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The effect of promoting factors on learning by four different delivery modes

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Abstract

Background In the digital era, developing effective teaching methods is crucial due to the challenges of maintaining students' concentration amidst distractions. This study assessed the effects of learning-promoting factors both across group boundaries and within RCT learning groups examined in our previous study on the effectiveness of online versus live teaching.

Methods The participants' experiences in the domains of Concentration, Anticipation, Liking and Desire to reuse were evaluated online immediately after a lesson on diagnosing pediatric respiratory issues implemented either in a Live, Live-stream, Vodcast or Podcast setting. The students rated their experiences on a scale of 1–10 with scores above a median of 8 indicating high experience levels in each factor. Learning was evaluated using a Webropol e-Test immediately and five weeks after the teaching session. The 15-minute test, comprised of 10 multiple-choice questions and real-life video scenarios, measured both theoretical and diagnostic skills. The test score scale ranged from –26 to 28 points.

Results High concentration was experienced by 70/72 (97.2%) students in the Live, 41/75 (54.7%) students in the Live-stream, 53/72 (73.6%) students in the Vodcast and 36/79 (45.6%) students in the Podcast teaching groups ($P < 0.01$). High concentration promoted learning the most, resulting in a 1.93 score improvement in the short-term test and a 1.65 score improvement in the long-term test. Among those with high concentration, the average test scores ranged from 21.9 to 23.4, while the range for low concentration was 18.3–20.0.

Conclusion In our study, good concentration promoted higher test scores in comparison with low concentration across all the learning modalities, both in digital and live settings. However, the live teaching modality resulted in the highest levels of concentration. Our results suggest that teachers should use various teaching modalities and utilize related special features to engage learners and maintain their concentration.

Keywords Vodcast, Podcast, Team-teaching, Streamed teaching, Learning, Remote learning, Concentration, Anticipation, Desire to reuse, Liking, Teaching modalities

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Background

In this rapidly evolving era that involves different teaching modalities, the shift to distance learning has revolutionized learning experiences, demanding new digital competencies from both teachers and students. However, to this point, it has not been shown whether the same factors promote learning in different learning modalities, in digital or live settings. In this study, we wanted to measure the realization and learning impact of previously known learning-promoting factors in a digital setting in comparison to live teaching.

Based on the present knowledge, learning arises from the interplay of various factors that mutually influence one another (Fig. 1). Notably, the ability to concentrate and maintain interest has a strong correlation with positive anticipation and learning outcomes [1–6] as it promotes the capacity of working memory to transport knowledge to long-term memory [7–10].

Working memory can only handle a very limited amount of information at once, and as it becomes overloaded, less and less information is transferred to long-term associative memory, leading to a decrease in learning [11]. Based on observational studies on the case series of the functions of working memory [7, 8, 12, 13], perceptions remain in working memory for only seconds, after which they are either transferred to long-term memory or vanish. To avoid overloading an individual's working memory abilities and de-focusing, teachers should only deal with a few topics at a time, unless the described items can be quickly interconnected, for example by using mnemonics [13–16].

The significance of concentration in learning

The student's individual learning style (auditory, visual, kinesthetic) seems not to have an influence on concentration [17, 18], even though the ability to concentrate is vital for good learning outcomes [10, 19]. Concentration can be improved by using visual materials, testing knowledge after lessons, and incorporating interactive practical content in the teaching [10, 20, 21].

The student's ability to concentrate is dependent on their motivation and engagement with the topic. As a result, the teacher should focus on creating a relaxed and friendly learning environment that enables achieving a flow state of concentration that boosts working memory. Deep concentration can be enhanced by the teacher's personal characteristics, such as enthusiasm for the topic, good communication skills and the ability to inspire and engage the students in the teaching subject. As a result, the student's motivation improves and leads to better learning outcomes by more effective transfer of information from working memory to long-term memory [8, 9, 22, 23].

On the other hand, a teacher presenting content in an unclear manner is perhaps the biggest factor that impairs concentration [22, 24]. In our study, we wanted to enhance concentration and expectations for learning among students by implementing interactive activities and practising diagnostics through patient videos, in line with CTML (cognitive theory of multimedia learning) theory [3, 4, 25, 26].

