

# Leveraging experiential learning training through spaced learning

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## Abstract

**Purpose** – Spaced learning (SL) and experiential learning (EL) have been identified as being more efficient to long-term knowledge retention than other forms of learning. The purpose of this paper is to confirm these benefits of SL and EL in a work-based learning environment.

**Design/methodology/approach** – This case study research monitored changes in learning outcomes of a work-based EL training, the Model Warehouse, when adding SL. The Model Warehouse of the Karlsruher Institute for Technology, Germany intends to educate professionals in lean warehouse logistics. Following a pragmatic standpoint, two groups of students were considered and compared by using multiple-choice question based knowledge tests where one group participated in an additional SL session. The experiences and perceptions of students were assessed by conducting in-depth interviews.

**Findings** – Findings revealed that adding SL to the EL training resulted either in students' knowledge retention or knowledge improvement. Additionally, participants of the SL session did not perceive it as being required to strengthen understanding of lean warehouse management.

**Practical implications** – This study recommends considering SL as an effective means to significantly enhance long-term knowledge retention of any work-based or EL training.

**Originality/value** – This study confirms the benefits of SL and EL drawn from laboratory-based studies in a real business context. Adopting both learning theories in training programmes which converge with realities of the workplace results in a significant improvement of long-term knowledge retention.

**Keywords** Experiential learning, Knowledge retention, Work-based learning, Cognitive stimulation, Spaced learning

**Paper type** Research paper

## Introduction

Since 1885, researchers argue that distributing learning across time increases efficient long-term knowledge retention as it leads to the spaced learning (SL) effect (Kang, 2016; Sobel *et al.*, 2011). The SL effect facilitates the establishment of new neural representations in the brain which are needed to build long-term memory (Cepeda *et al.*, 2006; Dempster, 1988; Spitzer, 2009). Experiential learning (EL) is described to be more effective than any other form of learning as it enhances the motivation to learn and allows for better knowledge retention by supporting the learner to actively engage in the learning process (Austin and Rust, 2015; Egbert and Mertins, 2010).

The benefits of both EL and SL to knowledge retention have been analysed in-depth in previous studies (Kolb, 1984; Schenck and Cruickshank, 2015; Cepeda *et al.*, 2006; Carpenter *et al.*, 2012). What remains to be investigated is how learning retention develops when combining EL and SL. By utilising the Model Warehouse, it is intended to investigate whether even better learning outcomes are possible when adding an SL session or not. The Model Warehouse is a work-based training offered by the Karlsruher Institute for Technology in cooperation with a globally based consulting company. It intends to primarily educate experienced professionals in lean warehouse logistics in an EL environment.

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Based on the results of this research, recommendations are derived for any work-based EL training programme which seeks a means to help ensure knowledge retention thereafter. Moreover, this research contributes to academic research in the field of learning as it offers new insights about a specific phenomenon, learning in the Model Warehouse and a way to improve it.

Summing up, the purpose of this paper is to enhance the learning outcomes of work-based and EL training programmes with the help of SL, whilst deriving results from participants' experiences and points of view. Thereby, this research is guided by the following research question:

*RQ1.* How and to what extent does spaced learning improve the learning outcomes of students in an experiential learning programme in Germany?

The case of the Model Warehouse training offered by the Karlsruher Institute for Technology.

## Critical literature review

### *Learning theory*

To date, learning is defined in different ways and as a consequence, no universal definition of the term exists (Ertmer and Newby, 2013). This is due to the fact that different practitioners focus on different criteria central to learning (Schunk, 2012). Still, many of those different approaches employ similar elements (Ertmer and Newby, 2013) which can be summarised as follows:

Learning is an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience. (Schunk, 2012, p. 3)

The roots of modern learning theories trace back to the works of Plato and Aristotle. At the end of the nineteenth century, Ebbinghaus (1885) and Wundt (1893) pioneered in taking higher mental processes into experimental laboratories and laid the foundation for the psychological study of learning. In the second half of the nineteenth century, behaviourism arose. It promotes that the most critical reasons for learning are the environmental conditions in which learning takes place. Therefore, the learner is not an active participant in the learning process but reactive to environmental conditions (Ertmer and Newby, 2013).

As a shift away from the behavioural learning approach, cognitivism evolved, which considers the learner to be an active participant in the learning process, as learning requires the learner to actively code and to structure the newly learnt internally. Constructivism is the latest development in learning theory and is a branch of cognitivism. Yet, it distinguishes itself from the latter as it emphasises that the experience in which learning takes place needs to be considered when examining the learning process (Khalil and Elkhider, 2016).

Several learning theories exist, yet behaviourism, cognitivism and constructivism are seen as the main learning theories used in children, teenage and adult education to date (Taras, 2005). These three theories can be differentiated in terms of definition, the role of the learners and the best learning methods used (Khalil and Elkhider, 2016). Table I summarises the major arguments.

Those different learning theories provide different frameworks of how to handle learners and the learning material: behavioural approaches recommend periodic, spaced repetitions to strengthen the recall of a response, whereas cognitivist and constructivist approaches argue that a meaningful presentation of learning materials allows participants to organise and recall it better in the future (Schunk, 2012).

### *The SL effect*

The SL effect is widely recognised as being one of the oldest, most reliable and remarkable phenomena in the field of human learning (Carpenter *et al.*, 2012; Dempster, 1988). The SL effect refers to the finding that long-term memory retention and recollection are higher when

**Table I.**  
Primary  
learning theories

	Behaviourism	Cognitivism	Constructivism
Definition of learning	Learning is the acquisition of new behaviour	Learning involves the acquisition and reorganisation of cognitive structures	Learning is search for meaning
Learner's role	Passive participants in the learning process	Active participants in the learning process	Active participants in the learning process
Main strategy implications	Facilitates knowing what Objective-based instruction Competency-based education Skill development and training	Facilitates knowing how Concept maps Reflective thinking	Reflection in action Authentic case-based learning environment Reflective practice Collaborative construction of knowledge
Example of teaching method	Lecture Simulation Demonstration Programmed instruction	Problem solving Concept mapping Advanced organiser	Diaries/reflection Role modelling Problem-based learning Collaborative learning

**Source:** adapted from Khalil and Elkhider (2016)

reviewing learnt materials spaced out over time compared to a massed, single study session as previous studies revealed (Kang, 2016; Kornell and Bjork, 2008; Sobel *et al.*, 2011).

