Creative Education, 2022, 13, 149-166
https://www.scirp.org/journal/ce
ISSN Online: 2151-4771
ISSN Print: 2151-4755

Video-Based Learning Compared to Face-to-Face Learning in Psychomotor Skills Physiotherapy Education

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How to cite this paper: Eidenberger, M., & Nowotny, S. (2022). Video-Based Learning Compared to Face-to-Face Learning in Psychomotor Skills Physiotherapy Education. *Creative Education, 13,* 149-166.
https://doi.org/10.4236/ce.2022.131011

Received: December 20, 2021
Accepted: January 17, 2022
Published: January 20, 2022

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Abstract

Background: In physiotherapy education, cognitive knowledge is combined with psychomotor skills classes. Evidence that psychomotor skills can be aquired by Video-Based Learning (VBL) only is scarce. The purpose of the research was to compare VBL with face-to-face learning of one such skill (Proprioceptive Neuromuscular Facilitation, PNF) and to assess students' acceptance of VBL. **Methods:** The experimental group (EG) received electronic access to a video and supplementary written material. The control group (CG) attended a face-to-face lesson, accessing the same written material. Both groups were instructed to learn and practice the technique for one week. Afterwards, a blinded examiner tested for psychomotor skills, a multiple-choice test tested for cognitive knowledge. Student satisfaction was tested with a Likert-scale based questionnaire. **Results:** The mean (SD) exam points for experimental-group and control-group were 30.23 (2.976) and 30.36 (2.706), respectively (p = 0.830). The mean multiple-choice test points for EG/CG students were 14.23 (2.204)/12 (2) points (p = 0.014). The questionnaire revealed significant differences in the timeframe adequacy, the comprehensiveness of verbal instructions and the knowledge of improval of weaknesses (p = 0.025/0.038/0.007). Our exam results yielded no statistical difference between VBL and face-to-face learning, our multiple-choice test revealed significant differences, favoring the EG. The uncertainty regarding the improval of weaknesses was likely due to the lack of feedback during practice. Nonetheless, EG exam results were satisfactory and comparable. **Conclusions:** VBL can produce comparable exam results in teaching psychomotor PNF skills. It suggests, that circumscribed psychomotor skills can be taught using VBL only. Overall student acceptance of VBL was high.

Keywords

Video-Based Learning, Psychomotor Skills, Physiotherapy Education

1. Introduction

Video-based learning (VBL) is a long standing learning method to enhance the effectiveness of education (Yousef, Chatti, & Schroeder, 2014). VBL has been integrated into teaching methods such as the flipped classroom, where the video is watched in advance of the face-to-face lesson (Røe, Rowe, Ødegaard, Sylliaas, & Dahl-Michelsen, 2019). In recent years, various publications have addressed the question of whether VBL can facilitate learning and lead to improved learner outcome (Noetel, Griffith, & Delaney, 2021; Miner & Stefaniak, 2018; Kay, 2012). Last year and COVID-19 have, in particular, shown university lecturers the necessity of relying more or even totally on VBL and e-learning in general. A growing body of evidence examines the use of podcasts, i.e. video/audio files originating from the internet or created by instructors/students in higher education, which promise to support the teaching and learning process (O'Bannon, Lubke, Beard, & Britt, 2011). Zhang et al. (2006) stated that videos are a powerful source in e-learning. E-learning is defined as "all types of learning with the use of digital media, either the presentation or the distribution of learning material or the communication between students and teachers" (Kerres and Preußler, 2012). Embedded in appropriate contexts, it can provide teaching and learning quality (Ossiannilsson, 2011). Coman et al. (2020) also saw e-learning as the transfer of knowledge and education by using different electronic devices. For the purpose of this study, we have decided to rely on the definition that VBL is one method of e-learning using videos to acquire skills and knowledge.

As a theoretical model, we imbed VBL within a constructivist learning model. In constructivism, active learners establish new knowledge and skills (Jha, 2017) with teachers promoting learner autonomy and initiative (Ramnath & Sivakumar, 2011). Learners are supposed to achieve better learning outcomes if they acquire learning contents by themselves and have the opportunity to control their own progress (Zhang, Zhou, Briggs, & Nunamaker Jr., 2006). VBL thus reinforces a shift towards student-centered education. Videos, in particular, can shift the acquisition of new skills into constructivist learning (Carmichael, Reid, & Karpicke, 2018). Constructivism is of particular relevance in physiotherapy (PT) education where each patient presents a unique problem. In this setting, skills and knowledge need to be newly adapted to patient complaints. Based on constructivism, Mayer's "generative theory of multimedia learning" suggests active learners combine visual and verbal information to gain better knowledge (Mayer, 1997). We are convinced that this theory applies to VBL.