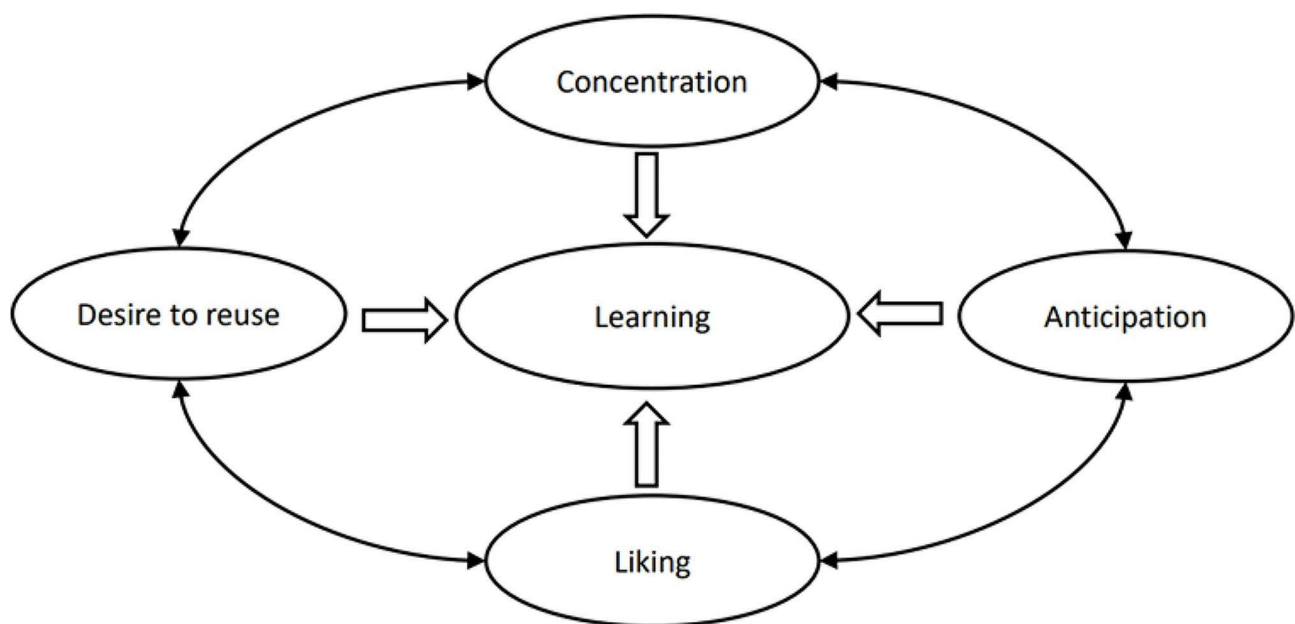


Fig. 1 The connections between factors that promote learning

The impact of positive anticipation, liking and teaching modality on learning

Anticipation is an individual's subjective assessment of learning expectations [6, 27]. Positive anticipation promotes concentration and affects the transfer of learned information to long-term memory [5, 6].

Teachers can use many teaching methods to create positive anticipation. However, incorporating irrelevant entertaining details or images to provoke the learners' interest can harm the learning process, even if the learners like it [1]. Therefore, simply liking the teacher, content, or teaching method does not necessarily lead to effective learning [1, 2, 4].

Promoting students' positive anticipation and liking, either face-to-face or online, influences the learning outcomes by improving their ability to concentrate [28–34]. However, research results have been contradictory: some studies have shown similar learning outcomes from live and video teaching [28, 30, 34], although students seem to find live lectures more entertaining and prefer them over pre-recorded video lectures, streamed sessions and podcasts [29, 34]. For example, a German study compared students' liking of live and recorded video lessons. Based on the students' subjective evaluations, 48% preferred live lessons, 27% favored video lessons, and 25% did not perceive a difference between the modalities [29]. Although video lessons offer many advantages, the benefits of live teaching should not be overlooked. Live teaching enables real-time interaction, instant feedback, and the ability to adapt to students' needs, creating a dynamic and engaging learning environment [17, 23, 24, 35]. A demonstrated benefit of live teaching is that it fosters a sense of community and cooperation, leading to better concentration [36].

Desire to reuse the teaching modality as a marker of anticipation

Students' desire to reuse a teaching modality is related to anticipation and liking [1, 4–6, 27]. The experience of learning effectively with the method strengthens the desire to use it again. Emotionally engaged and actively participating students are more likely to integrate new knowledge into existing frameworks, which leads to better learning outcomes. Positive emotions such as liking, positive anticipation and interest significantly boost concentration, engagement, and desire to reuse, which further enhance learning [37–39].

Objectives

In the present study, we aimed to evaluate the impact of key factors promoting learning — Concentration, Anticipation, Liking and Desire to reuse the teaching method — on learning outcomes using an activating team-teaching approach in a single 45-minute lesson implemented

by four different delivery modes. Our specific interest was to investigate whether the learning-promoting effect of each factor was the same regardless of the delivery modes: live or streamed teaching, recorded videos or podcasts that may only be accessed once. Our hypothesis was that the realization of the learning-promoting factors would lead to better learning outcomes regardless of the learning modality.

