Evidence for Innovation in Clinical Pharmacy Education Through a Digital Tool: Development and Evaluation of Video-Based Teaching Approaches for Conveying Blood Pressure Measurement Skills to Pharmacy Students

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Samieh Farahani
aus Bottrop

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Berichterstatter:

1. Prof. Dr. med. Stephanie Läer

2. Prof. Dr. rer. nat. Georg Hempel

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I. Eidesstattliche Erklärung

Hiermit versichere ich an Eides statt, dass die vorgelegte Dissertation mit dem Titel:

Evidence for Innovation in Clinical Pharmacy Education Through a Digital Tool: Development and Evaluation of Video-Based Teaching Approaches for Conveying Blood Pressure Measurement Skills to Pharmacy Students

von mir selbstständig und ohne unzulässige fremde Hilfe unter Beachtung der Grundsätze zur Sicherung guter wissenschaftlicher Praxis an der Heinrich-Heine-Universität Düsseldorf erstellt worden ist. Die Dissertation wurde in der vorgelegten oder in ähnlicher Form noch bei keiner anderen Institution eingereicht. Ich habe bisher keinen erfolglosen Promotionsversuch unternommen.

Düsseldorf, den 31.08.2021 Samieh Farahani

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III. Zusammenfassung

Basierend auf technologischen Fortschritten finden zunehmend digitale Lehrstrategien Einzug in die Hochschullandschaft, was durch die COVID-19 (*coronavirus disease 2019*) Pandemie nochmals verstärkt wurde. Dabei können Videos ein bedeutsames digitales Medium in der Lehre von Heilberuflern sein. Es kommt allerdings auf den sinnvollen Einsatz digitaler Lehrstrategien an, um den maximalen Nutzen aus ihnen zu ziehen. In diesem Kontext war das Ziel dieser Dissertation die Entwicklung und Evaluierung eines modernen digitalen videobasierten Lehransatzes zur erfolgreichen Vermittlung praktischer klinischer Fähigkeiten für Pharmaziestudierende am Beispiel der oszillometrischen Blutdruckmessung.

Im Rahmen dieser Arbeit wurde ein Selbstschulungsvideo zur akkuraten oszillometrischen Blutdruckmessung zugeschnitten auf Pharmaziestudierende entwickelt. In einer randomisierten, kontrollierten Nichtunterlegenheitsstudie im Pre-Post-Design mit einer Nichtunterlegenheitsgrenze von −10% wurden die Effekte des Selbstschulungsvidoes im Vergleich zu einer Face-to-Face Schulung untersucht und es wurde bewiesen, dass das Selbstschulungsvideo im Vergleich zu einer Face-to-Face Schulung in Bezug auf die Fähigkeiten der Blutdruckmessung der Face-to-Face Schulung nicht unterlegen war. Hinsichtlich des Selbstvertrauens bzw. der selbstwahrgenommenen Fähigkeit war das Ergebnis in Bezug auf die Nichtunterlegenheit des Selbstschulungsvideos im Vergleich zur Face-to-Face Schulung uneindeutig. Die Fähigkeiten der Pharmaziestudierenden bei der Blutdruckmessung wurde mittels *Objective structured clinical examinations* (OSCEs) erhoben. Das Selbstvertrauen bzw. die selbstwahrgenommene Fähigkeit wurde mittels eines Fragebogens erfasst. Beide Lehransätze wurden überwiegend positiv von den Studierenden angenommen. Nach der jeweiligen einzelnen Schulungsmaßnahme gab es bei beiden Gruppen sowohl bei der Fähigkeit in der Blutdruckmessung als auch im Selbstvertrauen bzw. der selbstwahrgenommenen Fähigkeit noch Verbesserungspotenial.

Deswegen wurde der alleinige Ansatz des Selbstschulungsvideos in zwei Blended Learning Ansätzen in einem Flipped-Classroom-ähnlichen Format

weiter ausgearbeitet und in einer weiteren randomisierten kontrollierten Studie mit Pharmaziestudierenden untersucht. Während die Schulung der einen Studiengruppe ein Selbstschulungsvideo und kurze Präsenzeinheit umfasste, erhielt die andere Studiengruppe das Selbstschulungsvideo und eine erweiterte Präsenzeinheit. Die Effekte der zwei Ansätze wurden mittels Fragebögen und OSCEs untersucht. Beide Flipped-Classroom-ähnlichen Strategien steigerten die Fähigkeit bei der Blutdruckmessung sowie das Selbstvertrauen bzw. die selbstwahrgenommene Fähigkeit der Studierenden signifikant. Da die erweiterte Präsenzeinheit im Vergleich zur kurzen Präsenzeinheit keinen signifikant höheren Nutzen in Bezug auf Fähigkeiten bei der Blutdruckmessung sowie des Selbstvertrauens bzw. der selbstwahrgenommenen Fähigkeit zeigte, reichte eine Flipped-Classroom-ähnliche Strategie mit kurzer Präsenzeinheit aus, um Pharmaziestudierenden eine qualitativ hochwertige Blutdruckmessung zu vermitteln. Diese Strategie könnte für weitere klinische Ausbildungsinhalte von Pharmaziestudierenden überprüft und angewendet werden.