In PT education, theoretical lessons aiming at cognitive knowledge, are combined with psychomotor skills classes, which imitate real life clinical situations with students practising on fellow students, actors or volunteer patients (Dennis, Sainsbury, Redwood, Ng, & Furness, 2016). Students acquire psychomotor skills in multiple staged settings by mirroring their lecturers and receiving constant feedback from fellow students, lecturers (Amin, Patel and Bamania, 2017) and practice supervisors (Klemme, 2012; Schmutz, Meyer and Archer, 2019).

Proprioceptive neuromuscular facilitation (PNF), which is one example of such skills, includes three basic dimensional movement patterns, either performed against a therapist's resistance or as a form of stretching. Patterns of the limbs, trunk and head represent this concept. It is widely used in neurological and traumatological rehabilitation to improve patients' active and passive range of motion, strength and coordination (Sharma & Kaur, 2017; Birinci, Ozdincler, Altun, & Kural, 2019). Due to time restraints, physiotherapy education curricula are often limited to the limbs and trunk. PNF head patterns can, however, improve students' abilities to treat cervical- and subsequently trunk-located complaints.

The acquisition of psychomotor skills can thus be supported by VBL, as it offers students the possibility of independent learning and technique repetition. VBL as an additional method was well accepted by physiotherapy students in a non-randomized controlled trial and improved their psychomotor skills (Preston, Ada, Dean, Stanton, & Waddington, 2012). Another study used VBL within a cross-over design evaluating the psychomotor and cognitive results of PT students. The authors concluded that podcasting and face-to-face learning were similarly effective (Moore & Smith, 2012). A recent pilot study by Rowe and Sauls applied a similar approach using a muscular-scelettal treatment to explore the differences between VBL and face-to-face learning. Results yielded similar average grades for the two study arms (Rowe & Sauls, 2020). However, reliable evidence that psychomotor skills can be acquired by VBL only in practice-dominated disciplines, such as PT is scarce (Back et al., 2014). Therefore, our primary research goal, stated as psychomotor skills, was to compare the VBL of PNF head patterns with the face-to-face learning of the same topic. Secondly, we strived to evaluate cognitive knowledge and student satisfaction with and the acceptance of the VBL concept.

2. Methods

2.1. Participants

In 2019, second-year undergraduate PT students (n = 42) were invited to participate in a quasi-experiment and were quasi-randomized according to the median of their first-year psychomotor exam results (n = 13 different exams). Participants' flow is shown in **Figure 1**. Students were ranked by the median of these grades and assigned to the experimental or control group accordingly (EG; CG). The quasi-randomization should ensure an equal allocation of skilled students to the two study arms (Schulz and Grimes, 2007). Participation was voluntary and participants signed an informed consent declaration. This project was evaluated and approved by the ethics board of our university (A-2019-055). Before entering the study, students had finished classes accounting for 28.5 European credits (ECTS) on various other psychomotor skills, e.g., massage therapy or hydrotherapy. At the time of the study intervention, all the students had completed PNF lessons of 180 minutes, where they had been given basic information on