Ebbinghaus (1885) was the first who studied the SL effect and argued that learning and recalling depend on how often someone was exposed to the material. Since then, numerous studies have confirmed the benefits of the SL effect (Cepeda *et al.*, 2006; Dempster, 1988; Glenberg, 1976; Melton, 1970). The SL effect is applicable to various domains such as animal conditioning, verbal learning, motor learning, as well as learning of educational materials (Kornell and Bjork, 2008).

Nevertheless, research on learners' (college students as well as undergraduates) experience reveals that learners feel that massed learning is superior to and achieves better results than SL, although better test results were achieved after the SL sessions (Simon and Bjork, 2001; Zechmeister and Shaughnessy, 1980).

SL can be assigned to the learning theory behaviourism as it, amongst other thoughts, assumes that intervallic, spaced repetitions strengthen the recall of a response (Schunk, 2012). Therefore, one can argue that although theoretically SL is a behavioural approach, in practice it has traits of the cognitive approach. Hintzman (1974), Dempster (1988), and Russo *et al.*, (1998) propose three predominant reasons for the spacing effect to occur:

- (1) Encoding variability – taking information and record it in memory.
- (2) Proficient processing – leading to long-term memory success.
- (3) Learning-strategy adaption – learning through retrieval failures.

Numerous researchers question whether there are particular schedules to follow or not and how long the spacing gap should be to achieve the most efficient improvement in long-term memory retention (Carpenter *et al.*, 2012). Karpicke and Bauernschmidt's (2011) approach distinguishes between absolute and relative spacing. Absolute spacing refers to the total number of repetitions that take place between all tests undertaken; relative spacing refers to the repeated tests distributed relative to each other. According to Landauer and Bjork (1978) relative spacing can follow an expanding, an equal or a contracting schedule (see Table II).

Karpicke and Bauernschmidt (2011) conclude that the highest improvement in long-term memory retention is achieved by increasing the absolute spacing of repetitions, although they could not find evidence that one relative spacing schedule achieves better results than another. Any form of spacing, whether expanded, equal or contracted promotes learning and long-term

memory retention (Carpenter *et al.*, 2012). Still, it is proven that the longer the retention intervals and the more often the repetitions, the higher the likelihood of correct recall (Cepeda *et al.*, 2006). However, having extensive gaps between repetitions may result in forgetting what was learnt previously and the SL effect becomes offset (Carpenter *et al.*, 2012).

Nevertheless, it should be mentioned that within the majority of SL research, no feedback on occurred errors is given to restudy them for future tests. This is due to the fact that SL research mainly focuses on the direct effects of SL rather than on mediated effects (Karpicke and Bauernschmidt, 2011).

Still, researchers like Dempster (1988), Grote (1995) and Seabrook *et al.* (2005) claim that besides the widely proven evidence for the SL effect, it receives little attention in educational programmes, class-based learning and teacher training. Cognitive processes can be stimulated and problem-solving skills can be enhanced through incorporating SL techniques either prior to or after the study session. The most important concepts and activities of the study sessions can be previewed and re-presented. This allows participants to develop a more profound understanding of the new material (Dunlosky *et al.*, 2013).

Interactive learning, meaning the combination of class-based learning and e-learning, should be considered for implementing SL into academic and industry training (Chang, 2016). Engaging in interactive learning, participants can take advantage of both the consolidation of their core skills and knowledge during the classroom-based training and individual rehearsing schedules which are adaptable to the participants' learning style, weaknesses, and learning progress during e-learning (Chang, 2016). Thereby, a 15 per cent improvement of the participants' satisfaction and learning performance is revealed (Chang and Wills, 2013). Karpicke and Roediger (2007) postulate to increase knowledge testing, arguing that when learners engage in tests, they must access information stored in their memories, transfer and apply it to new situations.

*EL theory*

The theory of EL has evolved in the last three decades. Well recognised is Kolb's work on EL which is seen as universal (Daraban and Byrd, 2011; Schenck and Cruickshank, 2015). Kolb (1984, p. 41) defined learning as:

[...]the process whereby knowledge is created through the transformation of experience. Knowledge results from the combination of grasping and transforming experience.

The EL theory traces back to the work of Dewey, Lewin and Piaget. Kolb and Kolb (2005, p. 194) put forward six propositions on which the EL theory is built on, namely:

- (1) Learning is best conceived as a process, not in terms of outcomes.
- (2) All learning is relearning.
- (3) Learning requires the resolution of conflicts between dialectically opposed modes of adaption to the world.

	Relative spacing		
	Expanding schedule The intervals between tests progressively lengthen	Equal schedule The intervals between tests are constant	Contracting schedule The intervals between tests progressively shorten
Absolute spacing			
Short (15)	1-5-9	5-5-5	9-5-1
Medium (30)	5-10-15	10-10-10	15-10-5
Long (90)	15-30-45	30-30-30	45-30-15

Source: adapted from Khalil and Elkhider (2016)

**Table II.** Spacing schedules (in number of repetitions)

- (4) Learning is a holistic process of adaption to the world.
- (5) Learning results from synergetic transactions between the person and the environment.
- (6) Learning is a process of creating knowledge.

Concluding, EL asks for the learner to actively engage in the learning process and therefore encourages reflective thinking, to understand the how of a process and to find the meaning of the same whilst doing it (Alkan, 2016; Kolb and Kolb, 2005). Yet, Illeris (2007) argues that experience is a subjective matter. Thus, if the learners do not experience a situation in which they are personally encouraged to learn, an external person cannot label it to be experiential (Illeris, 2007). Nevertheless it has to be acknowledged that it also is a constructivist approach to learning yet it has cognitive traits (Corbett, 2005).

Based on his definition, Kolb (1984) develops a dynamic, holistic learning cycle that comprises of two dialectical modes of grasping experience: concrete experience and abstract conceptualisation; and two dialectical modes of transforming experience: reflective observation and active experimentation (see Figure 1). Kolb's learning cycle can be entered at any stage; however, all stages follow a sequential order. Whilst students take part in the learning cycle several times, feedback is provided, which allows taking new actions to evaluate those actions taken (Akella, 2010).

Research claims that EL is more effective than any other form of learning as it enhances the motivation to learn, allows for better knowledge retention and enables transformational thinking in real-life context, meaning that people are prepared to actively apply what was learnt (Austin and Rust, 2015; Egbert and Mertins, 2010). Learners are taking part in an interactive experience in which they can experiment and have the freedom to fail in a risk-free environment (Whitmore, 2002). Furthermore, neuroscientific research supports the EL theory arguing that memory pathways and connections are established (Schenck and Cruickshank 2015).