IV. Summary

Based on technological advances, digital teaching strategies are increasingly finding their way into the university landscape. These approaches have been further reinforced during the ongoing coronavirus disease 2019 (COVID-19) pandemic. Videos can be an important digital medium in health profession teaching. Nevertheless, the thoughtful use of digital teaching strategies is important for obtaining the maximum benefit from them. In this context, this dissertation aimed to develop and evaluate a modern digital video-based approach to successfully convey practical clinical skills to pharmacy students using the example of oscillometric blood pressure measurement skills.

In the scope of this work a self-instruction video on adequate oscillometric blood pressure measurement tailored for pharmacy students was developed. The self-instruction video's impact was investigated compared to face-to-face instruction in a randomized controlled non-inferiority study with a pre-post design considering a non-inferiority margin of −10%. Although this investigation demonstrated the non-inferiority of the self-instruction video compared to face-to-face instruction regarding students' blood pressure measurement skills, the analysis of self-confidence or self-perceived proficiency yielded an inconclusive result regarding non-inferiority. Students' blood pressure measurement skills were determined by objective structured clinical examinations (OSCEs), and students' self-confidence/self-perceived proficiency was measured using a survey. Both instruction approaches were predominately well received by the students. Because both standalone approaches left room for improvement in students' blood pressure measurement skills and self-confidence/self-perceived proficiency, the self-instruction video standalone approach was further elaborated into 2 blended learning approaches in the format of a flipped classroom–like setting which were evaluated in a randomized controlled study. Whereas 1 group was provided with a self-instruction video and a brief in-class session, the other group received the self-instruction video with an extended in-class session. The impact of the teaching approaches was evaluated by surveys and OSCEs. Both flipped classroom–like approaches improved students' blood pressure measurement skills as well as

self-confidence/self-perceived proficiency significantly. Because the extended in-class session did not result in significantly better effects in terms of blood pressure measurement performance as well as self-confidence/self-perceived proficiency as compared to the brief in-class session, the flipped classroom–like approach including a brief in-class session was sufficient for conveying high-quality blood pressure measurement skills to pharmacy students. Such a strategy might be evaluated and used for teaching other skills in clinical pharmacy education.

V. Table of Contents

VI. List of Abbreviations

ABDA	Federal Union of German Associations of Pharmacists *(Bundesvereinigung Deutscher Apothekerverbände e. V.)*
ABPM	Ambulatory blood pressure monitoring
ACC	American College of Cardiology
AHA	American Heart Association
ApBetrO	Ordinance on the Operation of Pharmacies (*Apothekenbetriebsordnung*)
BP	Blood pressure
bzw.	*beziehungsweise*
CI	Confidence interval
COVID-19	Coronavirus disease 2019
CPBP	Community pharmacy blood pressure
DALY	Disability-adjusted life-year
DBP	Diastolic blood pressure
eg	*Exempli gratia*, for example
ESC	European Society of Cardiology
ESH	European Society of Hypertension
EuroPharm Forum	European Forum of National Pharmaceutical Associations
FTFI	Face-to-face instruction
HBPM	Home blood pressure monitoring
ie	*Id est*, that is
IQR	Interquartile range

mm Hg	Millimeters of mercury
OSCE	Objective structured clinical examination
SBP	Systolic blood pressure
SD	Standard deviation
SIV	Self-instruction video
SP	Simulated/standardized patient
WHO	World Health Organization

VII. List of Tables

VIII. List of Figures

1. Introduction

1.1 Educational Approaches in Academic Pharmacy Education

Over the past decades, the pharmacist's role and tasks have been evolving from their original focus of medicine dispenser and compounder towards more patient-centered care.[1,2] These changes also need to be considered in the pharmacy curriculum.[1,3] These patient-centered aspects can be addressed in clinical pharmacy education.[4] Moreover, the German “Federal Chamber of Pharmacists” (*Bundesapothekerkammer*) emphasizes the importance of competency-based teaching and assessment in pharmacy education.[5] To convey clinical skills, various teaching methods are possible.[6] Traditionally, face-to-face laboratory settings have been used for hands-on clinical skill teaching in health professions students for decades.[7] Moreover, keeping technological advancements in mind,[8] there are also settings in which digital tools are integrated into the teaching format to support clinical skills teaching in health professions education.[9-11] A relatively overarching definition for digital education “is the act of teaching and learning by means of digital technologies.”[12] For example, for teaching clinical skills instructional videos[13-15] or blended learning formats[16] can be used. However, the impact of changes in educational practice should be evaluated in educational research and the adoption of new teaching methods should be evidence-based.[17,18] In this context, a method to evaluate clinical competencies are objective structured clinical examinations.[19]

