Spaced education reduces the influence of learning styles on examination results in a basic radiological science course: a cohort study

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Abstract

Background: The present study aimed at highlighting if the addition of spaced education to traditional face-to-face lectures changed the correlation between learning styles and examination results.

Methods: The study comprised two cohorts of 21 third-year dental students who were scheduled for the theoretical radiological science course. Both cohorts (traditional group and spaced education group) followed a traditional face-to-face course. The spaced education group also received e-mails with a delay of 14 days to each face-to-face lecture with multiple choice questions which had to be answered. On return of the answers the students received an additional e-mail that included the correct answers and explanatory material. All students of both groups documented the time they worked on the learning content of the different lectures before a multiple choice exam was held.

All students completed the Index of Learning Styles questionnaire and the TRIL questionnaire (Trierer Inventar zur Lehrevaluation) which is a validated modular German-language questionnaire for the evaluation of courses at university.

Both cohorts were compared using the Mann-Whitney-U test. The correlation between learning styles and examination results was assessed by calculating Spearman’s rho.

Results: The spaced education group spent significantly more time (216.2±123.9 min) on keeping busy with the learning content compared to the traditional group (58.4±94.8 min, p<.0005). The spaced education group rated the didactics of the course significantly better than the traditional group (p=.034). The spaced education group also felt that their needs were fulfilled significantly better compared to the traditional group as far as the communication with the teacher was concerned (p=.022). For the traditional group there was a significant correlation between an active/reflective learning style and the examination results (p=.012) and a sequential/global learning style and the examination results (p=.013). For the spaced
education group there were no significant correlations between learning styles and examination results.

Conclusions: Adding spaced education to a face-to-face course allows leveling the influence of learning styles on examination results. Combining spaced education with face-to-face lectures gives a view to a more balanced way of education that does not prefer specific learning styles.

Keywords: e-mail, face-to-face lecture, learning style, spaced education
Introduction

Spaced education

Factual knowledge plays a critical role in the development of clinical expertise [1]. Unfortunately, acquired knowledge is often quickly forgotten [2]. Such forgetting raises the important question as to whether the educational process itself might be tailored to improve students’ retention of the curricular material [2]. Spaced education refers to educational programs that are structured to take advantage of the pedagogical benefits of the spacing effect [3]. The spacing effect is the psychological principle that educational encounters that are repeated over time result in more efficient learning [3]. Using standard e-mail to deliver educational content over spaced intervals, several trials have demonstrated the educational efficacy of this methodology as a means to improve overall learning [4]. A spaced education item consists of an evaluative component (multiple choice questions) and an educational component (correct answers and a detailed explanations of the answers). Upon submitting an answer to a question via e-mail the learner receives the educational component [5].

Learning styles

Learning styles are characteristic preferences for alternative ways of taking in and processing information [6]. As a consequence, some students prefer to work with concrete information (facts, experimental data), while others are more comfortable with abstractions (theories, symbolic information). Some students are partial to visual presentation of information (pictures, diagrams, flowcharts) and others get more from verbal explanations [7]. Some like to learn by trying things out and seeing and analyzing what happens, and others would rather reflect on things they plan to do and understand as much as they can about them before actually attempting them [7]. In an ideal situation the teaching style matches with the learning styles of the students avoiding students’ demotivation. Learning styles can be determined by the Index of Learning Styles (ILS). It is an online questionnaire designed to assess prefer-
ences on four dimensions of a learning style model [8]. The ILS consists of four scales: sensing-intuitive, visual-verbal, active-reflective, and sequential-global. Assessing students’ learning styles helps educators checking if a certain course fulfills the students’ needs.

Aim of the study

So far, spaced education interventions have focused on improving knowledge [9]. To the best of our knowledge there is no information available in the current literature, if the preferred learning style of students has an influence on the efficacy of spaced education. Therefore, in the present study a cohort of students, who exclusively received face-to-face lectures, was compared to a cohort of students, who received face-to-face lectures in combination with spaced education via e-mail, as far as the correlation between learning styles and examination results were concerned.
Material and methods

The study was approved by the institutional ethics committee of the University of Erlangen-Nuremberg (approval no. 4725). Two cohorts of 21 third-year dental students were scheduled for the theoretical radiological science course. The learning content comprised radiation physics, X-ray production, X-ray interactions, radiation dose, imaging equipment, radiation protection, image creation, and normal radiological anatomy of the teeth and jaws.