Participants and methods

This study involved 325 students, including 175 medical students and 150 nursing students. The medical students were in their fifth year (six years of education) at the University of Eastern Finland and participated in an 8-week pediatric course spanning from August 2021 to May 2022. Simultaneously, first- to fourth-year students of emergency nursing (paramedic) from the Savonia University of Applied Sciences in Kuopio, Finland, joined this study during their course in pediatrics. While participation was voluntary, the content covered in the study unit was a mandatory part of the medical students' curriculum, focusing on respiratory distress in children. All fifth-year medical students and all emergency nursing students from each of the four classes were asked to participate in the study with an initial email detailing the study's purpose and background.

The study participants were randomized into four groups: classroom teaching (Live), streamed teaching (L-stream), Podcast, and Vodcast groups, as demonstrated in Fig. 2. They participated in three tests on their knowledge to diagnose and treat breathing difficulties held before the lesson (baseline test), immediately after the lesson (short-term test) and 5–7 weeks later (long-term test). Out of those who attended the baseline test, 27 students either did not consent to participate in the research or their data could not be matched in the analysis phase due to issues with identification codes. This resulted in a total participation rate of 92% in the Experience survey. The number of dropouts in the long-term test was 27 (15%) for the medical students and 73 (49%) for the nursing students.

Measuring learning outcomes and experiences

The study focused on measuring participants' improvement in identifying respiratory problems in children. The evaluation utilized the Webropol e-Test, administered via email at three time points: baseline test before the lesson, short-term test immediately after the lesson, and long-term test 5–7 weeks after the lesson. The tests were time-constrained (15 min) and consisted of 10 multiple-choice questions: five theoretical questions and five video clips of children with respiratory distress. Each question had one or more correct response alternatives. Every correct choice accounted for plus 2 points, and every incorrect

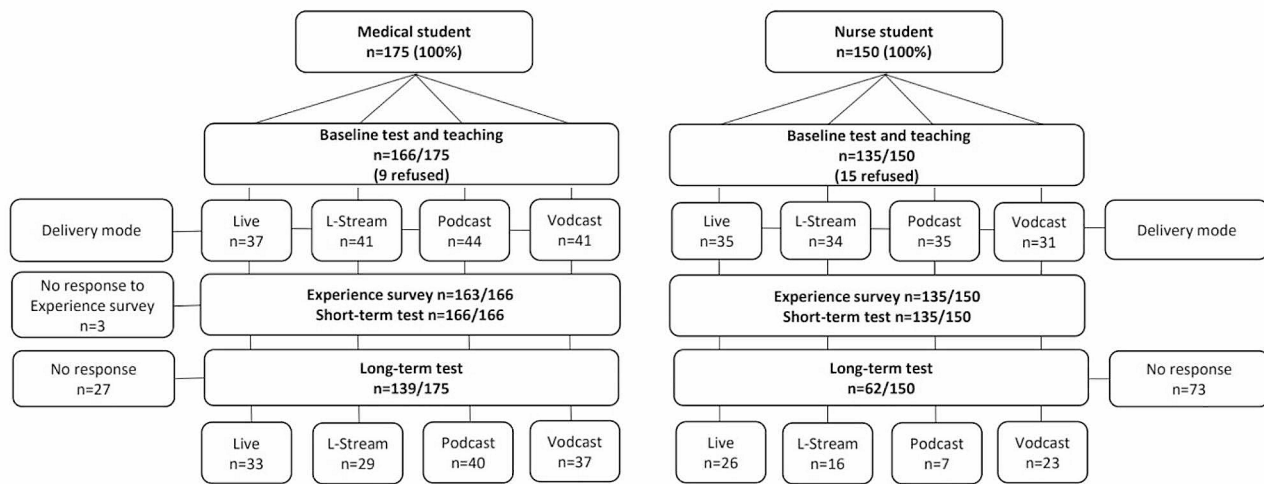


Fig. 2 Study design

Table 1 Statements used to assess the learning-promoting factors (experience survey)

Learning-promoting factor	Used statement
Concentration	I was able to concentrate on the teaching
Anticipation	I believe the learning method produced learning
Liking	I liked the teaching method
Desire to reuse	I would like to use this learning method in the future

choice deducted 1 point. The maximum score was plus 28 points, and the minimum was minus 26 points. As there were no significant differences in the baseline results between the different teaching modality groups, it was possible to use the direct test scores in the analyses. The scores in the baseline test, presented as mean (SD), were 10.25 (6.1) in the live group, 9.1 (4.9) in the live-stream group, 9.5 (5.8) in the vodcast group and 9.6 (6.0) in the podcast group.

After attending the teaching by one of the four methods, the students responded to targeted questions to assess their experiences with factors which potentially promote learning (Table 1). We call these factors in this study “learning-promoting factors”. We scored the answers on a scale of 1 to 10, using whole numbers (where 1=not at all and 10=very much). The participants were divided into two promoting factor groups based on the median of the results: a high promoting factor group (\geq median) and a low promoting factor group ($<$ median). The results were analyzed first in the entire study population and then separately within each teaching group (see statistical analyses). The wording of the questions and the decision to use a 1–10 Likert scale in the Experience survey tests were made after piloting. The questions were

designed and scripted based on multidisciplinary collaboration with medical and pedagogical experts.