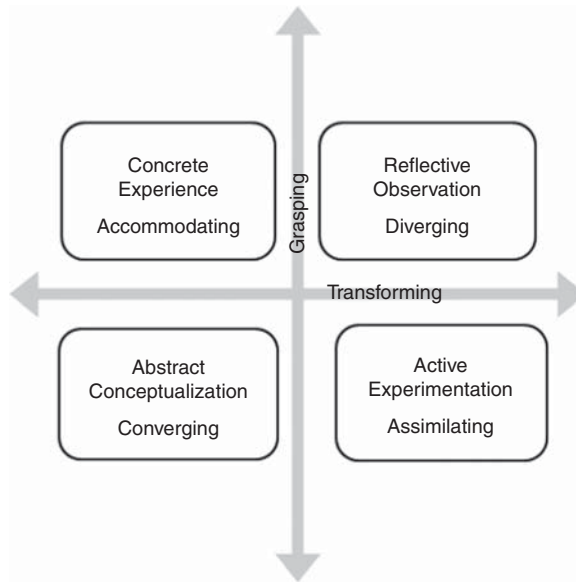


Figure 1.  
Experiential  
learning cycle

Source: Adapted from Kolb and Kolb (2008)

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Engaging in EL also enhances an individual's lateral (what we know) and vertical (how we know) development, which helps individuals to handle emerging challenges and to create new "realities" (Spence and McDonald, 2015).

### *Learning in the model warehouse*

Learning in the Model Warehouse is based on the previously described principles of Kolb's EL theory. It represents a form of work-based learning which is defined as:

an educational process which drives learners to engage intellectually, socially, emotionally and physically in an unpredictable work-related environment where they will go through the experiential process of potential failure, taking measured risks, experiencing adventure through creativity and innovation, and [...] achieving successful outcomes. (Chrisholm *et al.*, 2009, p. 327)

As discussed earlier, observative reflection is one of the four major parts of Kolb's learning cycle. Also, Siebert and Walsh (2013) and Chrisholm *et al.* (2009) point out that reflective thinking is the most important aspect to learn from any work-based learning environment. Additionally, Helyer (2011) argues that the combination of theory and work-based skills leads to active critical reflection, which in turn encourages changes and innovations in current workplace practices. Yet, when designing assessments focus needs to be put on developing theoretical frameworks rather than one-off memories.

All in all, one can claim that any EL training in which learning takes place through work and for the means of improving both workplace and life skills of participants is also a form of work-based learning. Thus, the EL taking place in the Model Warehouse can also be defined as being work-based.

### *Context for the study*

The Model Warehouse is a capability-building centre of the Karlsruhe Institute of Technology that imparts the latest knowledge on the approaches used in lean warehousing (Institute for Material Handling and Logistics, 2018). The training aims at optimising existing warehouse operations and thus, is mainly tendered for experienced professionals in lean warehouse logistics. Yet, the training is also offered to students enrolled in supply chain degree programmes.

## **Methodology and methods**

### *Research methodology and design*

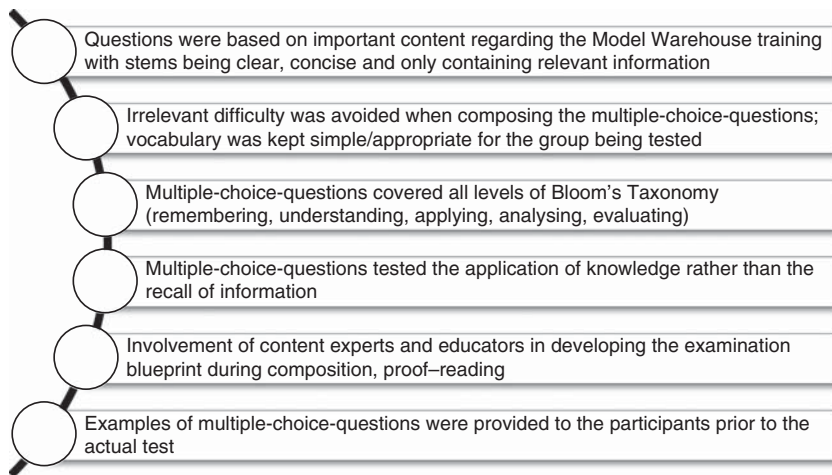
This research has been conducted as a single case study research. Case studies are intended to investigate real-life phenomena thoroughly when boundaries between the phenomena itself and its' real-life context cannot be drawn (Yin, 2014). Thereby, this research aimed to draw conclusions to explore and improve the practice, understanding and the situation in which learning takes place in the Model Warehouse as a single typical case of an educational institution. It followed the philosophical approach of pragmatism, which is argued to emerge from actions, situations and consequences by intervening in a work-based training programme while SL sessions are added and learning outcomes are measured. According to Creswell (2014), pragmatism allows combining multiple methods of data collection and analysis to best meet the need and purpose of the research to be conducted. Therefore, a mixed-method design, which allowed the researcher to use interpretations and adapt to the unanticipated (Robson and McCartan, 2016), has been used. In accordance with Yin (2014) for a single case study research, based on a typical case, multiple sources of evidence are required. Thus, this research applied a quantitative and qualitative data collection and analysis to examine the learning outcomes and experiences of the involved students.

Assuming that learning is socially constructed as there are as many realities to learning as there are participants, the results drawn from this research were used to generate positive effects within a specific training programme, which enables capability building in lean warehousing. Summing up, this research sought to address the question as of how SL influences an EL training programme whereby an existing EL training has been modified to monitor changes in participants' learning outcomes. Thereby, an SL session in form of e-learning was added for participants of group 2 five weeks after the EL training to revise the topics learnt during the initial training.

*Knowledge tests to collect primary data*

Multiple-choice question knowledge tests generated quantitative data which were collected in two student groups with seven participants each. Participants were recruited by self-selection sampling: Members of the Lean Student Group of the Karlsruhe Institute for Material Handling and Logistics were invited to express their desire to participate in the study. Those individuals who signed up for the study were the study population and were divided into two groups by using systematic sampling. None of the students was known by the researcher and the research followed the guidelines of the Ethics Committee of Liverpool John Moores University.