In introductory explanatory face-to-face sessions the students were asked to join the study. Participation in the study was optional. Students were excluded from the study if they did not have access to the Internet via a personal computer that was not provided by the university. Demographic data of the students were documented. One cohort of students followed a traditional course with mandatory attendance of the lectures (traditional group). The second cohort also followed the face-to-face lectures on a mandatory basis. In addition, they received e-mails with a delay of 14 days to each face-to-face lecture with multiple choice questions which they had to answers (spaced education group). E-mail reminders were sent out after 3 days in order to secure the answering of the multiple choice question within one week. On return of the answers the students received an additional e-mail that included the correct answers and explanatory material. All students of both groups documented the time they worked on the learning content of the different lectures before the exam was held.

During the introductory session the students had to complete the Index of Learning Styles questionnaire (ILS, http://www4.ncsu.edu/unity/lockers/users/felder/public/ILSdir/styles.htm). The ILS consists out of 44 items that refer to four scales:

i) Sensing (concrete, practical, oriented towards facts and procedures) or intuitive (conceptual, innovative, oriented toward theories and underlying meanings)

ii) Visual (prefer visual representation of presented material, such as pictures, diagrams, and flow charts) or verbal (prefer written and spoken explanations)
iii) Active (learn by trying things out, enjoy working in groups) or reflective (learn by thinking things through, prefer working alone or with one or two familiar partners)

iv) Sequential (linear thinking process, learn in incremental steps) or global (holistic thinking process, learn in large leaps)[6]

The answers to the 44 questions could be given in a bipolar fashion (“yes” or “no”). For the determination of the individual learning styles an online tool was used (http://www.engr.ncsu.edu/learningstyles/ilsweb.html).

Subsequently, the face-to-face course was delivered as eight didactic lectures of 45 minutes each over a period of two months. The PowerPoint presentation of each lecture was available for downloading on an online platform named Medlearn (http//medlearn.uni-erlangen.de) before each lecture was held. This online platform is provided by the Erlangen Medical and Dental School. For each lecture 3 multiple choice questions were sent out.

They only had to indicate which group they were in. The questionnaire had been put together by the authors. 30 questions focused on eliciting students’ prior e-learning experience, and attitudes and perceptions regarding e-learning and face-to-face lectures.

Three weeks after the end of the theoretical radiological science course the students of both groups were asked to fill in the questionnaire on their attitude towards face-to-face lectures again together with the TRIL questionnaire which is a validated modular German-language questionnaire (TRIL, Trierer Inventar zur Lehrevaluation) for the evaluation of courses at university (Appendix I)[10]. It comprises 6 topics. Topic 1 (“structure and didactics”) consists of 8 questions that concerned the lecturer’s skills in didactics and structuring of the learning content. Topic 2 deals with the motivational skills of the lecturer consisting of 8 questions. Topic 3 (5 questions) addresses the lecturer’s skills in creating a favourable climate during the course. Topic 4 consisted of 4 questions and asks the students to evaluate practical relevance of the course by providing a connection between theory and practice. Topic 5 subsumes 5 questions on different additional aspects of courses. Topic 6 (“homework”) consisted out of 6
questions that concerned the multiple choice questions sent out by e-mail. This topic had only
to be answered by the spaced education group. This group also had to answer 10 additional
questions that were put together by the authors and concerned the students’ attitude towards
receiving and answering e-mails on the learning content of the course (Appendix II). For all
questions the answers could be given on a scale from 1 to 6 (1=I totally disagree, 6=I totally
agree). In the same session a multiple choice exam on the theoretical radiological science
course was held. 20 questions had to be answered.

Statistical analysis
Mean values are given with standard deviations. The $\chi^2$ test was used to test if there was a
statistically significant difference in the gender distribution between the two groups. For
comparison of continuous variables in unpaired samples the Mann-Whitney-U test was
adopted. In order to assess the correlation between learning styles and examination results
Spearman’s rho was calculated. P-values less than or equal to .05 were considered significant.
All calculations were made using SPSS Version 14.0 for Windows (SPSS, Chicago, USA).
Results

All students of both of the cohorts chose to join the study. None of the students had to be excluded from the study because of a lack of access to the Internet by a computer that was not provided by the university. The analysis of the demographic data revealed that there was no statistically significant difference in age between the two groups (24.7±2.2 years in the traditional group, 24.3±2.8 years in the blended-learning group, p=.837). In both groups there were more females than males (15 females and 6 males in the traditional group, 16 females and 5 males in the spaced education group). However, the distribution in gender did not differ statistically significantly for the two groups (p=.726). During the scheduled period of the theoretical radiological science course no technical problems were encountered either with the Medlearn platform or the distribution of the e-mails. All face-to-face lectures took place as scheduled. All questionnaires that were filled in before and after the theoretical radiological science course were adequately completed and returned.