1.1.1 Face-to-Face Instruction Versus Educational Video

For decades, clinical skills have been taught traditionally in face-to-face settings.[7] Face-to-face instruction (FTFI) refers to a setting in which the learner and instructor are in the same location and participate in the instruction at the same time.[20] There are various benefits of face-to-face teaching. It offers, for example, students the opportunity to directly interact with the educator[21] and directly ask questions.[22] Moreover, students might be more committed to participate in and prepare for the topic in a face-to-face rather than in an online environment in order to make a good impression.[21] On the other hand, face-to-face teaching requires qualified teaching staff and appropriate educational infrastructure (eg, classrooms and/or simulation models), both of which may be limited particularly in low-resource settings.[23] Moreover, traditional face-to-face teaching approaches may be influenced by the instructor's ability to ensure that all students are engaged in learning.[22] Another potential disadvantage of using FTFI to demonstrate clinical skills is that depending on the class size, not every student might have an optimal view of the clinical skill being demonstrated.[22] Furthermore, the quality and content of face-to-face teaching tend to vary between different instructors.[23] Moreover, in FTFI, there is no possibility of unlimited repetition of the clinical skill demonstration.[24]

To overcome some of these drawbacks, educational videos might be a valuable option to assist clinical skills teaching.[14,22] The advent of information and communication technologies in education[25] offers to employ video-based teaching approaches such as educational videos on a broad scale. Moreover, videos can be used synchronously and asynchronously.[26] For health professions education, the literature describes several types of educational videos, such as

video lectures,[27] clinical skill demonstration videos,[28,29] and video cases.[30] Moreover, videos in health care education can be used to provide feedback and for evaluation.[31-35] Educational videos can be valuable teaching tools for health professions education[23,29,36-40] and can be used in face-to-face teaching as well as in distance teaching.[41] A benefit of educational videos for the instruction of clinical skills is that learners can be taught in a standardized way which may contribute to consistent content and quality of clinical skill teaching.[23,42,43,40] Providing an educational video online also enables the students to watch and engage with the content of the video in any place, at any time convenient to them, at their own pace, and as often as they wish.[7] During the current coronavirus disease 2019 (COVID-19) pandemic when in-person teaching in educational institutions has been restricted around the globe, and settings and tools for distance education have gained high importance,[44-46] educational videos as a possible tool for distance education[41] has become important.

In the literature, instructional videos for clinical skills education have been, for example, investigated in addition to traditional instructor-led teaching,[29,36,37] or as a replacement for traditional instructor-led teaching as self-directed learning,[13-15,22,47,48] with mixed results. For example, Alqahtani et al analyzed the impact of a procedural video compared to live demonstration in transferring orthodontic laboratory skills to dental students. The authors revealed no significant differences in students' performance when comparing both groups.[14] A study by Dissanayake et al investigated whether a videotape, a live demonstration, or a combination of both methods is more effective in acquiring skills in direct ophthalmoscopy in medical students. In contrast to Alqahtani et al, the authors found that the group that received live demonstration showed better performance

than the group receiving video demonstration. Moreover, the performance scores of the group that received the combination of both approaches were better than those of the other 2 groups.[49] Lee et al evaluated the impact of a series of podcast videos on airway management in addition to conventional one-to-one hands-on training on airway skills; they found that the group who received videos in adjunct performed significantly better on the clinical skills exam than those who did not,[50] which is in line with the findings of Holland and colleagues who analyzed the application of an online video of a best practice exemplar as an adjunct to standard clinical skills teaching for oral medication administration.[36] The different results in the literature indicate that the efficacy of an educational video might depend on the skill meant to be taught and on the target audience. Moreover, depending on the skill intended to be taught, a combination of educational video and instructor-guided activities might be required.