The multiple-choice question knowledge tests contained 15 items covering all levels of Bloom's Taxonomy (remembering, understanding, applying, analysing, evaluating) in accordance to Dubins *et al.* (2016) on lean warehousing and aimed at getting quantitative evidence for the change of the participants' learning outcomes. Significant differences could be examined taking the multiple-choice knowledge tests as pre- and post-interventions. Multiple-choice questions are a popular tool to assess competencies and knowledge in professional curricula as they are reliable, easy to administer and analyse (Dubins *et al.*, 2016). However, to overcome the major criticisms of this type of tests, the lack of familiarity with the multiple-choice question format, the danger of over-exaggerating pattern recognition for answering the multiple-choice questions and the perceived luck in participants' performance, the steps outlined in Figure 2 were taken.



**Figure 2.**  
Steps taken to reduce error in multiple-choice questions

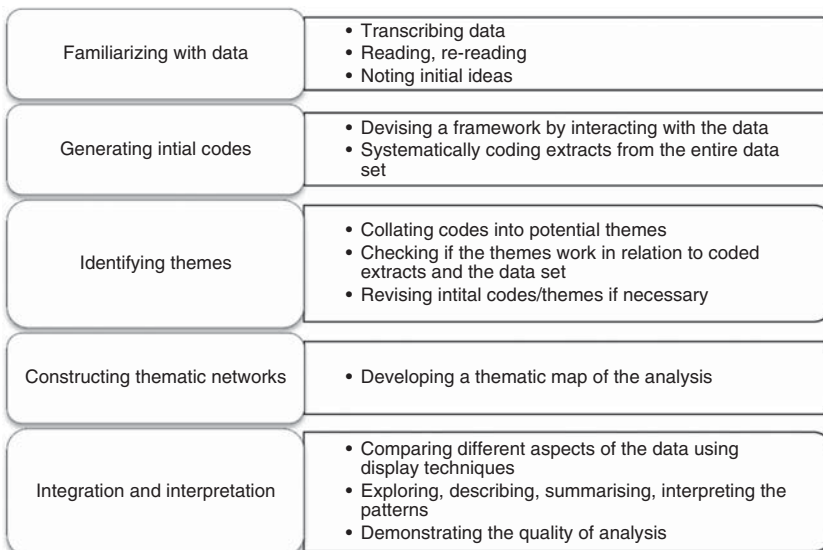
**Source:** Dubins *et al.* (2016)

The first multiple-choice question test was conducted prior to the very first Model Warehouse training. The second test took place on the same day after the training session ended. Five weeks later, group 2 took part in a repeating online study session and thereafter a four-week test delay occurred. All in all, both group 1 and 2 conducted the third multiple-choice question test nine weeks after the Model Warehouse training. As in previous SL research, the test questions remained the same (Arnold and McDermott, 2013).

All test results of the participants in both groups were tallied into a numerically ordered table. Conclusions on relative frequency and percentage distribution of the number of correct answers and their development over the three tests were drawn. Afterwards, the mean average of correct answers of both groups was calculated after each test. From this, the improvement of knowledge retention of the groups over the duration of the three tests was evaluated. Thus, the focus was put on the participants' individual overall results rather than question-specific results.

*Interviews to collect primary data*

Qualitative data were collected through semi-structured in-depth interviews in group 2 only, as this research was aiming at gathering detailed insights into their experiences and beliefs with and regarding the influence of the SL session to the EL training. All interviews were conducted by the researcher in form of face-to-face and telephone interviews and lasted between 20 and 35 min. Open and closed questions, in form of scale items, with regards to the participants' perceptions and experience during and after the training sessions were asked. To allow the interviewees to expand on their responses and to explore those that were substantial to the research, probes and prompts were used. The thematic coding analysis was used to analyse the interview data. The steps taken are listed in Figure 3.



**Figure 3.**  
Steps of thematic coding and analysis

**Source:** Adapted from Robson and McCartan (2016)

In accordance to Miles *et al.* (2014), initial codes, such as magnitude, descriptive or values codes, were developed during first cycle coding. Within the second cycle coding, themes were identified.

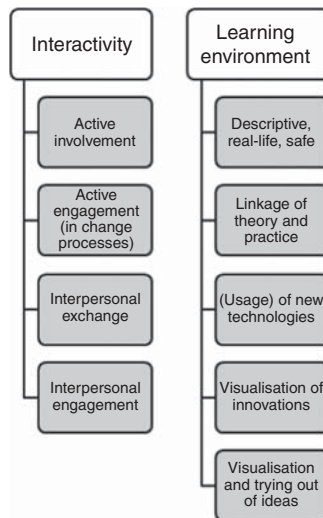
### Findings

#### *Benefits of experiential and SL*

Prior to the Model Warehouse training, it was queried whether participants had already taken part in a Model Warehouse before or not: none of the participants had participated in it before, yet six of the 14 participants already had a basic understanding of lean warehousing or lean management in general.

Consistently, participants named two aspects they appreciated about the training: interactivity and the learning environment (see Figure 4). Thereby, the latter was seen as more encouraging as it resembled a real-life situation, equipped with state of the art technology and the opportunity to try out and fail without causing damage. Yet, without the participants' active participation and their interaction within a process, as well as the interpersonal exchange with others, the learning environment of any EL training programme would not be successful. One could argue that the participants' interactivity led to a better understanding of the materials taught in the work-based training. The participants' increased enjoyment factor might have been due to the combination of interactivity and learning environment which also led to a stimulation of their cognitive processes.

Furthermore, an important level of curiosity on how things are being done was evoked. Therefore, it can be assumed that a high degree of attention of the students was given to the session. Yet, to ensure prominent levels of attention, focus has been put on the participants' personal needs and prior knowledge as the qualitative analysis revealed that participants with different background knowledge had different learning needs during the training programme. Students acknowledged e-learning to be their preferred SL medium.