Content of teaching

The examined case was an interactive 45-minute team-teaching lesson on the identification of breathing difficulties. The focus was on the most common respiratory problems in children including laryngitis, epiglottitis, bronchiolitis, obstructive bronchitis, and asthma. The topics and contents of the 45-minute learning sessions were the same in each teaching group: they began by providing an understanding of the nuances between breathing difficulty and respiratory failure and continued by recognizing causes for alarm (“red flags”) in children with respiratory distress. The objectives set for the lesson were to learn how to recognize laryngitis, epiglottitis, bronchiolitis, obstructive bronchitis, and asthma, and to treat acute respiratory distress using the IREDO mnemonic (I=Identify, R=Rescue, E=Examine, D=decision and treatment, O=observe).

During each lesson, various methods were used to maintain the students’ interest and concentration. The lessons included real-life video recordings of patient cases including laryngitis, bronchiolitis, and obstructive bronchitis. Additionally, they demonstrated and simulated inhalation and exhalation difficulties by breathing through straws. The lessons included a discussion of the differential diagnostics of laryngitis and epiglottitis. The teachers discussed the complexities of wheezing and crackles in breathing, including their pathophysiology, and the significance of silent lung sounds. Students were encouraged to draw wheezing and crackling sounds with continuous and intermittent lines. The lesson addressed specific breathing patterns in diabetic ketoacidosis and Cheyne-Stokes respiration, along with the Pediatric Early

Warning Score (PEWS) criteria. The lesson ended by discussing special challenges in newborns' breathing.

Lesson planning and piloting

The lesson and test on learning were designed and scripted based on multidisciplinary collaboration with medical and pedagogical experts. At first, the lesson was implemented exactly according to the script as a video recording known as a vodcast. Subsequently, the sound was isolated from the vodcast to create an audio recording known as a podcast. To form an understanding of the usefulness and accuracy of the used test for gained knowledge, we conducted a pilot study among paramedic students ($n=14$). They were randomized to three groups, namely the Vodcast, Podcast and Live groups, and participated simultaneously in the lesson following the exact same script. The learning results were estimated by the designed online test (Webropol E-test) before and after the lesson. The pilot test was focused on testing just one promoting factor, liking, as presented in Table 2.

Ethical considerations

In the research plan, we described the equitable recruitment process, collection of consent from the students and the anonymous data collection method including informed consent, confidentiality, privacy, equitable recruitment, scientific validity, and respect for autonomy.

Participants were randomly assigned to groups using a randomization tool available at www.randomizer.org. This ensured that the selection of participants was random instead of favouring or benefiting any individuals.

Before their participation, the students were informed about the objectives, methods, potential risks, and benefits of the study. They gave their informed consent to participate after becoming aware of these aspects. The autonomy of the participants was respected. This means they had the freedom to decide on their participation in the study without any coercion, and a possibility to withdraw from the study at any time.

We ensured the privacy and confidentiality of the participants by collecting the data anonymously with the Webropol electronic survey platform and using a freely chosen code that allowed no linkage between the data and an individual participant. The collected data are

stored on a locked computer and are not disclosed to third parties.

We designed and conducted the research using scientifically validated methods, which guaranteed the reliability of the results and the scientific validity of the study. The research plan was evaluated and the current study was approved by the Research Ethical Committee of the University of Eastern Finland (UEF) in March 2021.

Statistical analyses

We assessed the relationships between students' experiences of promoting factors and learning outcomes using multivariate linear regression analyses. We included concentration, anticipation, liking and desire to reuse as *independent variables* in the analysis. The *dependent variables* were the outcomes of learning (scores) in the short- and long-term tests. We standardized all variables prior to the analysis to account for potential scale differences. We controlled the regression model for potential *confounding variables* such as gender, field of study, and prior education. We set the statistical significance at 0.05 (alpha level), and the power at 0.80 (1-beta). We used Pearson's correlation coefficient to test the association between the promoting factors (anticipation, liking and concentration) within the whole cohort and separately within each teaching group. To explore the effect of positive anticipation (≥ 8) and concentration (≥ 8), we further analysed the association of these promoting factors with short-term and long-term outcomes in all teaching groups. The Pearson correlation coefficient analyses explored the relationship between all promoting factors across various delivery modalities. We conducted the analyses using the IBM SPSS statistical software 27.0.

Results

Experiences of learning promoting factors

Table 3 presents the number (%) of students who experienced above median level scores for the promoting factors for learning in each teaching method group (delivery modes). The Live teaching method significantly excelled in fostering Concentration, Anticipation, Liking and Desire to reuse among learners. In the Vodcast group, all the promoting factors were also better realised compared to the Live-stream and Podcast groups, although they were not comparable to the results in the Live group.