After the single lectures were given the spaced education group spent significantly more time (216.2±123.9 min) on keeping busy with the learning content compared to the traditional group (58.4±94.8 min, p<.0005).

The results for the TRIL questionnaire are given in Table 1. The members of the spaced education group rated the didactics of the course significantly better than the members of the traditional group (Q2, p=.034). The spaced education group also felt that their needs were fulfilled significantly better compared to the traditional group as far as the communication with the teacher was concerned (Q21, p=.022). The answers of the spaced education group to the TRIL topic 6 “homework” showed that the students considered working on the multiple choice questions sent out by e-mail an adequate way of improving their knowledge in the field (Table 1).

The answers to the additional 10 questions put together by the authors revealed that the students appreciated the e-mails because they helped them working continuously of the learning
content of the course (Table 2). The students did not consider the sending of e-mails on the course content an intrusion of their private lives. Sending out the e-mails two weeks after the specific lecture was held was seen as an optimal time span. The answers to the questions showed that the students would not have preferred receiving the multiple choice question directly after the single lectures or at the end of each presentation.

The scores for the learning styles for both of the cohorts are given in Table 3. There was no statistically significant difference in the distribution of the different learning styles between the traditional and the spaced education group.

For the traditional group there was a significant correlation between an active/reflective learning style and the examination results with improved results for an active learning style (p=.012) and a sequential/global learning style and the examination results with improved results for a sequential learning style (p=.013).

Sensing/intuitive (p=.849) and visual/verbal (p=.721) learning styles did not show statistically significant correlations to the examination results.

For the spaced education group there were no significant correlations between learning styles and examination results (active/reflective: p=.165, sequential/global: .784, sensing/intuitive: .826, visual/verbal: .932).
Discussion

Spaced education is an evidence-based form of education that has been demonstrated to improve knowledge acquisition and to boost knowledge retention [11]. Especially, it enhances the effect of traditional face-to-face lectures [11]. However, so far it is not completely understood, whether student preference for learning environment, learning style and performance are linked [12]. Therefore, the present study aimed at comparing a cohort of students, who exclusively received face-to-face lectures, to a cohort of students, who received face-to-face lectures in combination with spaced education via e-mail, as far as the correlation between learning styles and examination results were concerned.

In the past it has already been mentioned that spaced education is well accepted by learners [13,14]. The same was true for the present study. The students rated the didactics of the course significantly improved, when spaced education was used. It has been described previously that students using online material in addition to face-to-face lectures reported a better understanding of the learning content [12]. Also in the present study the students were positive about receiving multiple choice questions via e-mail and getting explanations on the correct answers via e-mail later on (Table 2).

The way spaced education was delivered in the present study seems to be a form of communication that students really appreciate. This aspect is reflected by the answers to Q21 of the TRIL questionnaire (Table 1) where students of the spaced education group rated the ability of the teacher to fulfill their needs as far a communication was concerned significantly more positively compared to the students of the traditional group. Although learning was extended to their spare time directed by the teacher who even sent e-mail reminders, in the present study the students were positive about this form of teaching and learning. Answering the questions put together by the authors the students denied that the e-mails sent to them on the course content intruded their private lives in a negative way (Table 2). Instead, theses e-mails offered a new possibility to structure learning with the consequence that the members of the
spaced education group spent significantly more time on keeping busy with the learning content compared to their counterparts of the traditional group.

Several different time intervals have been proposed for the delivery of spaced education items [4]. In the present study a time interval of two weeks was chosen between the lectures and e-mails containing the spaced education Items. The answers to the questionnaire put together by the authors reveal that the time interval was well accepted by the students (Table 2). They did not go for a shorter time interval or direct delivery of the multiple choice questions at the end of each presentation. The latter aspect also shows that delivering the spaced education items by e-mail is the preferred way of providing additional information on lectures today.