**Figure 4.**  
SL Participant's  
perceived Model  
Warehouse benefits

Source: Authors' own compilation

Participants named the repetition, the time-efficiency, the re-stimulation of cognitive processes as well as the flexibility to bridge times without active operation as the benefits of SL (see Figure 5). The following quotes taken from the students' interviews support this:

[...] through repeating the material learnt, deeper understanding is created and the information remains longer [...] [retain in memory, remains in the brain...]. (Interviewee 8)

[...] through the spaced learning session, linkages were built between the in-person session and the repetition which helps to create lasting memory [...]. (Interviewee 6)

[...] during the repetition session I could set my personal focus on topics I hadn't understood so far and was able to skip those I already understood in a very short time [...]. (Interviewee 4)

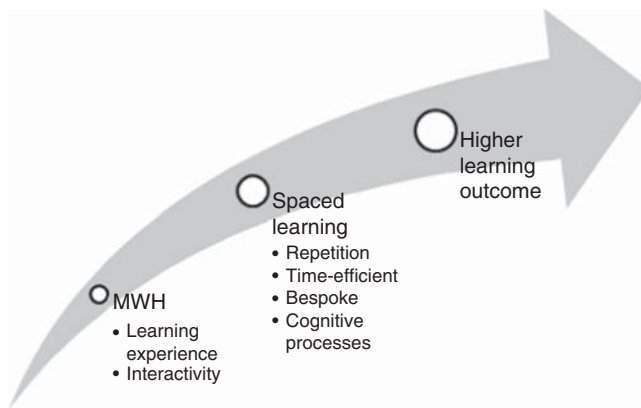
Yet, SL is only judged to be supportive and would not work without the initial classroom-training and EL of lean logistical processes.

*Application of SL to an EL training*

The analysis of the mean average of correct answers in both groups 1 and 2 over the duration of the study revealed that:

- (1) both groups had a profound understanding of lean warehousing prior to the EL training;
- (2) in the initial test group 1 scored better than group 2;
- (3) the EL training led to an increase of correct answers in both groups; and
- (4) following the SL session group 2 furthermore increased their number of correct answers, whilst group 1 experienced a loss.

The mean averages of correct answers in both groups can be found in Table III.



Source: Authors' own compilation

Figure 5. SL impact on model warehouse

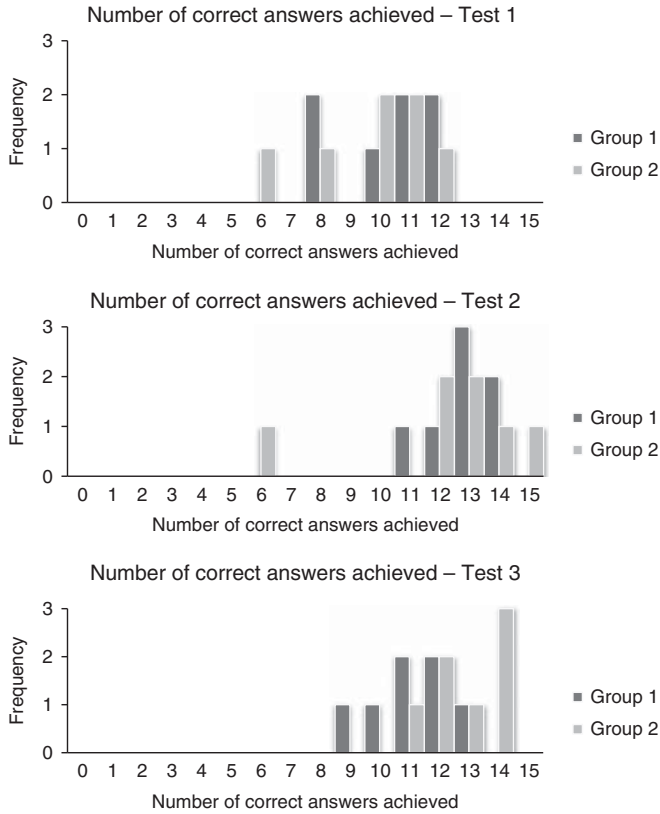
	Mean average of correct answers		
	Test 1 – prior EL training	Test 2 – after EL training	Test 3 – after SL session of group 2
Group 1	10.29	12.86	11.14
Group 2	9.71	12.14	12.86

Source: authors' own compilation

Table III. Mean average of correct answers

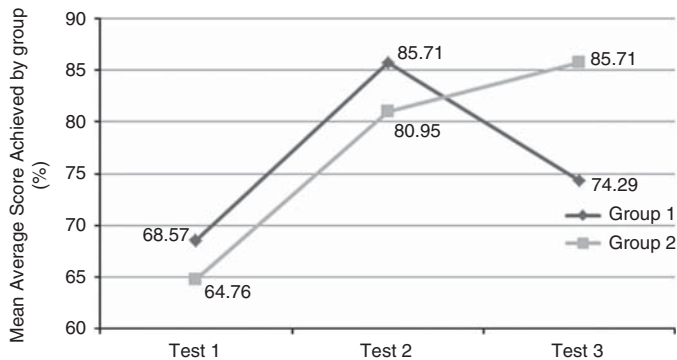
The exact development of correct answers achieved of both groups over the duration of the three tests can be found in Figure 6.

This can further be visualised by comparing both groups' cumulative average percentage score of mean average of correct answers (Figure 7).



**Figure 6.**  
Histograms  
for the number of  
correct answers  
achieved – Test 1-3

Source: Authors' own compilation



**Figure 7.**  
Cumulative  
percentage of  
the mean average  
group score

Source: Authors' own compilation

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### *Effect on the learners' self-perceptions and self-confidence*

No participant had a negative feeling about the SL session. Yet, all participants unanimously voted that the EL training was their preferred training as it was a learning environment which engenders and supports a high degree of interactivity.

During the interviews, only one student acknowledged that the SL session allowed him to remember the material better than just the Model Warehouse training, whilst advocating that the SL session offered the possibility to revise forgotten parts. Additionally, the same one student claimed to feel more self-confident with regards to the materials learnt after the SL session. The remaining six participants argued that the SL session did not improve their learning, did not entail any additional information, failed to stimulate cognitive processes beyond those from the Model Warehouse training and was unenjoyable.

## **Discussion**

### *Benefits of EL*

The findings of this research suggest that from the participants' point of view the learning environment, the interactivity, and the resulting comparatively high stimulation of cognitive processes are the main benefits of the Model Warehouse training. Additionally, participants rate the enjoyment which results of the Model Warehouse training as a benefit.

Participants argue that the EL work-based learning is much different to normal class-based training, they are more greatly committed to actively participate and engage in the process, effective group dynamics and a higher exchange of information which lead to the development of new viewpoints and the stimulation of reflective thinking.

These findings affirm what is already revealed by previous research: EL differentiates itself from, thus is more beneficial than, teacher-centred learning seeing as learners are actively taking part in an interactive, risk-free experience in which they can experiment with new ideas and fail without causing damage (Austin and Rust, 2015; Egbert and Mertins, 2010).