Regarding students' satisfaction and attitudes towards educational videos for clinical skill teaching, the results are mixed.[14,42,48,51,52] For example, in the study by Alqahtani et al in which the impact of live demonstration versus procedural video for teaching an orthodontic procedure was analyzed, there was no significant difference in students' preference for either approach.[14] On the other hand, Bazyk et al reported that students preferred live over videotaped instruction.[48]

1.1.2 Blended Learning

There are different definitions of the term blended learning in the literature.[53,54] For example, blended learning is considered to be "the thoughtful integration of

classroom face-to-face learning experiences with online learning experiences."[54] In a blended learning setting, by combining face-to-face teaching and online teaching, blended learning might address some disadvantages of both standalone approaches.[55] As such, the shortcomings of personal interaction with peers and instructors in online teaching and the lack of self-paced learning in face-to-face teaching could be balanced in a blended learning setting.[55] In recent years, blended learning approaches have been increasingly investigated in health professions students' education, with the results indicating positive effects.[56-61] Gong et al evaluated a blended learning approach compared to a traditional lecture-based approach for clinical skills teaching in medical students. They found that the theoretical and practical performance in the blended learning group were significantly better compared to the control group.[61] Furthermore, a meta-analysis by Li et al investigating the effect of blended learning on nursing students' knowledge, skills, and satisfaction, showed that compared to traditional teaching, blended learning significantly improved nursing students' knowledge and satisfaction. However, they found no significant difference between blended learning and traditional teaching regarding skills. Moreover, they reported a high degree of heterogeneity in the included studies.[62] A blending learning approach can be implemented in various formats,[55,63,64] one of which is the so-called "flipped classroom."[64,65]

1.1.3 Flipped Classroom

Different definitions of the flipped classroom approach can be found.[66-70] In the literature, the term "inverted classroom" can be found frequently as a synonym for the flipped classroom.[71,72] The flipped classroom approach can be described

as a pedagogical strategy in which students are generally in charge of acquiring fundamental knowledge and content attainment out of class by provided material, before coming to class.[70,73] In class, the instructor guides and facilitates concept application.[70] There is no universal flipped classroom setting.[71,74] O'Flaherty and Phillips conclude in their review the following to be core features of the flipped classroom: "content in advance" (…), "educator awareness of students understanding, and higher-order learning during class time."[71] Flipped classroom is not simply the re-ordering of activities traditionally taking place in class and at home.[69,74] It also takes into account that the learner is in the center of the process and not the instructor[74] and emphasizes active learning.[75,76] Active learning can be defined as "instructional activities involving students in doing things and thinking about what they are doing"[77] with the core elements being "student activity and engagement in the learning process."[78] Various pre-class modalities are described in studies, including, but not limited to, reading assignments and/or videos.[71,73,79,80] Also, the range of in-class modalities is wide and may include discussions, problem sets, simulations, and/or think-pair-share tasks.[71,79] Furthermore, the flipped classroom approaches sometimes may contain post-class activities after an in-class session for students to control their understanding and/or reflect on their practice.[81-83]

The framework of the flipped classroom approach was already described in 2000.[76,84] Later on, through the work of Bergmann and Sams, the flipped classroom approach achieved high awareness and attention.[65,74] However, the main features of the flipped classroom model can be traced back to the work of King in 1993.[85] She demanded and emphasized the change of the professor's role "from sage on the stage to guide on the side," meaning that the class should

be student-centered.[86] Flipped classroom approaches can increase instructor–student interaction[74,87] and can lead to improved class time efficiency because the in-class time is used for more student-centered active learning activities.[72] Nevertheless, the amount of work and time required to initially transform the traditional course design into a flipped one should not be neglected.[83,88] The time efforts should decline in subsequent offerings of the course because the repertoire of materials may only need to be updated.[83,88] Moreover, students might deem the allotted preparation material for the out-of-class portion as an additional burden.[72,89]

Flipped classroom approaches were found to improve outcomes in examination/test scores and course grades in various disciplines.[79,87,90,91] However, there are still controversies regarding the efficacy of flipped classroom approaches on student learning outcomes in the literature.[70,79,92-99] A meta-analysis by Hew et al on the effects of flipped classroom approaches on students' learning in health professions education, including 28 studies, found an overall significant effect in favor of flipped classrooms over traditional classrooms.[94] However, their analysis indicated heterogeneity.[94] Furthermore, the meta-analyses by van Alten and colleagues, which included 114 studies and compared flipped versus non-flipped classrooms in secondary and postsecondary education, found a small positive effect on learning outcomes but again underlining the heterogeneity between studies.[97] A meta-analysis by Chen et al found that if objective structured clinical examination (OSCE) scores were used as an outcome measure, no significant effect in favor of the flipped classroom was found.[93] However, only 2 studies with OSCEs were included in their subgroup analysis.[93] Determining which aspects might contribute to positive

student outcomes is still necessary.[100] Furthermore, it appears that the design of the flipped classroom influences the differences in its effects[101,102], and different learning domains and objectives might require different flipped classroom designs[101]. Therefore, research evaluating which elements contribute to the efficacy of a flipped classroom approach is required.[100]