So far, there are only little data available on the influence of learning styles on the effect of spaced education. It has been shown that active, intuitive and global learners were twice as likely to use online study materials as reflective, sensing and sequential learners [12]. Also, visual learners were 1.5 times more likely to use the online study materials than their verbal counterparts. In the present study active and sequential learners performed better in the examinations than reflective and global learners, respectively, when only the traditional face-to-face lectures were delivered. It has been show previously that face-to-face lectures favor learners with specific learning styles [15]. However, one learning style is neither preferable nor inferior to another, but is simple different with different characteristic strengths and weaknesses [15]. Therefore, courses should address all learning styles. It is well known that greater learning may occur when teaching styles match learning styles than when they are mismatched [16]. However, the point of identifying learning styles is not to label individual students and tailor instruction to fit their preferences. In order to function effectively in their future profession students will need skills characteristic of each type of learner: the power of observation and attention to detail of the sensor, the imagination and abstract thinking ability of the intuitor, the ability to comprehend information presented both visually and verbally, the systematic analysis skills of the sequential learner and the multidisciplinary synthesis skills of
the global learner [15]. If instruction is heavily biased toward one category of a learning style dimension, mismatched students may be too uncomfortable to learn effectively. On the other hand students whose learning styles match the teaching style will not be helped to develop critical skills in their less preferred learning style categories [17]. Therefore, it seems that the optimal teaching style is a balanced one that sometimes matches students’ preferences, so their discomfort level is not too great for them to learn effectively, and sometimes goes against their preferences, forcing them to stretch and grow in directions they might be inclined to avoid if given the option [15]. The combination of face-to-face lectures with spaced education may have the desired effect. In the present study the effect of spaced education was that the superiority of specific learning styles in achieving better examination results was leveled. To the best of our knowledge, this effect of spaced education has not been described in the current literature before. It seems that spaced education gives a view to the solution of a problem that has questioned the relevance of face-to-face lectures for a large number of students. So far a single one-size-fits-all approach to teaching cannot meet the needs of every student. The problem is that no two students are alike. They have different backgrounds, strengths and weaknesses, interests, ambitions, senses of responsibility, levels of motivation, and approaches to studying [15]. On the other hand, tailoring instruction to each individual student seems to be an effort that is far too complex under real life circumstances. In this context, spaced education is kind of a compromise that allows students achieving comparable examination results independent of their preferred learning styles. Combining face-to-face lectures with spaced education via e-mail seems to overcome this correlation and improves the chances of benefiting from the course for all the students whose learning style is not perfectly suited for face-to-face lectures.
Conclusions

Adding spaced education to a face-to-face course allows leveling the influence of learning styles on examination results. Combining spaced education with face-to-face lectures gives a view to a more balanced way of education that does not prefer specific learning styles.

Competing interests

The authors declare that they have no competing interests.

Authors’ contributions

EN and FS made substantial contributions to conception and study design and wrote the manuscript. EV and SE made substantial contribution to conception and study design. AB1, AB2 and CK carried out the data collection and performed the statistical analysis. All authors interpreted the results, drafted the manuscript and read and approved the final manuscript.

Acknowledgements

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References


Table 1. Results of the answers to the TRIL (Trierer Inventar zur Lehrevaluation)

Answers could be chosen between 1 and 6 (1=I totally disagree, 6=I totally agree). For Question 30 possible answers were 1=too low, 2=low, 3=adequate, 4=high and 5=too high.

The complete questionnaire is given in Appendix 1.

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**Topic 5 “questions on different additional aspects”**

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**Topic 6 “homework”**

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Table 2. Data of the answers given by the spaced education group to the questionnaire on students’ attitudes towards spaced education

Answers could be chosen between 1 and 6 (1=I totally disagree, 6=I totally agree).

The complete questionnaire is given in Appendix 2.

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</tr>
<tr>
<td>9</td>
<td>21</td>
<td>2.6</td>
<td>.9</td>
</tr>
<tr>
<td>10</td>
<td>21</td>
<td>2.7</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Table 3. Index of Learning Styles results

For each of the two dimensions of each learning style scale reached to a maximum value of 11. Scores equal to or below 3 indicate that the learning style is balanced on the two dimensions. Scores larger than 3 indicate that there is a preference for one dimension of the learning style.

<table>
<thead>
<tr>
<th>Learning styles</th>
<th>Traditional group</th>
<th></th>
<th>Spaced education group</th>
<th></th>
<th>p</th>
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<tr>
<td></td>
<td>n</td>
<td>Mean value</td>
<td>SD</td>
<td>n</td>
<td>Mean value</td>
</tr>
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<td>2.1</td>
<td>21</td>
<td>Active 2.5</td>
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<tr>
<td>Sensing/intuitive</td>
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<td>4.7</td>
<td>1.9</td>
<td>21</td>
<td>Sensing 3.3</td>
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<tr>
<td>Visual/verbal</td>
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<td>2.0</td>
<td>21</td>
<td>Visual 6.9</td>
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<tr>
<td>Sequential/global</td>
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<td>1.3</td>
<td>2.2</td>
<td>21</td>
<td>Global 1.3</td>
</tr>
</tbody>
</table>
Appendix 1 TRIL (Trierer Inventar zur Lehrevaluation) questionnaire for the evaluation of courses at university.