Through building up emotive connections within an EL environment, cognitive processes are launched that create neural linkages which lead to lasting knowledge retention (Schenck and Cruickshank, 2015). These findings mean that by utilising the Model Warehouse training, a strong method is in use to provide initial training to learners in the field of lean warehousing as it is a stimulating atmosphere where curiosity is created and the learner feels not obliged to, but wants to learn. The learner effectively gains knowledge in the subject and can relate this information to real-world scenarios. Furthermore, during the interviews it became apparent that EL leads to reflective thinking which in real-life can stimulate change processes in current businesses. This appears important as it confirms the current practice of the Model Warehouse training. Finally, it is in line with the major assumptions of Kolb's EL theory model (Kolb, 1984).

### *Benefits of SL*

The findings of this research advocate several benefits of the SL session. Especially, the spaced revisions itself, as well as its adaptability to the individual, are two of the beneficial aspects of the SL session. In addition, the participants emphasise the small-time requirement of the SL session and the continuation of the cognitive processes that are initiated by the EL training.

It appears that participants appreciate the repetitive nature of the SL session, which aims to capture the material taught in the EL training to strengthen overall knowledge building. Moreover, SL represents a means which can bridge times without active operations for participants not to forget what has been taught in the Model Warehouse training.

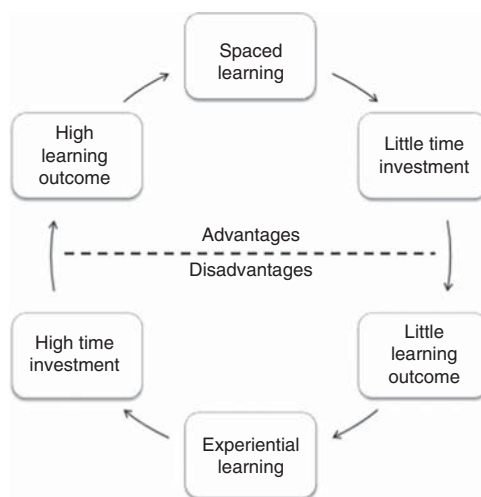
Also, participants highlight that the gap between the initial Model Warehouse training and the succeeding SL session is very helpful to be able to reflect on what they have learnt

during the initial training. When engaging in the SL session, the cognitive processes initially started during the Model Warehouse training are re-stimulated, existing linkages are strengthened and obscurities that may have developed after processing the information of the Model Warehouse training are eliminated through the following SL session. This perception of participants is in line with what previous research has proven, namely, that the recollection of information is higher when reviewing that information spaced out over time compared to a massed, single study session, in this case the Model Warehouse training (Kang, 2016; Sobel *et al.*, 2011).

Participants claim the SL session offers another additional benefit, namely, the little time investment compared to the previous Model Warehouse training. However, at the same time the participants note that although the SL session requires less time investment from their side, it does not impart as much learning output as the Model Warehouse training (see Figure 8).

A further observation is that participants appreciate economical learning, which means that more can be achieved in a short amount of time. In other words, participants prefer high learning outcome with low time investment. Yet, they acknowledge that the SL session would not have had such a significant impact in case of the Model Warehouse training would not have laid substantial cognitive foundations. Therefore, the little time investment should be disregarded as a general benefit.

The participants' choice of the preferred SL medium, namely E-learning, is in line with their appreciation of economical training. They prefer a bespoke medium in which every single participant can autonomously decide when and how what to revise of the previous Model Warehouse training to achieve their individual optimum learning result. Choosing any form of e-learning as the SL medium to be added to the Model Warehouse training would resemble what Chang (2016) defined as interactive learning in which an in-person training is combined with an e-learning-based rehearsal session. As the findings of both the primary data and previous research are corresponding it can be concluded that they are valid for the case of this research. Moreover, they appear important in view of future training and how to design the spaced rehearsal sessions.



**Figure 8.**  
Advantages and disadvantages of SL and EL

Source: Authors' own compilation

*Application of SL to an EL training*

The comparison of the knowledge tests of group 1 and group 2 suggests that the SL session (group 2 participated in) has a significant impact on the knowledge development of the students in this group (see Figure 9).

Participants of the SL session are either able to retain or improve upon the knowledge level. It indicates that a single SL session has a positive influence on the participants' knowledge retention. Assuming that the research on the SL effect is correct and three or more repetitions are even better with regards to increasing knowledge retention than one single revision session (Bahrick, 1979; Bahrick *et al.*, 1993; Shebilske *et al.*, 1999), one could assert that the participants' knowledge retention could still be improved much further.

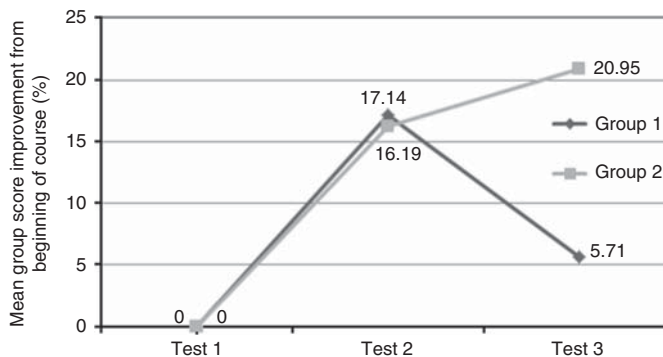
Yet, participants regret that they did not receive any feedback on their test results to understand their areas of improvement which they could restudy for future correct application. However, in SL research this is not applied either as focus is put on the direct effects an SL session has rather than the mediated effects (Karpicke and Bauernschmidt, 2011).

Concluding, letting learners know the errors they made may lead to an adaption of the learning strategy of the individual learner. Thereby, information is said to be processed more intensely and better encoding strategies are developed (Bahrick and Hall, 2005). Hence, previous failures will be diminished and an improvement in knowledge retention is achieved as learners who engage in tests have to access information stored in their memories, transfer and apply it to new situations and hence, lead to an increase in learning and knowledge retention (Karpicke and Roediger, 2007). This underpins the third predominant reason for the SL effect to occur and it appears inevitable to give test feedback to the participants in the SL session.

Overall, the above-mentioned results lead to the suggestion that SL sessions should be incorporated into any existing EL or work-based training programmes, especially into the Model Warehouse training, to enhance knowledge retention.

*Effect on the learners' self-perception and self-confidence*

The findings of this research indicate that most participants who engaged in the SL session did not properly appreciate the impact the SL session had towards their knowledge retention. They argue that the SL session is not as effective as the real-life environment of the Model Warehouse training they participated in: the initial training has a higher input; more detailed knowledge and they were actively engaged and part of the overall process. Yet, the minority of participants indicate that the SL session helps to remember material better than solely the Model Warehouse training. Furthermore, they say that the Model



Source: Authors' own compilation

Figure 9. Cumulative percentage polygons of the groups' overall improvement

Warehouse training is overloaded with information and time is needed to restructure and organise them; after a break they can revise the information again and structure everything according to their needs. This also highlights that training groups should be differentiated according to skill levels.