1.1.4 Objective Structured Clinical Examinations

Objective structured clinical examinations (OSCEs), first described by Harden and colleagues in 1975,[103] are defined as an "approach to the assessment of clinical competence in which the components of competence are assessed in a planned or structured way with attention being paid to the objectivity of the examination."[104] OSCEs are also used in educational research in health care professions students to assess clinical performance.[19] OSCEs address the "show how" competence[105] in the Miller Pyramide, a ranking of levels of clinical assessment in clinical education.[106] Typically, an OSCE comprises a series of stations through which the examinee rotates at a predetermined time period.[104,107] At each station, the examinee is required to perform a predefined task.[19,107] The stations can represent "procedure stations" or "question stations."[19,103,107] In a "procedure station," the examinee is observed and assessed by an examiner (hereafter also referred to as a rater) while performing a clinical procedure such as patient counseling.[19] Thereby, the examinee might interact with a patient, who can be depicted by, for example, real patients, simulated patients, standardized patients, manikins, or interact with other health care professionals in addition to or instead of patients.[19] In a "question station," the examinee answers questions, mostly based on the previous station.[19,103,107]

Whereas some researchers use the terms “standardized patient” and “simulated patient” as synonyms,[108,109] others differentiate between them, with varying definitions.[110-112] For the sake of simplification, in this dissertation, the terms “standardized/simulated patient” (SP) are considered interchangeable and describe a person (faculty member or student) who plays a patient role and is instructed to adhere to a standardized setting. To ensure an objective evaluation, the examiner assesses the performance by applying a checklist or rating scale.[19] The task of the examiner can be undertaken by briefed faculty members,[113] health professionals,[19] students,[19,113] SPs,[19] or real patients.[19] OSCEs can not only be used for clinical assessment but also for training and teaching purposes.[114,115]

1.2 Hypertension

1.2.1 General Aspects

Hypertension is a global health issue.[116] High blood pressure is a known risk factor for death due to cardiovascular diseases and chronic kidney disease.[117-119] Frequently, hypertension coexists with other cardiovascular risk factors[120] such as dyslipidemia, glucose intolerance, obesity, and left ventricular hypertrophy.[121] In 2019, 626 million women and 652 million men aged 30 to 79 were estimated to have hypertension globally.[122] Arterial hypertension "is defined as the level of blood pressure at which the benefits of treatment (either with lifestyle interventions or drugs) unequivocally outweigh the risks of treatment, as documented by clinical trials."[123] Hereafter, arterial hypertension is referred to as hypertension. The blood pressure thresholds for defining hypertension in adults can vary depending on the measurement approach and guideline.[123-125] For example, the European Society of Cardiology/European Society of Hypertension (ESC/ESH) guidelines as of 2018 for the management of arterial hypertension classify blood pressure as optimal, normal, high–normal, or grades 1 to 3 hypertension, according to office blood pressure. They describe hypertension as office systolic blood pressure (SBP) values ≥ 140 mm Hg and/or diastolic blood pressure (DBP) values ≥ 90 mm Hg.[123] This classification applies to adults and boys and girls ≥ 16 years.[123,126] On the other hand, the 2017 American College of Cardiology/American Heart Association (ACC/AHA) guideline for high blood pressure in adults has changed the thresholds for diagnosis of hypertension to office SBP of at least 130 mm Hg and/or office DBP of at least 80 mm Hg.[125]

Hypertension can be further divided into primary or secondary hypertension. Primary hypertension accounts for the majority of adults with hypertension.[127-129]

It is assumed that primary hypertension has a multifactorial etiology, including genetic, environmental, behavioral factors, and social determinants.[130-134] Other researchers divide the risk factors for primary hypertension into modifiable and non-modifiable risk factors.[135] Table 1-1 depicts examples of risk factors for primary hypertension.