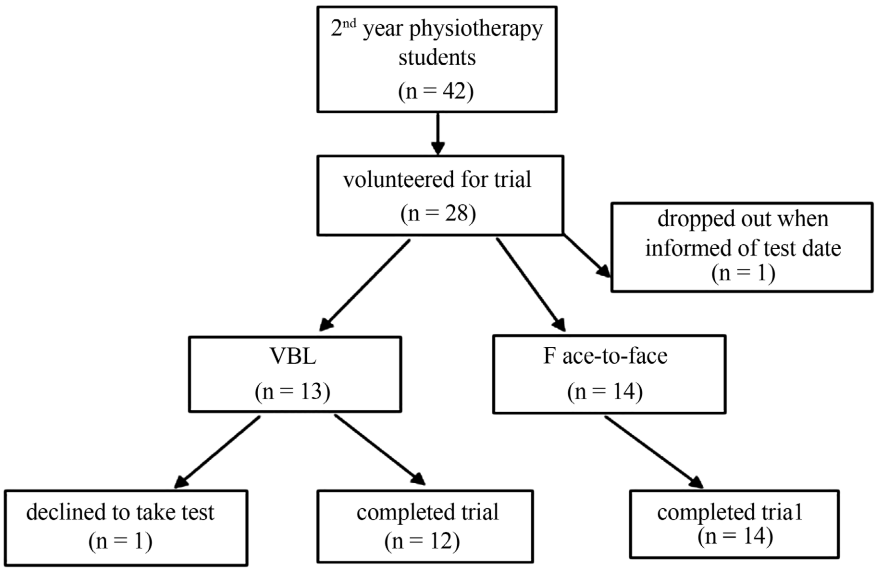

Figure 1. Participants' flow.

the PNF concept and been taught scapular and pelvic movement patterns. 60 minutes were spent on theoretical content, 120 minutes on practicing following a tutor demonstration, including feedback. For the trial, we selected a PNF technique of the head (Buck, Beckers and Adler, 2013), because it is not represented in the main curriculum and has no similarities to scapular or pelvic patterns. With this choice, we wanted first to avoid a bias with learning content from the main curriculum. Secondly, we wanted to give participating students an incentive to enhance their participation, namely learning an additional PNF technique for patient application.

2.2. Material

The technical data security was guaranteed by strictly limited file access. Participants were anonymized by generating and distributing codes for each person, because students should not incur any disadvantages in their regular studies as a result of the study participation.

The EG received electronic access to an educational video and supplementary written material, which should be downloaded. The video and script were made available on the university's electronic learning platform. The video showed three short sequences (3 minutes each) with the PNF head technique demonstrated by an experienced lecturer (13 years' teaching experience in the field and constant patient application) on a healthy volunteer. For the video's length, we relied on the literature stating that different short sequences are preferable (Balslev, De Grave, Muijtjens, & Scherpbier, 2005; Kay, 2012). The video was text- and audio-assisted to highlight the essentials and reach different perceptual senses. The written material comprised additional information about the applicability, potential patients, contraindications, exercise duration and intensity. On the same day of the material release, the CG attended a face-to-face lesson of

90 minutes with the same lecturer on this technique, including practising and correction, if necessary. They had access to the same written material as the EG. Both groups were instructed to learn and practice the PNF in a way that could be applied to healthy subjects.

2.3. Outcomes

The primary outcome was the application of psychomotor skills on healthy fellow students. A blinded assessor, likewise, familiar with the technique, conducted the exam. Students randomly picked one of three questions (cp. **Table 1**) for this exam. A standardized evaluation tool was created for the assessor (cp. **Table 5**, Appendix) (Gisler and Staehelin, 2012). This tool followed the Objective Structured Clinical Exams (OSCE) principles (Raheel and Naeem, 2013; Pandya, Bhagwat and Kini, 2010; Bhatnagar, Saoji and Banerjee, 2011; Schleicher et al., 2017). It measured items such as starting/end position, adequate resistance, pace, security and verbal as well as tactile stimulus (cp. **Table 5**). The tool was graded using a 4-point Likert scale (0 = insufficient; 1 = deficient; 2 = largely correct; 3 = totally correct). The items were scored and added. This led to a theoretical maximum score of 36 points used for further statistical analysis. The percentage score interpretation and grading of the performance were determined using the model of Bhatnagar et al. (2011). The model was modified according to our university's scoring standards (100% - 89% = excellent, 88% - 76% = good, 75% - 63% = satisfactory, 62% - 51% sufficient, ≤50% insufficient) to create grades from the exam results. Furthermore, students were asked to assess their own performance using the standardized Austrian 5-point grading scale (1 = excellent; 5 = insufficient) after the exam to compare external and self-grading. The exam took place one week after the release of the digital material and the face-to-face lesson. This was necessary due to a modular semester schedule alternating university courses and internships. During internships students are not available for exams. We also wanted to avoid a collision with other regular exams, which could have reduced participation.

Table 1. Baseline data and log diary time. Key: EQ exam question.