For each of the promoting factors, the median of the experience survey scores was 8 (scale: 1–10), and the quartiles were 7–9 for Concentration and Anticipation, 5–10 for Liking and 7–10 for Desire to reuse factors. The results did not change when analyzed separately in each teaching group.

Table 2 Piloting study

Piloting tests	Test scores, mean(SD)		
	Baseline *	Short-term**	Liking ***
Live ($n=7$)	8.4 (8.1)	24.1 (3.5)	9.6 (0.7)
Vodcast ($n=4$)	8.4 (8.1)	23.3 (3.4)	9.3 (0.5)
Podcast ($n=3$)	8.4 (8.1)	17.0 (4.1)	6.3 (2.1)

* test scores before the lesson

** test scores immediately after the lesson

***Experience survey scores immediately after the lesson

Table 3 Realization of learning-promoting factors based on the students' experiences

Learning-promoting factor	Number (n) and percentage of participants with a high (\geq median) promoting factor by the teaching methods					
	Live n(%)	L-stream n(%)	Vodcast n(%)	Podcast n(%)	Total n(%)	P value (chi ² test)
Concentration	70 (97.2%)	41 (54.7%)	53 (73.6%)	36 (45.6%)	200 (67.1%)	< 0.001
Anticipation	67 (93.1%)	41 (54.7%)	54 (75.0%)	31 (39.2%)	193 (64.8%)	< 0.001
Liking	69 (95.8%)	43 (57.3%)	57 (79.2%)	29 (36.7%)	198 (66.4%)	< 0.001
Desire to reuse	63 (87.5%)	41 (54.7%)	48 (66.7%)	24 (30.4%)	176 (59.1%)	< 0.001

Cross-tabulation of all promoting factors and each separate teaching group.

High promoting factor=scores \geq median

Table 4 The effect of concentration on learning results

Teaching method	High concentration, n=200		Low concentration, n=98	
Short-term learning				
Short-term test	n=200	Test score mean (SD)	n=98	Test score mean (SD)
Live	70	23.0 (3.8)	2	19.0 (2.8)
Live-stream	41	21.9 (5.1)	34	17.6 (8.2)
Vodcast	53	23.4 (5.2)	19	20.0 (5.3)
Podcast	36	22.1 (4.2)	43	18.3 (6.1)
Total	200	22.7 (4.5)	98	18.4 (6.7)
Long-term learning				
Long-term test	n=156	Test score mean (SD)	n=53	Test score mean (SD)
Live	59	22.3 (5.2)	0	-
Live-stream	25	22.8 (5.2)	18	15.9 (8.1)
Vodcast	46	23.2 (5.3)	14	19.1 (7.5)
Podcast	26	24.0 (3.6)	21	20.9 (5.1)
Total	156	22.9 (5.0)	53	18.7 (7.1)

Concentration

A total of 200 (67%) students achieved high concentration scores (high-concentration group) and 98 (33%) obtained low concentration scores (low-concentration group) in teaching. The attendance in the long-term test carried out 5–7 weeks after the lesson was lower in the

low-concentration group (54%) than in the high-concentration group (78%). Those who were able to concentrate well got better results in both exams, regardless of the teaching method. Interestingly, when analyzed separately in high and low-concentration groups, the best results in the long-term test were achieved in the Podcast teaching group. (Table 4)

The impact of the effective implementation of learning-promoting factors on test scores

In the total cohort, the high-concentration group's mean scores were 1.928 points higher ($p=0.010$) in the short-term test and 1.649 ($p=0.106$) points higher in the long-term test compared to the low-concentration group, regardless of the teaching method. (Table 5)

The high-anticipation group achieved mean scores that were 2.09 points higher ($p=0.026$) in the long-term test in comparison with the low-anticipation group's test scores, regardless of the teaching method. No such association was apparent in the short-term test. Liking and desire to reuse were not related to test scores in either test.

Promoting factors in multivariate analyses

The analyses were further continued with multivariate analysis and high concentration was found to significantly

Table 5 The effect of promoting factors on learning outcomes (scores) in the short- and long-term test results by multivariate linear regression analysis

Learning promoting factor	Short-term test scores)			Long-term test scores)			Short-term outcome score improvement (MD) confidence interval 95.0%	Long-term outcome score improvement (MD) confidence interval 95.0%
	B	St.B	p	B	St.B	p		
Concentration	0.616	0.159	0.010	0.438	0.122	0.106	1.928	1.649
Anticipation	0.245	0.071	0.391	0.727	0.164	0.026	0.843	2.088
Liking	-0.165	0.023	0.504	-0.298	0.035	0.230	0.283	0.455
Desire to reuse	0.082	-0.04	0.699	0.225	-0.028	0.313	-0.491	-0.341

Adjustment variables: medical student/ nurse student, gender and previous education

B=regression coefficient (confidence interval 95.0%)

MD=mean difference between high and low promoting factor groups regardless of the teaching method

St.B=standardized beta (confidence interval 95.0%)

enhance short-term learning and showed a positive but less significant impact on long-term learning (Table 3). Anticipation was less influential in the short-term test results but became significantly impactful in the long term. Desire to reuse and liking had negligible and statistically insignificant effects in both tests. (Table 5).