Table 1-1: Examples of Risk Factors for Primary Hypertension

Non-modifiable risk factors	Modifiable risk factors
• Age[136,137] • Family history[136,138,139] • Gender[140] • Race[141] • Genetic factors[142]	• High sodium intake[136,143-145] • Low potassium intake[136,143,146] • Excessive alcohol consumption[136,143,147,148] • Obesity[136,143,149,150] • Lack of physical activity[136,143,151] • Unhealthy diet[143,152] • Mental stress[136,153]

Moreover, cigarette smoking,[154] air pollution,[155] psychological stress,[156,157] sleep disorders[158], reduced sleep duration and consolidation[159], and noise exposure[160,161] have been suggested to be other potential risk factors for hypertension.[143] Regarding cigarette smoking, the immediate effect of smoking is an acute increase in blood pressure.[162,163] However, although cigarette smoking is a well-recognized cardiovascular risk factor, the long-term effects of smoking on blood pressure and hypertension incidence appear unclear.[154,164,165]

Secondary hypertension, which accounts for approximately 5 to 10% of adults with hypertension, [127,166-168] is characterized by having an identifiable cause and

may be curatively treatable by interventions, in particular, in younger affected people.[123] The prevalence of secondary hypertension may vary depending on the clinical characteristics and age of the screened population.[166-170] Possible causes of secondary hypertension are for example obstructive sleep apnoea, renal parenchymal disease, primary aldosteronism, phaeochromocytoma, Cushing's syndrome, or the coarctation of the aorta.[123] Moreover, drugs or other substances or monogenetic disorders may cause secondary hypertension.[123] Nevertheless, it may be that patients whose cause of secondary hypertension had been cured, remain hypertensive which may be caused by concomitant primary hypertension or irreversible vascular remodeling.[166]

Hypertension is often called a silent killer because it rarely causes symptoms.[116,123,171] Nevertheless, sometimes symptoms such as headache, shortness of breath, dizziness, chest pain, palpitations of the heart, and nose bleeds can occur.[116] In this regard, Middeke et al have suggested a strong correlation between the severity of blood pressure and the symptoms of dizziness and headache.[172] Moreover, specific symptoms can indicate secondary hypertension.[173]

It has been researched and recognized that blood pressure-lowering treatment reduces the risk for major cardiovascular disease events, in particular, coronary heart disease, stroke, and heart failure across various population subgroups, various baseline blood pressure levels, and comorbidities.[174] Despite the availability of knowledge on prevention[175] and treatment strategies for hypertension,[123,174] high systolic blood pressure is a major contributor to the global burden of disease.[117,176] This may be partly due to inadequacies in the prevention, diagnosis, and control of hypertension in an aging world.[122,177,178] A

publication of the Global Burden of Disease Study 2017, found that high systolic blood pressure (according to the Global Burden of Disease Study 2017: SBP of over 110 to 115 mm Hg) was the leading risk factor accounting for 10.4 million deaths and 218 million disability-adjusted life-years (DALYs) in 2017 worldwide when ranked by risk-attributable DALYs.[176] However, there are global disparities in the burden of hypertension.[122,178] The literature indicates that in 2010 approximately 75% of people with hypertension resided in low- and middle-income countries and that the awareness, treatment, and control of hypertension was considerably lower in low- and middle-income than in high-income countries.[178] Even among high-income countries, the awareness, treatment coverage, and control of hypertension differ considerably. For example, in Germany among women aged 40 to 79 years, the prevalence of hypertension was estimated at 43%, the awareness rate was estimated at 87%, the treatment rate was estimated at 80%, and the control rate was 58% (years 2008 to 2011). On the other hand, in Finland, among women aged 40 to 79 years (for the year 2017), the prevalence was estimated at 52%, the awareness rate was estimated at 77%, whereas the treatment rate was estimated at 59%, and the control rate was 29%.[179] Moreover, even in high-income countries, control rates fall behind those reached in high-quality hypertension programs (eg, the Kaiser Permanente Northern California hypertension program).[179,180] This indicates the need for strategies to further improve hypertension diagnosis, therapy, and control also in high-income countries.[179] Pharmacists have the potential to contribute to hypertension management.[181]

The relevance of arterial hypertension and the need to take actions to address the global burden of raised blood pressure on current and future generations is

strongly emphasized by the global initiative of the "Lancet Commission on Hypertension."[177] They defined 10 essential goals and 10 accompanying key actions relating to the 4 categories "Prevention: lifestyle and environmental changes," "Diagnosis and evaluation," "Pharmacological prevention and treatment," and "Blood pressure and health-care systems" to enhance blood pressure management worldwide. One goal they state is that "[e]very adult should know their blood pressure" and in this context, they outline the importance of access to blood pressure measurement to direct this goal.[177] Considering this aspect, there are different settings, where the blood pressure can be measured, such as in physicians' offices or in community pharmacies.[182,183]

1.2.2 Pharmacists' Role in Hypertension Therapy Management

Community pharmacists are well positioned to support the management of hypertension. They are not only one of the most accessible health professionals,[184,185] but also have the potential to perform multifaceted activities such as patient education and counseling on lifestyle; medication and medication adherence; feedback to health care professionals; medication management; blood pressure measurements; teaching patients about blood pressure self-measurement; reviewing of home blood pressure measurements; and medication reminders.[181,186,187] In particular, in Germany, 18 753 community pharmacies were available in 2020 having approximately 1 billion patient contacts per year.[188] The role of pharmacists in hypertension management is highlighted by many organizations.[123,125,186,189] In 2018, the updated ESC/ESH guidelines for the management of arterial hypertension emphasized "[a] key role for nurses and pharmacists in the longer-term management of hypertension."[123] Moreover, the