Variable	VBL	Face-to-face
Female/Male (%)	7/6 (53.8/46.2)	9/5 (64.3/35.7)
Age mean (SD)	21.6 (2.2)	22.3 (2.5)
First year psychomotor exam results median (min; max)	2 (1; 3)	2 (1; 3)
EQ 1 "radial thrust" (no.)	3	3
EQ 2 "head flexion" (no.)	7	6
EQ 3 "head extension" (no.)	3	5
Log Diary Time Minutes (SD)	128.08 (60.7)	132.93 (25.22)

One secondary outcome was cognitive knowledge. All the participants completed a multiple-choice test, graded using the aforementioned scoring standards with a theoretical maximum score of 19 points used for group comparison. The test referred to the written material and incorporated indications, contraindications and the cognitive framework required for treatment. It took place at the university prior to the exam. The next secondary outcome was student satisfaction with and acceptance of the new concept using the methods proposed by Arroyo-Morales et al. (2012), Back et al. (2014) and Leszczynski et al. (2018). CG students expressed their satisfaction/acceptance on a theoretical basis, relying on experience from other lessons. This questionnaire was assembled according to the literature (Williams, 2003) and pre-tested with another student group for comprehensibility and feasibility. The tool included items reflecting their personal skills. Therefore, we adapted propositions by Jun and Shin (2011) as well as Duvivier et al. (2011), respectively. The questionnaire was completed after the above-mentioned test. The answers were given using a 4-point Likert-scale (1 = "fully disagree"; 2 = "somewhat disagree"; 3 = "somewhat agree"; 4 = "fully agree" with the exception of question 23, which was coded in reverse because of the semantical meaning (cp. **Table 3**). For analysis, the Likert-scale based answers were converted into the above-mentioned numerical items.

Students kept a log diary about the time practising and/or learning. Specific online log-in time was not measured because students downloaded the material and the log-in time was not considered relevant. What was relevant for our purpose was the time spent practising PNF to achieve psychomotor competency.

2.4. Statistics

Data was analyzed by SPSS (IBM Version 26). The significance level was set at $\alpha = 0.05$, a mutually agreed upon value. Data was also analyzed on an intention-to-treat basis. The missing data (forgotten questions, test refuser) were imputed using the median or the mean, respectively. Metric values were tested via the Mann-Whitney-U-test (non-normal distributed data). Ordinal data from the questionnaire was compared with Fisher's Exact Test. Further, we correlated the log diary time students specified with exam and test points achieved by using a Spearman rank correlation coefficient (Spearman's rho = ρ) to analyze any possible connections.

3. Results

Forty-two students were eligible for this experiment. Twenty-eight students volunteered to take part and were quasi-randomly allocated to the EG (n = 14) and the CG (n = 14). One student was excluded after the randomization due to consent withdrawal. A second student declined to take the test and the exam stating a lack of time to prepare properly (cp. **Figure 1**). Socio-demographic characteristics and the distribution of the three possible exam questions are depicted in **Table 1**. One of these questions was chosen by each student randomly.

Groups were well-balanced for gender, age and the exam question. The quasi-randomization succeeded in creating skill-balanced groups based on their first-year psychomotor exam results. 59.3% of our participants were female, the mean age was 21.6 (SD 2.2; EG) and 22.3 (SD 2.5; CG) years (cp. Table 1).

The mean (SD) exam points for EG and CG students were 30.23 (2.976) and 30.36 (2.706), respectively (cp. Table 2); this was not significant ($p = 0.830$). The mean multiple-choice test points for EG and CG students were 14.23 (2.204) and 12 (2) points, showing a significant difference ($p = 0.014$).

The questionnaire testing student satisfaction is depicted in Table 3. Significance in group comparison was reached in the following three questions: no. 4 (The timeframe was adequate), no. 6 (The verbal instruction was easy to comprehend) and no. 26 (I know how to improve my weaknesses) with $p = 0.025$/0.038/0.007, respectively.

The mean log diary time for the whole group was 130.6 minutes (SD 45.0). The EG had a mean log diary time of 128.08 (SD 60.7) minutes. The CG had a mean log diary time of 132.93 (SD 25.22) minutes (including the 90-minutes face-to-face lesson), the difference was not significant ($p = 0.78$). The CG had a mean log diary time of 42.93 (SD 25.22) minutes without the 90-minute lesson (cp. Table 1).

We found a weak correlation within the EG for log diary time and exam points (Spearman's $\rho = 0.412$) and no correlation for the CG for log diary time and exam points (Spearman's $\rho = 0.090$), both without reaching significance ($p = 0.162$ and 0.761, respectively). For this and details on the test points correlation with time spent cp. Table 4.

