information by presenting it to each other, use practice-tests, and spread their study sessions. Practice-testing and spreading study time are highly effective study



techniques (Dunlosky et al., 2013) and cross-cueing, reexposure, and relearning through retrieval are success factors for collaborative learning (Nokes-Malach et al., 2015). During these activities, students used each other and the SI leader's complementary knowledge for error-correction, and collaborative learning strategies such as the jigsaw method allowed them to off-load working memory resources, by dividing a complex assignment across team-members.

Finally, most students emphasized the importance of the pedagogical climate. In line with findings in the peer assisted learning literature (e.g., Lockspeiser et al., 2008), students claimed that the small-scale, room for questions, and the openness of the SI-leader created a more informal atmosphere. We can assume then that this pedagogical climate is more supportive and tolerant for making mistakes by trying difficult things such as presenting the content to each other. This context also is more inductive to the forming and improvement of social relationships.

### ***Conceptual Model for the Mechanism of SI-PASS***

Theoretically, there is overlap between the social interdependence theory of collaborative learning and the framework of desirable difficulties and effective study techniques (Nokes-Malach et al., 2015). Both induce active learning through effortful retrieval and desirable difficulties. Our results indicated that there might also be an interplay between the three different mechanisms. Arguably then, it will be of added value to integrate the mechanisms in a preliminary model that could visualize how the different components relate to each other in a parsimonious manner.

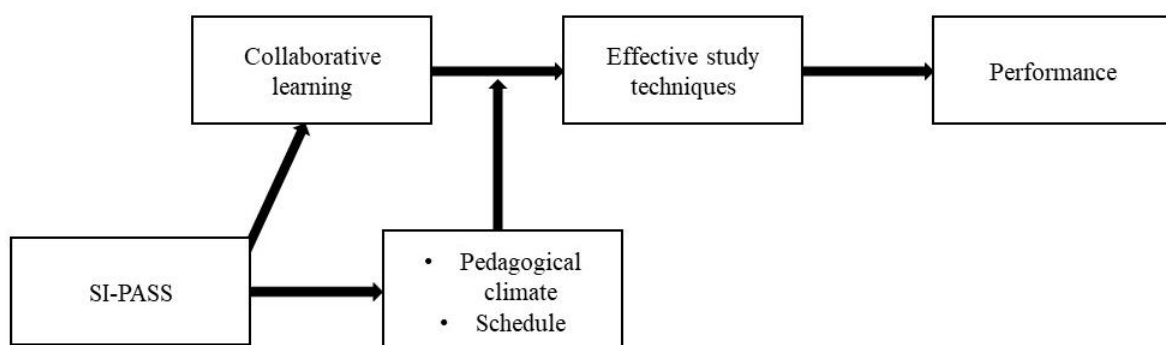
The small scale of the SI-PASS sessions and the identity of the SI-leader as peer create a motivating and safe pedagogical climate in which collaborative learning strategies induce students to change their more passive forms of learning (rereading) to more active and

effective ones. Starting late into the term and ‘cramming’ is replaced by distributed practice because the sessions stimulate and motivate students to start earlier and spread their study time. Simply reading and rereading the text is replaced by practice testing and error-correction through collaborative learning strategies such as presenting to each other and making and applying flash-cards.

The rhythm of the sessions and the motivation to study -which were stimulated by the pedagogical climate and social learning-, in turn, stimulated distributed practice. This interaction can be illustrated in the model depicted in Figure 1 which shows that pedagogical climate, peer leaders and small scale sessions are a requirement for the collaborative learning strategies to work and trigger effective study techniques because they enable students to feel safe and motivated to test themselves, for example, by presenting to others. The increase in desirably difficult and effortful retrieval through the usage of effective study techniques in turn, leads to higher performance. In line with Allen et al. (2018), students reported that beneficial scheduling positively affected attendance.

**Figure 1.**

*Conceptual model for the mechanism of SI-PASS with effective study techniques as mediating variable and pedagogical climate and schedule as moderators.*



### ***Limitations***

For this study, we interviewed students who were part of the treatment group in an experiment and showed up more than 4 out of the 7 or 8 SI-PASS sessions. The experiment showed significant average treatment effects, and these treatment effects were largest in groups with high attendance (Authors, 2023). Yet, average effects cannot be ‘drilled down’ to all individuals within the experimental group (Deaton & Cartwright, 2018). Maybe some of the interviewed students did not benefit from SI-PASS, even though they did self-report to experience beneficial effects from SI-PASS. We assessed this risk as relatively low because the answers that the students provided inductively aligned really well with the theories about effective learning through difficult and effortful retrieval.

### ***Future Directions***

Thus far, to our knowledge and according to the last systematic literature review on SI-PASS, rigorous qualitative studies that used learning theories to study SI-PASS were missing in the literature (Dawson et al., 2014). The findings from this study contribute to the SI-PASS literature by providing a model that uses active learning theories to explain the mechanisms behind SI-PASS. Other qualitative studies could explore whether these or other mechanisms are also brought forward by participants in other countries and/or cultures or from different types of domains. Future studies can derive hypotheses from this preliminary model that can be tested inferentially to test and adjust the theory.

## **Conclusion and Relevance for Practice**

SI-PASS is used and implemented across the globe in a relatively uniform manner. Many studies have tested the effectiveness of SI-PASS on academic performance, but far less is known about the underlying mechanisms. Understanding the program theory and mechanisms may help to understand what parts of SI-PASS are essential for what specific processes and may aid successful implementation fidelity across contexts in line with the Professional standards for higher education (CAS, 2023). This study explored the underlying mechanisms as experienced by participants of an effective SI-PASS program. The findings indicate that the SI-leaders (as peers) and the small-scale of the setting create a pedagogical climate that stimulates asking questions and lowers the threshold for engaging in collaborative learning strategies. These collaborative learning strategies are effective because they stimulate the students to actively engage in desirable difficulties such as practice-testing their knowledge, presenting to each other and correcting each others errors. Social interdependence and pedagogical climate motivate students to engage in these learning strategies. The regularly scheduled SI-PASS sessions also stimulate students to start studying earlier in the term and spread their study time more evenly across a term. This information can be used to highlight the importance of the role of the SI-leader and inform the training program of the SI-leaders. It can also be used to help SI leaders and faculty to better understand and communicate why certain collaborative learning strategies are particularly useful. Finally, the findings can be used to study whether SI-PASS or similar programs are functioning effectively, by observing the application of collaborative learning strategies and used study techniques in addition to academic performance.

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<sup>i</sup> All student names are pseudonyms in order to ensure anonymity.