When analysed separately within each teaching modality group, concentration was related to better test scores both in the short-term (B 3.594, St.B 0.321, $p=0.01$) and in long-term tests (B 3.588, St.B 0.394, $p=0.028$) but significantly in the Podcast group only. Anticipation showed a significant association with better scores in the long-term test (B 6.770, St.B 0.476, $p=0.01$) of the Vodcast group. No other associations were found between individual learning-promoting factors and the test results. In the Live teaching group, linear regression analysis could not be used in testing the long-term outcome due to participants' consistently positive experiences. (Table 6).

Correlation between concentration and anticipation

The expectation to have learned during the lesson (anticipation) correlated with the ability to concentrate in all the teaching modality groups ($p<0.0001$) (Fig. 3). Anticipation and concentration correlated significantly in all the teaching modality groups (Fig. 3). The correlations

between all other promoting factors were also tested and found to be statistically significant, with p -values of at least 0.004. However, the strongest significances were observed in the associations with concentration and anticipation, with p -values less than 0.0001.

Discussion

Main results

In this study, we aimed to investigate the accomplishment and effect of previously known learning promoters on learning based on four different teaching modalities: Live, Live-Stream, Vodcast and Podcast. Our hypothesis was that high levels of these promoting factors would lead to improved test scores.

In our study, concentration played a major role in achieving good learning outcomes, regardless of the used teaching method. The best learning outcomes were achieved in the Live and Vodcast groups, where concentration levels were also the highest. Concentration was closely linked to anticipation, which seemed to particularly affect long-term learning outcomes. When the students reported that they were able to concentrate well, they also indicated higher anticipation scores. Despite students enjoying the teaching method, such as live

Table 6 The effect of promoting factors on the learning outcomes (scores) within teaching modality groups in the short and long term by multivariate linear regression analysis

Live	Short-term learning			Long-term learning		
	B	St.B	p	B	St.B	p
Learning-promoting factor						
Concentration	1.638	0.072	0.650	-	-	-
Anticipation	3.276	0.221	0.261	-	-	-
Liking	0.870	0.046	0.738	-	-	-
Desire to reuse	-2.477	-0.218	0.196	-	-	-
Live-Stream	Short-term learning			Long-term learning		
Learning-promoting factor	B	St.B	p	B	St.B	p
Concentration	2.372	0.171	0.290	2.140	0.145	0.368
Anticipation	1.075	0.077	0.681	2.604	0.177	0.321
Liking	2.031	0.145	0.429	2.824	0.190	0.272
Desire to reuse	-0.591	-0.043	0.840	4.364	0.296	0.105
Vodcast	Short-term learning			Long-term learning		
Learning-promoting factor	B	St. B	p	B	St.B	p
Concentration	1.845	0.152	0.333	-0.276	-0.019	0.901
Anticipation	2.177	0.176	0.319	6.770	0.476	0.010
Liking	-0.672	-0.051	0.757	-0.632	-0.044	0.804
Desire to reuse	2.280	0.201	0.195	1.029	0.082	0.605
Podcast	Short-term learning			Long-term learning		
Learning-promoting factor	B	St.B	p	B	St.B	p
Concentration	3.594	0.321	0.010	3.588	0.394	0.028
Anticipation	1.109	0.097	0.503	-1.373	-0.149	0.466
Liking	-1.590	-0.137	0.390	0.546	0.060	0.815
Desire to reuse	-0.486	-0.040	0.784	-1.497	-0.154	0.421

Adjustment variables: medical student/ nurse student, gender and previous education

B=regression coefficient (confidence interval 95.0%)

St.B=standardized beta (confidence interval 95.0%)