4. Discussion

Our objective was to compare VBL with a face-to-face lesson in a psychomotor skills PT class by using PNF head patterns. We analyzed the outcomes given as psychomotor skills as well as cognitive knowledge. We also focused on evaluating student satisfaction with the VBL. We did not calculate an a-priori sample size because potential eligible students were restricted anyway to 42 persons.

4.1. Psychomotor Skills

In PT, acquiring psychomotor skills is a crucial component (Hurst, 2016). They are learned and practised with healthy probands and/or with volunteer patients in a practice classroom setting (Moore & Smith, 2012). After passing the corresponding exam, students access various internships to further optimize their

Table 2. Exam/test points group comparison. Key: †EG. † = Experimental group. So the other number after the slash stands for the Control group.

Variable	VBL n = 13	Face-to-face n = 14	Percent achieved out of 100	*p*-value
Exam mean (SD)	30.23/36 (2.976)	30.36/36 (2.706)	83.9†/84.3	0.830
Test mean (SD)	14.23/19 (2.204)	12/19 (2)	74.9†/63.2	0.014

Table 3. Results and group differences for the student questionnaire. All values are mean (SD) except: Key: * = median (SD) according to the Austrian official grading system. ** = significant at $p = 0.05$; † = calculated with reversed coding because of the semantical meaning.

Question Number	Item	E-Learning n = 13 mean (SD)	Control group n = 14 mean (SD)	*p*-value
1	Theoretical and practical elements were well combined	2.92 (0.28)	3.14 (0.77)	0.402
2	The level of difficulty was appropriate	3.69 (0.63)	3.29 (0.47)	0.061
3	I recognize the usefulness of the demonstrated PNF-pattern for my clinical practice	3.54 (0.66)	3.07 (0.83)	0.169
4	The timeframe was adequate	3.69 (0.63)	2.93 (0.92)	0.025**
5	The written material was easy to comprehend	3.31 (0.75)	3.21 (0.80)	0.793
6	The verbal instruction was easy to comprehend	3.08 (0.86)	3.79 (0.43)	0.038**
7	The lesson was well-structured	3.46 (0.52)	3.64 (0.50)	0.430
8	E-learning provides a more flexible learning experience	3.85 (0.38)	3.57 (0.65)	0.350
9	My personal time management is better with e-learning options	2.62 (0.87)	2.36 (0.93)	0.550
10	When given a choice, I prefer e-learning to conventional lessons	1.85 (0.90)	1.71 (0.47)	0.981
11	Learning with an e-learning concept is fun	2.62 (0.77)	2.21 (0.58)	0.155
12	E-learning should be offered more frequently	3.46 (0.78)	3.21 (0.70)	0.350
13	E-learning helps me reach the learning objectives	3.46 (0.66)	3.14 (0.53)	0.202
14	A video supports the learning of practical skills	3.77 (0.44)	3.86 (0.36)	0.720
15	E-learning is a suitable form of instruction	2.62 (0.96)	2.50 (0.94)	0.756
16	E-learning facilitates communication between instructor and students	1.54 (0.66)	1.93 (0.62)	0.155
17	I have the technical requirements to use e-learning	4.00 (0.00)	4.00 (0.00)	1.00
18	I can demonstrate the PNF-pattern on a healthy volunteer	3.62 (0.65)	3.64 (0.50)	0.943
19	I can demonstrate the technique in a patient setting	3.15 (0.55)	2.86 (0.95)	0.458
20	I can adapt the technique for use in patients with different diagnoses	2.08 (0.64)	2.29 (0.91)	0.720
21	I know indications and contraindications for this technique	3.15 (0.69)	2.86 (0.66)	0.325
22	I can explain the uses of the exercise to a patient	3.31 (0.63)	3.21 (0.58)	0.720
23	Additional feedback from the lecturer would enhance my practical capabilities	1.15 (0.38)†	1.36 (0.63)†	0.550
24	My practical skills improved with this lesson	3.08 (0.76)	3.21 (0.58)	0.685
25	I know my strengths and my weaknesses	2.54 (0.97)	3.00 (0.78)	0.202
26	I know how to improve my weaknesses	2.08 (0.76)	3.00 (0.78)	0.007**
27	My learning success with this lesson was high	2.69 (0.48)	2.86 (0.66)	0.616
28	I would rate this lesson with a … (1 - 5)	2* (0.44)	2* (0.69)	0.678

Table 4. Correlations log diary time and exam/test points.