Still, most of the participants recognise the added value the SL session offered to deepen understanding and refresh materials learnt during the Model Warehouse training. They argue that the external push they got to sit down and revise again is useful to reorganise and freshen up memory in a customised way. However, the minority of participants does not judge the SL session to be an added value to the Model Warehouse training. They reason that the SL session would only be an added value for novices who do not have any prior understanding of lean warehousing.

Nevertheless, when considering the majority who argue that the SL session is inferior to the Model Warehouse training, their test results show an improvement in knowledge retention following SL in comparison to those whom did not undertake SL. Zechmeister and Shaughnessy (1980) trace that back to the participants' perception that a massed learning session, in this case the Model Warehouse training, gives learners the feeling to be more familiar with the material taught and therefore, participants assume to have a greater understanding of this material.

Zechmeister and Shaughnessy's (1980) explanation on why participants perceive the way they do can be also considered with regards to why most participants says that they feel more self-confident after the Model Warehouse training than after the SL session. In this research, all participants claim that they enjoy the interactive part of the Model Warehouse training better and therefore, both interpersonal and intrapersonal engagement in the training is increased. Moreover, this aspect is missing during the SL session; thus, most participants perceive it to be less effective than the Model Warehouse training.

Regarding the minority of participants who rate the SL session higher in terms of self-confidence and claim to recall information more easily after the SL session, it should be noted that they still say that the Model Warehouse training is most important in building the foundation for the following SL session and its associated learning success. Still, by revising those aspects they forget about and which they do not get in full during the Model Warehouse training, their self-confidence in the overall topic increases as well as the ability to recall information. Thus, the SL session would not have been needed and would not have been as successful as it is without an enlighten Model Warehouse training.

## Conclusion

### *Implications of adding SL to an EL programme*

It can be concluded that the benefits of the SL session are the spaced repetition itself, the adaptability within and the re-learning SL imparts. However, compared to the EL training, the benefits of SL are perceived to be inferior as the latter will not lead to any success if the benefits of the EL training are not made use of to their fullest extent. Therefore, it is required for practitioners to be aware of the benefits any EL training possesses, to make best use of them and then transfer them to the subsequent SL sessions.

Regarding the effect a single SL session has on the participants' knowledge development it can be concluded that compared to those participants who only participated in the EL training, 57 per cent of SL learners were able to retain the knowledge level they achieved on completion of the EL training. Yet, 29 per cent of SL participants were even able to gain further knowledge. Moreover, it could be shown that when participants participated in an SL session five weeks after the EL training and taking part in a knowledge test four weeks later, no loss in knowledge occurred. Whereas the participants that only participated in the EL training experienced an average loss in

knowledge of 11.42 per cent over the nine-week test-delay period compared to what they knew after the work-based EL training.

In terms of self-perception of most participants that participated in the SL session it should be concluded that the extra session was not viewed as being a help to improve knowledge outcomes or self-confidence with regards to the subjects studied. Yet, the test results verified that the SL session had a positive impact on the participants' test results. Therefore, participants' awareness on the influence and impact SL has on their knowledge retention should be established for them to build a more accurate self-perception.

#### *Recommendations for future research*

Analysing more than one unit of the Model Warehouse training will increase the validity of the findings of this research. Thus, further analysis of work-based EL training programmes should be considered whilst replicating the research at hand.

In doing so, it needs to be figured out how many SL sessions are needed to achieve best results in knowledge retention for the case of the Model Warehouse training. In addition, it should be worked out which spacing intervals are best to achieve long-term success and which e-learning format should be used to best create anticipation to sustain the learners' enjoyment over the course of the SL sessions. Furthermore, it is recommended to measure the mediated effects feedback on participants' learning results has on their overall knowledge improvement.

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i. "Tasks" test

Warehousing Multiple Choice Test

Choose the correct answer by circling the appropriate letter.

1. Lean Warehousing targets at
  - a. Significantly reducing warehousing operating cost by maintaining productivity, at the same time as improving quality
  - b. Significantly reducing warehousing operating cost by increasing productivity over time
  - c. Significantly reducing warehousing operating cost by increasing productivity, at the same time as improving quality
2. "Lean" turned which car manufacturer into the world's leading car maker?
  - a. Ford
  - b. Toyota
  - c. Daimler
3. Please complete the sentence: Waste
  - a. Is work or use of resources that does not add any value to a product
  - b. Is work that directly increases the value of the product in the eyes of the customer
  - c. Is work that does not directly add customer value, but which is currently necessary to maintain operations
4. Which is the so-called 8th type of waste?
  - a. Motion
  - b. Over-processing
  - c. People potential
5. "Repeated order checking for accuracy" is an example of
  - a. Overproduction waste
  - b. Over-processing waste
  - c. Rework waste
6. What is an example of motion waste?
  - a. Walking long distances because the product placement is not up to date
  - b. Rearrange product in a container to fit heavy products at the bottom
  - c. Waiting for trucks at goods in
7. What are spaghetti diagrams used for?
  - a. To show waste in form of waiting and transport
  - b. To show waste in form of inventory and rework
  - c. To show waste in form of motion and transport
8. Transformational change can take place
  - a. At an organisation's board level only
  - b. At an organisation's managerial level
  - c. At all levels of an organisation
9. Which part of the picking process is value adding?
  - a. Picking
  - b. Walking
  - c. Searching
10. If pickers walk to the location, pick, walk to the next, etc. and then drop the order, how is this called?
  - a. Goods to man
  - b. Man to goods
  - c. Random picking

11. In which setup are smart glasses preferably used?
  - a. Single-order setup
  - b. Reverse picking setup
  - c. Multi-order setup
12. What is a low cost approach to quality checking in warehousing?
  - a. Weight checks
  - b. Barcodes
  - c. Double checks
13. What is the typical performance improvement in picking when smart glasses are used in a warehouse?
  - a. 10–20%
  - b. 20–30%
  - c. 30–40%
14. How do you not operate a smart glass in a warehousing context?
  - a. Voice controlled
  - b. Touch controlled
  - c. Gesture controlled
15. What is an example of over-processing in a warehouse context?
  - a. Unnecessary use of packaging material
  - b. More cartons folded than needed
  - c. Long distance between goods and warehouse

ii. "Solutions" test

Warehousing Multiple Choice Test

Choose the correct answer by circling the appropriate letter.