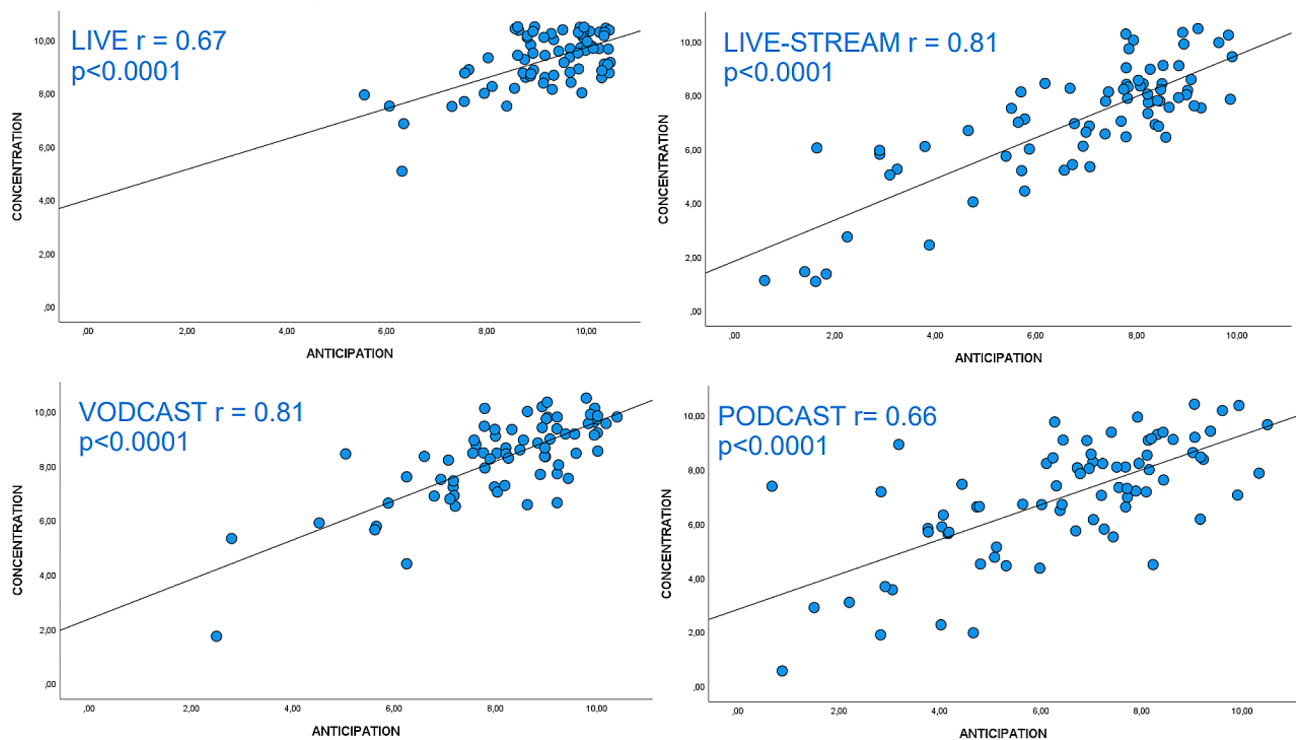


Fig. 3 Pearson's correlation between promoting factors, anticipation and concentration in different learning group analyses (Jitter Plot)

teaching, the promoting factor of liking was not associated with good learning outcomes.

Accomplishment of promoting factors in teaching

Our research dealt with the realization of Concentration, Anticipation, Liking and Desire to reuse in teaching, and their impact on learning outcomes. According to our research, concentration, and anticipation had significant effects on learning outcomes. Interestingly, liking and the student's preference to use the method in the future (Desire to reuse) had no relevance to improving learning outcomes.

The association between the accomplishment of promoting factors and learning

Flexibility and ease of use have increased the popularity of recorded teaching methods among teachers and students [2, 28, 40, 41]. However, it seems that students still prefer live teaching due to a better ability to concentrate, a more pleasant learning atmosphere and comprehensibility [29, 35, 42].

The promoting factors that we measured indicate that well-executed video recordings (vodcasts=video on demand) are significantly better for learning (better concentration, anticipation, desire to reuse, liking) than live-streamed teaching, even though both are on-screen methods. Teachers should invest in the design and implementation of high-quality learning videos (vodcasts) that engage viewers through prescribed storytelling, real-life

cases, relevant visual elements (authentic video clips) and incorporating practical tasks. Teachers can also improve the students' concentration by using clear expressions and showing their own enthusiasm on the topic [17, 23, 24, 35]. The best learning experience could be achieved by combining the strengths of vodcasts and live teaching, for example, through the flipped classroom approach [43, 44], where students watch a video before the lesson.

In our study, live teaching was overwhelmingly the most preferred teaching modality in terms of concentration, anticipation, liking and desire to reuse when compared to the remote learning methods. Vodcasts were also considered to promote learning, based on the students' experiences (learning-promoting factors) and objective test scores. Podcast and live-stream did not perform as well as Live teaching or Vodcast based on the students' test results or learning experiences. However, those who could concentrate well in these groups achieved test results comparable to the other delivery modes.

Effects of concentration on learning

The role of concentration has been previously highlighted as a major factor that promotes learning. In the present study, we demonstrated that good concentration enhances learning across different teaching modalities.