Correlation	N	Spearman's ρ	*p*-value
log diary time * exam points	13 (EG)	0.412	0.162
log diary time * exam points	14 (CG)	0.090	0.761
log diary time * test points	13 (EG)	0.319	0.288
log diary time * test points	14 (CG)	−0.242	0.404

skills under the supervision of experienced physiotherapists. Our results yielded no statistical difference between the VBL and the face-to-face learning of the chosen PNF technique when comparing the exam results ($p = 0.830$). This suggests that the teaching technique VBL vs. face-to-face made no difference in psychomotor skills PNF exam results in this student group. In a very similar approach, Rowe and Sauls (2020) tested patellar apprehension tests with 41 PT students. Similarly, Moore and Smith (2012) tested gait training and transfer skills with physiotherapists (n = 31) going for a PhD either live or via podcast. Rowe and Sauls found, that the average grades of their VBL and face-to-face group were comparable (67% vs. 63%, without stating a *p*-value). Our groups scored 83.9 (EG) and 84.3% (CG), respectively. This shows 1) comparability and 2) good percentages for both groups. Based on these results, the PNF application should be safe in a following education setting, such as a supervised internship. Rowe and Saul's exam was also performed using an objective structured practical examination, Moore and Smith focused on literature-guided "safety, fluency and accuracy of skill performance". The latter authors stated no significant differences for either test or exam scores. In a 4-armed group design (computer-assisted instruction (i.e. VBL), live demonstration (i.e. face-to-face learning), textbook instruction and control, n = 43) teaching musculoskeletal tests, Ford et al. (2005) found VBL as effective as face-to-face learning. The usability of videos or podcasts as the only teaching method for circumscribed psychomotor contents was also underpinned by Chester et al. (2011).

As there were no or only weak correlations between our log diary times and exam/test points, all with a non-significant *p*-value, we cannot draw the conclusion that the amount of time students spent and the exam/test points achieved are correlated. A possible explanation for these results could be that manually highly skilled students or students with a higher learning capacity maybe would have needed lesser time to prepare, whereas not so skilled students or with a lower capacity maybe compensated for this with putting in more effort, i.e. time.

Only an exam simulating a clinical situation ideally based on clearly defined criteria can yield a statement about a practical performance (St. Pierre and Breuer, 2013). Narrowly defined exam criteria facilitated an objective assessment, the traceability of the results and the transparence of the evaluation (Ostermayer, 2010). We tried to achieve this objectivity by employing our blinded examiner further supported by the assessment tool used (cp. **Table 5**). All the

Table 5. OSCE evaluation tool.

Exam	Grading			
	Totally accurate	Largely accurate	deficient	insufficient
Correct starting position of patient				
Explains process to patient				
Correct stimulus by proximal hand				
Correct stimulus by distal hand				
Gives verbal instruction				
Verbal instruction adapted to patients needs				
Performance of motion				
Bodymechanics of therapist				
Adjusts level of resistance				
Correct end position				
Security during demonstration				
Adequate speed				
I would rate my performance as (1 - 5)				

students in both groups passed the exam. Focused repetitions of psychomotor skills accompanied by self-reflection can lead to improvement, even if students lack psychomotor skills (Welford, 1968). Duvivier et al. (2011) tested this so-called "deliberate practice" with 875 first to third year medical students and found some improvements in student dedication, repetition and self-reflection. Deliberate practice means repetitive focused training to improve cognitive or psychomotor skills, a concept first described by Ericsson et al. (1993). This applies to many psychomotor skills taught in PT. In our profession, a deep approach to learning is crucial. It does not suffice to memorize or paraphrase contents, but the new psychomotor skills must be applied to real patients. Therefore, VBL and constructivism complement each other. In constructivism and based on cognitive curiosity, the learner is going to solve a problem, i.e., a patient's complaint. Conole et al. (2004) claimed that constructivism favours "hands-on, self directed activities" and thus creates authentic learning environments. Bridging theory and practice, PT presents an ideal discipline for implementing constructivist learning methods such as VBL. We also consider a self-reflecting focus crucial for learning, because only a change of perspective enables the realization of personal strengths and weaknesses. This can possibly lead to enhanced adaptation (Pachner, 2013).