1. Lean Warehousing targets at
  - a. Significantly reducing warehousing operating cost by maintaining productivity, at the same time as improving quality
  - b. Significantly reducing warehousing operating cost by increasing productivity, at the same time as improving quality
  - c. **Significantly reducing warehousing operating cost by increasing productivity, at the same time as improving quality**
2. "Lean" turned which car manufacturer into the world's leading car maker?
  - a. Ford
  - b. **Toyota**
  - c. Daimler
3. Please complete the sentence: Waste
  - a. **Is work or use of resources that does not add any value to a product**
  - b. Is work that directly increases the value of the product in the eyes of the customer
  - c. Is work that does not directly add customer value, but which is currently necessary to maintain operations
4. Which is the so-called 8th type of waste?
  - a. Motion
  - b. Over-processing
  - c. **People potential**
5. "Repeated order checking for accuracy" is an example of
  - a. Overproduction waste
  - b. **Over-processing waste**
  - c. Rework waste

6. What is an example of motion waste?
  - a. **Walking long distances because the product placement is not up to date**
  - b. Rearrange product in a container to fit heavy products at the bottom
  - c. Waiting for trucks at goods in
7. What are spaghetti diagrams used for?
  - a. To show waste in form of waiting and transport
  - b. To show waste in form of inventory and rework
  - c. **To show waste in form of motion and transport**
8. Transformational change can take place
  - a. At an organisation's board level only
  - b. At an organisation's managerial level
  - c. **At all levels of an organisation**
9. Which part of the picking process is value adding?
  - a. **Picking**
  - b. Walking
  - c. Searching
10. If pickers walk to the location, pick, walk to the next, etc. and then drop the order, how is this called?
  - a. Goods to man
  - b. **Man to goods**
  - c. Random picking
11. In which setup are smart glasses preferably used?
  - a. Single-order setup
  - b. Reverse picking setup
  - c. **Multi-order setup**
12. What is a low cost approach to quality checking in warehousing?
  - a. **Weight checks**
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  - c. Double checks
13. What is the typical performance improvement in picking when smart glasses are used in a warehouse?
  - a. 10–20%
  - b. **20–30%**
  - c. 30–40%
14. How do you not operate a smart glass in a warehousing context?
  - a. Voice controlled
  - b. Touch controlled
  - c. **Gesture controlled**
15. What is an example of over-processing in a warehouse context?
  - a. **Unnecessary use of packaging material**
  - b. More cartons folded than needed
  - c. Long distance between goods and warehouse

Interview phase	Question/phrases	Prompts/probes
Introduction	<p>It is good to see you again</p> <p>Thank you for being willing to take part in a follow-up interview to the MWH learning sessions you participated in</p> <p>Please be assured that all data and information are treated confidentially</p> <p>Would I be allowed to tape our conversation?</p> <p>If you allow, I would like to learn more about yourself first</p>	<p>Study subject</p> <p>Semester</p> <p>Years of experience in lean warehousing</p>
Warm up	<p>Did you ever participate in a MWH session?</p> <p>Yes: was it similar to the session that took part on Dec 14?</p> <p>No: what made you participate in the session?</p> <p>What did you like in particular about the training?</p>	<p>May I ask you to explain that in more detail?</p>
Main body	<p>Looking back, which type of learning did you prefer – the MWH session or the repetition? Why would you say so?</p> <p>From your perspective, did the experiential learning session or the spaced learning session helped better to remember the material taught</p> <p>Would you say that the spaced learning session added value to the MWH training session?</p> <p>Yes: to what extend?</p> <p>No: why not? What could have been better for you to achieve added value?</p> <p>Comparing both your perceptions after the experiential learning programme and the spaced learning session, have you felt more self-confident with regards to the material learned after either?</p> <p>Please evaluate your satisfaction with your learning results after each session by answering the following, using a scale of 1–5</p> <p>Overall, I am very satisfied with the learning outcomes of the experiential learning session</p> <p>Overall, I am very satisfied with the learning outcomes of the spaced learning session</p> <p>Overall, neither of the learning sessions were satisfactory</p> <p>Did you encounter any difficulties in any learning session?</p> <p>Yes: Please explain the reasons in more detail</p> <p>In your opinion, did you pay more attention to material in one type of practice?</p> <p>Why/why not?</p> <p>Please evaluate the spaced learning experience by answering the following on a scale of 1–5</p> <p>The SLE facilitated the understanding of the input given in the MWH session?</p> <p>The SLE was important in getting a greater understanding of the input given in the MWH session?</p> <p>The SLE would not have been needed to fully acquire</p>	<p>How did you come to this opinion? May I ask you to explain that in more detail?</p> <p>Please feel free to give examples on how you experienced the increase in self-confidence</p> <p>1 strongly disagree</p> <p>2 disagree</p> <p>3 undecided</p> <p>4 agree</p> <p>5 strongly agree</p> <p>Please explain your evaluation and add further comments, if you wish</p> <p>Did you encounter this in previous learnings? What kind of learnings were these?</p> <p>Please comment on why you answered this way</p> <p>1 strongly disagree</p> <p>2 disagree</p> <p>3 undecided</p> <p>4 agree</p> <p>5 strongly agree</p> <p>Please explain your evaluation and add further comments, if you wish</p> <p>1 strongly disagree</p> <p>2 disagree</p> <p>3 undecided</p> <p>4 agree</p> <p>5 strongly agree</p> <p>Please explain your rating and add further comments, if you wish</p>

(continued)

**Table AI.**  
Interview schedule students G2

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Interview phase	Question/phrases	Prompts/probes
	knowledge learnt in the MWH session? Overall, how would you rate the efficiency of the spaced learning session over the experiential session? On a scale of 1–5, would you agree that the spaced learning session was more efficient than the experiential learning session in terms of learning outcome? On a scale of 1–5, would you agree that the experiential learning session was more efficient than the SL session on in terms of learning outcome? On a scale of 1–5, would you agree that the experiential learning session increased in efficiency by combining it with the SL session in terms of learning outcome?	
Cool-off	Are there further aspects you would like to mention/ evaluate that have not been covered in this interview?	
Closure	Thank you very much for your time today. Your insights are highly valuable for the outcome of the research project and my studies	

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Table AI.

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