2017 ACC/AHA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults recommends a team-based care approach and lists examples of team members with the clinical pharmacist being stated as a possible team member among others.[125] Also, the World Health Organization (WHO) Countrywide Integrated Noncommunicable Diseases Intervention (CINDI) Programme sees the potential in pharmacists' involvement in hypertension care and has developed a pharmacy-based hypertension management model in cooperation with the European Forum of National Pharmaceutical Associations (EuroPharm Forum). In this context, they suggest involving pharmacists in a broad range of health care levels, namely in the primary prevention of hypertension, early detection of hypertension, and management of hypertensive patients on treatment.[186]

The literature demonstrates that pharmacist's interventions alone or in collaboration with other health care professionals can have a positive impact in improving blood pressure control.[181,187,190-195] Generally, regarding pharmacists' intervention in hypertension management, researchers emphasize the importance of patients' follow-up visits by their pharmacist in the long-term management of hypertension.[196] Pharmacists' hypertension care not only has the potential to improve patients' hypertension management but may also reduce the burden for physicians in primary and secondary care of hypertension.[192]

Pharmacists' intervention can include various tasks.[181,186,187] A meta-analysis by Santchi et al evaluating the effect of pharmacist interventions on blood pressure control found that in most studies included in the meta-analysis, pharmacist interventions comprised multiple components, whereby they could not clearly determine which intervention is the most efficient. A study by Zillich et al, that was

also included in the meta-analysis of Santchi et al, interestingly compared high- versus low-intensity intervention in community pharmacies. The patients in the high-intensity group had 4 face-to-face appointments with their pharmacist over 3 months, in which patient-specific education about hypertension was provided, blood pressure was measured by the pharmacist (at appointment 1,2,4), and a blood pressure monitor for self-blood-pressure measurement was provided to the patient at appointments 1 and 3 with the instruction to measure blood pressure at least daily.[197] Based on these blood pressure measurement data, the pharmacist developed written treatment recommendations for the patient's physician and contacted the physician.[197] In the low-intensity group, the patients met the pharmacist 3 times over 3 months, in which their blood pressure was measured by the pharmacist at each appointment with the pharmacist transmitting the measurement data to the patient's physician.[197] The patients in the low-intensity group were mostly referred to the physician if the blood pressure was above normal.[197] Comparing the groups, the authors found no significant difference in systolic blood pressure but a significant difference in diastolic blood pressure between high- and low-intensity community pharmacy intervention in favor of the high-intensity community pharmacy intervention.[197] Nevertheless, the systolic blood pressure and diastolic blood pressure decreased significantly in both groups.[197] This indicates that less labor-intensive and fewer complex pharmacy interventions might also be useful for improving blood pressure control.

In Zillich et al, the pharmacist's intervention in the high-intensity group included treatment recommendations for the physician.[197] Furthermore, there is research that showed pharmacists' potential in extending their scope of practice in hypertension management such as conducting prescribing or titration

practices.[198] For example, Tsuyuki et al evaluated enhanced pharmacist care that included among others independent patient assessment, counseling, and prescribing/titrating compared to usual care and they showed a positive impact on hypertension management.[198] In this regard, there are already countries such as the United Kingdom, Canada (variations across provinces), New Zealand, and the United States (variations across states) that legally expanded prescribing roles for pharmacists with different degrees, models, and underlying different requirements for authorization.[199-202] However, the extended care of prescribing is not permitted in Germany yet.[203]

Pharmacists are well positioned to monitor blood pressure in patients with hypertension, for example a contact point might be when they refill their antihypertension prescriptions.[204] Pharmacits are also well positioned to identify subjects who are not aware of their increased blood pressure and “who may not be being managed by a physician.”[196] Particularly for working adults, the community pharmacy appears to be a convenient and suitable place for screening for hypertension due to the high accessibility with often extended opening hours during evenings and weekends.[205,206] In a recent study conducted in Poland, 118 individuals who visited the community pharmacy and were above 18 years old and without previously diagnosed hypertension were randomly selected. In these individuals the blood pressure was measured, and 16.9% (20 individuals) of them were referred to a physician due to elevated blood pressure.[207] From these individuals, hypertension was diagnosed in 4 individuals.[207] In another investigation in German community pharmacies, pharmacists measured blood pressure with the aid of guidance worksheets in subjects with known hypertension and in subjects without a history of