4.2. Cognitive Knowledge

Our multiple-choice test revealed significant differences, favoring the EG. As we

based our quasi-randomization on psychomotor skills, there could have been a cognitive bias in this small group of students after randomization. In comparison, Nikopoulou-Smyrni and Nikopoulos (2010) allocated five postgraduate students to different kinesiology VBL or traditional lessons in an alternating-treatment design. The authors found, that VBL was equally effective as the traditional teaching. Our findings also differ from the above-mentioned results by Moore and Smith (2012), who did not find significant differences between the podcast and live group in the written exam.

4.3. Students' Satisfaction

When asked if they consider VB e-learning fun, our EG and CG had a mean value of 2.62 (SD 0.77) and 2.21 (SD 0.58), respectively, without reaching significance ($p = 0.155$). At the time, VBL was a new and interesting experience. This may depend on the amount of VBL within the curriculum. Too much VBL, which was forced on all of us during the pandemic could easily shift students' attitude against it. In comparison, the nursing students Kelly and colleagues taught clinical skills enjoyed VBL, but they preferred videos as a complement instead of replacing face-to-face lessons (Kelly, Lyng, McGrath, & Cannon, 2009). Comparably, 87% of students in Moore and Smith's podcast group learning patient transfer and gait training "strongly agreed" or "agreed" to this method being "interesting". For a literature review Kay (2012) retrieved various studies using video podcasts (n = 53), 11 of these in health sciences and approximately 50% of these 53 targeting psychomotor skills. Kay concluded that learning performance can be improved, but methodological and technical concerns persist. In a pre-post study with business and education students (n = 99), post questionnaires revealed that 68% of students considered the podcasted audio/video files contributed "somewhat" or "quite a bit" to their learning (Walls, Kucsera, Walker, Acee, & McVaugh, 2010).

Our results indicate a statistically significant difference in question 26: "I know how to improve my weaknesses" (cp. **Table 3**). Not one student from the EG, but 21% from the CG fully agreed to this question. 31% and 64%, respectively, answered with "somewhat agree". Obviously for the EG there was a lack of personal feedback from the lecturer on their performance during the PNF practice, which raises some concerns. Moore and Smith (2012) also mentioned the inability to ask questions during VBL practice as a weakness. Our open question allows further insight into the students' needs: one limitation of VBL is the uncertainty about the correct application of the PNF without the lecturer's personal guidance. For their skills' development students urgently need the lecturer's feedback, correction and guidance (Hurst, 2016; Sharpe & Oliver, 2013). Students should therefore be able to express and address weaknesses before the final exam. This also serves the purpose to avoid loss of motivation (Duvivier et al., 2011). However, despite lacking personal feedback, the EG exam results were satisfactory and comparable to CG and an exam can also serve as a final feedback before the technique is further developed. The best model moving forward

might be an inclusion of feedback possibilities into VBL. A well explained and maintained e-forum could be the first step in achieving this goal (Mason, 2011). To assess practical correctness, students need to be asked to produce a podcast while exercising or performing the skill in a live online session. Our results underline the fact that students are willing to try out the experience of VBL if it is supplemented by lecturer feedback. Another concern in VBL may be the potentially delayed feedback (Coman, Tiru, Meseşan-Schmitz, Stanciu, & Bularca, 2020) emerging from the immediate unavailability of lecturers. Lecturers need to provide a response in a reasonable timeframe for students to adjust their technique.

A disadvantage not yet solved is the issue of student isolation. Students lack the interaction with lecturers and peers (Coman, Tiru, Meseşan-Schmitz, Stanciu, & Bularca, 2020; Moore & Smith, 2012). While practicing psychomotor skills, peers are also crucial in giving informed feedback, which is not possible to the same extent with e.g., family members or friends. Social isolation and a lack of opportunity to share learning experiences in a profession relying on direct and frequent human contact must be taken into consideration (Silva, Souza, Silva Filho, Medeiros, & Criado, 2011), when it comes to VBL.