In our study, self-reported concentration was associated with good test results. It was notably high, particularly among students attending Live and Vodcast

teaching. Our results are in line with a previous finding that students with low levels of concentration also have low learning outcomes [19]. By contrast, only half of the students in the Live-stream and Podcast groups reported good concentration and they also displayed poorer learning outcomes in both short- and long-term tests, as published earlier [45].

Interestingly, the students with high concentration in the Podcast group represented the best results in the long-term test within the whole comparative framework. Furthermore, solely in the Podcast group, high concentration significantly increased the scores on both short- and long-term tests. While there is limited data on the effectiveness of learning through audio recordings (podcasts), we hypothesize that focusing on information obtained through one sense can enhance concentration and deeper learning. This might be due to the active engagement and deep cognitive processing required. Podcasts also allow the listeners to simultaneously perform cognitively easy tasks which might improve concentration, especially in kinesthetic learners. However, the modality does not seem to fit every learner as roughly half of the podcast listeners in our study reported that they were not able to concentrate well. Our observations might support the potential for increasing the use of podcasts as a learning tool.

Anticipation

In the present study, the expectation to learn (anticipation) was most prominent in the Live and Vodcast groups. Anticipation was lower in the Live-stream group and the Podcast group. Foresight promotes concentration and influences the transfer of learned knowledge to long-term memory, thereby affecting long-term learning outcomes [5, 6], as our research findings also indicate. Even anticipation alone was a significantly enhancing factor in short and long-term learning outcomes.

In the total cohort, both the high anticipation and high concentration groups achieved higher mean scores in the long-term test regardless of the teaching method. Based on our results, we can say that good anticipation and concentration significantly increase short-term and long-term learning outcomes.

Liking and desire to reuse

Previous research has indicated that merely liking a teaching modality does not significantly enhance learning outcomes (1,3,4). The conclusion is in line with our results: our students liked live teaching the most, followed by vodcasts. However, our analysis indicated that merely liking a particular method had a limited impact on test scores.

In the present study, students' experiences with Live teaching and Vodcasts showed a strong preference for

using these modalities again. However, this preference as a single factor was not linked to enhanced learning outcomes. Nevertheless, the desire to reuse and favor the teaching modality was tied to liking and anticipation, which in turn was found as a significant learning promotor.

Actually, the accomplishment of any learning promoting factor seemed to significantly affect on the realization of the other factors, too. In previous studies, also effective learning experiences with the used modality further have reinforced the desire to use it again [37–39].

Strengths

In our research on learning by the four teaching methods, we have utilized several references in constructing our survey, supporting the theoretical foundation of our study. The use of multimedia instruction, such as videos and audio recordings, along with practical exercises simulating breathing difficulties in line with CTML-theory recommendations, was instrumental in diversifying the learning environment and enhancing student engagement. The number of respondents was high (92%) and withdrawal rates were low, especially in the experience survey and the short-term test.

Weaknesses

We did not inquire about the activities students engaged in or neglected while participating in the online groups while watching the lesson. Furthermore, not inquiring whether the Podcast group students engaged in other activities while listening to the podcasts brings uncertainty to their learning experience.

The generalizability of our study results may also be limited by a lack of knowledge regarding whether the positive outcomes were influenced by the teachers' enthusiasm. Additionally, the significant number of drop-outs in the long-term test, 27 (15%) medical students and 73 (49%) nursing students, could further affect the reliability of our findings.

Conclusions and recommendations

The ability to concentrate seems to be essential for gaining good learning results. Based on the literature and recent research, it might be suggested that any teaching delivery mode can produce good learning results if the students feel capable of concentrating. As the learning promoting factors (concentration, anticipation, liking and desire to reuse) work in synergy, special attention should be paid in the accomplishment of all the factors in teaching. Above all, teaching should be designed to support students' ability to concentrate by using different, either digital or live, teaching modalities and taking advantage of their special features.

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Author contributions

Marko Tolonen has participated in study design, prepared the used teaching materials (podcast and vodcast) and carried out the team-teaching together with Eija Piippo-Savolainen. He has been responsible for the statistical analyses, writing the manuscript and providing funding for the project. Eija Piippo-Savolainen has led the research project. She participated in study design, taught in the teaching videos, podcasts and live lesson and written the manuscript together with Marko Tolonen. Miika Arvonen participated in reviewing the literature, power calculation and writing the manuscript. Marjo Renko helped in planning the statistical analyses and reviewed the manuscript. Heikki Paakkonen contributed to writing and reviewed the article.

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Data availability

All data generated or analyzed during this study are included in this published article.

Declarations

Ethics approval and consent to participate

The Research Ethics Committee of the University of Eastern Finland (UEF) approved the present study on 3rd March 2021. Informed consent was obtained electronically from all participants. All methods were carried out in accordance with relevant guidelines and regulations.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

Clinical trial number

This study is not a clinical trial involving medicinal products or therapeutic interventions, so the clinical trial number is not applicable.

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