Answers to the questions could be chosen between 1 and 6 (1=I totally disagree, 6=I totally agree) except for Question 30.

For Question 30 possible answers were 1=too low, 2=low, 3=adequate, 4=high and 5=too high.

Topic 6 had only to be answered by the spaced education group.

*Topic 1 “structure and didactics“*

Q1. The course materials (manuscripts, PowerPoint slides, etc.) provided during the course were helpful for the understanding of the learning content.

Q2. Didactic aids (blackboard, flipchart, etc.) were used in an adequate way.

Q3. The lecturer gave short summaries in order to make clear which were the crucial points for the understanding of the topic.

Q4. The time management of the lecturer was adequate.

Q5. The learning contents of the single sessions were adapted to the learning targets.

Q6. The course schedule at the beginning of the term gave me a good overview on the learning content.

Q7. The course had a reproducible structure.

Q8. The course materials were always provided on time.

*Topic 2 “motivational skills of the lecturer“*

Q9. The style of speech of the lecturer was fluently and clear.

Q10. The lecturer was able to explain difficult learning content in an understandable way.

Q11. The lecturer’s speech was acoustically understandable.

Q12. The lecturer was able to keep contact to the audience (e.g. by eye-contact).
Q13. The lecturer created an inspiring atmosphere.

Q14. The lecturer was able to deal with disturbances (technical problems, noisiness, etc.).

Q15. It was easy for me to remain concentrated during the course.

Q16. I was inspired to follow the train of thoughts during the course.

Topic 3 “Communicative competencies of the lecturer”

Q17. The lecturer stopped discussions at the right point of time.

Q18. The lecturer treated the students friendly and was open-minded.

Q19. The lecturer allowed asking questions that concerned the learning content and answered them adequately.

Q20. The students received the possibility to give contributions to the course.

Q21. The lecturer was able to fulfill needs expressed by the students concerning content, structure and organization of the course.

Topic 4 “practical relevance of the course”

Q22. During the course the relation between theoretical knowledge and practical application demonstrated.

Q23. The learning content of the course was adequately illustrated by practical examples (case studies, clinical applications, etc.).

Q24. I was inspired to deal with the learning content critically.

Q25. The practical relevance of the learning content should have been highlighted even more intensively.

Topic 5 “questions on different additional aspects”

Q26. The availability of the lecturer at other occasions than the lecture was satisfying.
Q27. Even at other occasions than the lectures the lecturer answered my questions in an adequate way.

Q28. I prepared myself for the lectures on a regular basis (e.g. by reading of additional literature).

Q29. I did follow-up course work on a regular basis (e.g. by discussion with other students or by reading of additional literature).

Q30. The degree of difficulty of the course was

1=too low, 2=low, 3=adequate, 4=high, 5=too high.

*Topic 6 “homework”*

Q31. The level of difficulty of the homework was adequate.

Q32. The homework had a good training effect.

Q33. The homework was an adequate way of preparing for lectures and following up lectures.

Q34. The homework was worded in an adequate way.

Q35. The homework improved my understanding of the learning material.

Q36. The amount of homework was adequate.
Appendix 2

Questionnaire on students’ attitudes towards spaced education. Answers to the questions could be chosen between 1 and 6 (1=I totally disagree, 6=I totally agree).

Q1. E-mails sent to me with questions on the course’s learning content helped me to keep me busy working on the learning content on a continuous basis.

Q2. Receiving e-mails with answers to the questions answered previously was an additional help.

Q3. The questions sent by e-mail helped me to get a deeper insight in the learning content.

Q4. The e-mails that contained questions regarding the learning content did negatively intrude my private life.

Q5. The amount of learning content that I had to work through in order to answer the questions sent by e-mail was adequate.

Q6. I would have preferred receiving more questions on the learning content by e-mail.

Q7. Answering the questions that I received by e-mail kept me from working on the content of other courses.

Q8. I would have preferred receiving questions on the learning content directly after the single lectures.

Q9. It would have been sufficient to just show the multiple choice questions on the final slide of each lecture.

Q10. I do not see any need to change the didactical concept of the course.