4.4. Technical Considerations

38% of our EG, but 79% of our CG group considered the verbal instruction easy to comprehend (cp. Q6) with "fully agree". This highlights the importance of using advanced technical tools for instruction quality (Welsh, Wanberg, Brown, & Simmering, 2003; Leszczynski et al., 2018). Our video was produced by a professional. Furthermore, the lecturer was used to give face-to-face lessons. Being recorded was a new and somewhat unfamiliar experience, which could have influenced her attitude and also wording. The primarily intended video upload onto our platform was not possible because of data limits. Instead, we were forced to use a personalized youtube-channel, only accessible to our students. This shows the need for updated technology and infrastructure, also mentioned by Zhang et al. (2004). One should also not underestimate the complex hindrances individuals and institutions face when considering the implementation of VBL strategies. Although academic staff was found to be reluctant in changing their teaching methods (Salmon, 2005), they can develop further, when initial obstacles (e.g., video production, data storage and availability) are solved. Teaching expert Ginny Salmon underpinned the fact, that it needs more than just a shift from face-to-face to VBL/e learning. It also requires a change in understanding and pedagogy.

One strength of VBL is its repeatability. Videos, once recorded can be used multiple times, they always convey the same content and may therefore improve outcomes (Walls, Kucsera, Walker, Acee, & McVaugh, 2010). This adds to other benefits such as offering learning tools for a media-savvy generation (Skiba and Barton, 2006), where students can watch lectures according to their own suitable timeframe (Weeks and Horan, 2013; Richmond, Copsey, Hall, Davies, & Lamb,

2017). Thus, the most evident benefits of VBL are: 1) flexibility in learning, 2) enhancement of self-paced learning which can be 3) reproduced without limits (Zhang et al., 2006); as well as the usage of various perceptual senses for learning. On the other hand, VBL shows a need for a new role definition and special preparation for lecturers creating online learning material (Peacock and Hooper, 2007). The new role model for lecturers should be a development from being a "disseminator" in conventional teaching to a "facilitator" (Ruiz, Mintzer and Leipzig, 2006).

Our results showed significant differences in question 4 "the timeframe was adequate" (cp. **Table 3**). 77% of our EG, but only 29% of the CG answered this question with "fully agree". When analyzing the students' logs, no significant differences emerged. The total time expended per student was similar in both groups. It became significant when we subtracted the face-to-face lesson (90 minutes) they spent with the CG lecturer. Nonetheless, the result could be biased because there was a high standard deviation within the EG, showing a great difference in the students' dedication given as the log diary time. This shows a good concordance with reality and human attitudes towards learning (Metzger, 2013). The more value students attribute to academic tasks, the better their engagement will be (Suárez et al., 2019). Zhang and colleagues (2004) drew our attention to the fact, that e-learning requires maturity and self-discipline from students. According to the self-determination theory, humans strive for competency based on an innate psychological need (Gray, McGuinness, Owende, & Carthy, 2014). This theory was confirmed by a survey of 730 adolescent students showing the effectiveness of intrinsic motivation (Suárez et al., 2019). Students' motivation is crucial, when introducing new techniques and motivation is based on students' enjoyment of instructional tools (Dennis, Sainsbury, Redwood, Ng, & Furness, 2016). Furthermore, qualitative research by Peacock and Hooper (2007) demonstrated that students want precise instructions on the timeframe required for e-learning to estimate the time dedication necessary in advance. Overall, adequate pre briefing can influence the outcome of new learning experiences (Dennis, Sainsbury, Redwood, Ng, & Furness, 2016).

The main limitation is the small sample size and the restriction to a single psychomotor skill. Therefore, we cannot claim generalizability to other techniques. Secondly, we did not assess differences in baseline PNF performance before enrollment in the study, but chose a technique which was new to the students. For future trials more students should be included and the trial expanded to other psychomotor skills. Finally, we did not use an e-forum for EGs' questions. Maybe some of them could have been solved in the first place.

5. Conclusion

This study has some implications for practitioners. First, our study established, that VBL can produce comparable exam results in teaching psychomotor PNF skills. It suggests, that circumscribed psychomotor skills can be taught using VBL. Overall student acceptance of VBL as a teaching method was high. Univer-

sity lecturers in PT education may use VBL as a stand-alone method but need to be aware of giving accurate and timely feedback.

Acknowledgements

We would like to thank Ms. K. Tresohlavy, MSc for taking the students' exam.

Funding

This work was funded by our university, covering extraordinary costs, such as the video production or literature.

Conflicts of Interest

The authors report no conflict of interest.

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