hypertension.[208] The participating pharmacists performed the blood pressure measurement procedure in 187 subjects (86 with known hypertension and 101 without known hypertension) and led to 55% of individuals with known hypertension being advised to see their physician due to poorly controlled blood pressure.[208] Out of the 101 individuals without a history of hypertension, 16 subjects were advised to visit their physician due to uncontrolled blood pressure.[208] However, this investigation did not provide follow-up data on whether the subjects actually visited a physician[208] or what the physician's action was. Such blood pressure checks are not only about detecting and managing hypertension; blood pressure checks in a community pharmacy can also induce useful conversations, irrespective of a normotensive or hypertensive outcome, informing the patient about potential risks of high blood pressure and emphasize a healthy lifestyle, and consequently, might contribute to the prevention of hypertension.[209]

1.2.3 Blood Pressure Measurement

To successfully support and realize models of hypertension management and screening programs, pharmacists have to master several skills. Among them, accurate and correct blood pressure measurement is an important skill.[186,189] It is a fundamental and common medical test.[210,211] According to the German Ordinance on the Operation of Pharmacies (*Apothekenbetriebsordnung*, ApBetrO) pharmacy-related services include among others simple health care tests,[212] which can, for example, be blood pressure measurements.[213] Currently, the scientific environment and health institutions have made major efforts to optimize blood pressure measurement skills among health care professionals.[214-

[216] Accurate blood pressure measurement plays a vital role in detecting hypertension, diagnosing hypertension, and managing patients with hypertension appropriately.[183,214]

1.2.3.1 Types of Blood Pressure Measurement

The blood pressure can be determined invasively (directly) or noninvasively (indirectly).[214] The direct invasive method to measure blood pressure should only be applied in specialized health care settings.[214] It is commonly used in critical care settings.[216] However, in the office setting (office blood pressure measurement), blood pressure is typically measured noninvasively.[183] Noninvasive blood pressure estimation techniques can be divided into manual or automated techniques.[214,217] Manual techniques are measurements per palpation or auscultation.[217] When applying the auscultatory blood pressure measurement technique, the observer estimates the blood pressure by using a manometer and listening to the Korotkoff sounds with a stethoscope.[218] Automated measurement techniques that mostly apply an oscillometric approach have become widely used.[214,217] The oscillometric blood pressure measurement devices estimate the systolic and diastolic blood pressure "from the mean arterial pressure using a device-specific algorithm and the oscillometric pulse waves detected in the blood pressure cuff."[218] Moreover, there are automated blood pressure measurement devices that have the ability to automatically perform multiple blood pressure measurements after a rest period, at set intervals with a single activation.[183,214] The 2018 ESC/ESH guidelines for the management of arterial hypertension recommend auscultatory or oscillometric semiautomatic or automatic sphygmomanometers for the office-blood pressure measurement in adults

equally.[123] Only recently, the consensus document “2021 European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement” has been published and recommends validated automated electronic oscillometric, upper arm cuff blood pressure measurement devices for office blood pressure measurement.[219] The use of manual electronic auscultatory devices is stated if validated automated devices are not available.[219] Furthermore, they prefer the use of devices that take triplicate readings automatically.[219]

For confirming the diagnosis of hypertension in adults, the ESC/ESH guidelines recommend repeated office blood pressure measurements or out-of-office blood pressure measurements[123] with ambulatory blood pressure monitoring (ABPM) and home blood pressure monitoring (HBMP) being possible approaches for the blood pressure measurement outside the clinical environment (out-of-office blood pressure measurement).[123]

1.2.3.2 Accurate Blood Pressure Measurement

Although blood pressure measurement is a common procedure,[211,220] various factors can affect its accuracy and health care providers should be knowledgeable of these factors.[220] Sources of inaccuracies in blood pressure measurement can be divided into patient-, device-, procedure-, and observer-related potential sources of inaccuracies.[220] A systematic review by Kallionen et al described a total of 29 potential sources of inaccuracy regarding the measurement of resting blood pressure at the upper arm in adults, with 27 of them having significant effects. However, for some of these 27 factors, the effects were inconsistent in direction.[220] Table 1-2 shows examples of the potential

sources of inaccuracies and their estimated effects on blood pressure. Inaccurate blood pressure measurement can cause diagnostic errors and inadequate decision-making and risk assessment.[214,221,222] For example, a false-positive diagnosis of hypertension can cause unnecessary treatment with redundant expenditures for antihypertensive medication to patients and the health care system as well as potential side effects from overtreatment.[210,223] On the contrary, if inaccurate measurement leads to underestimating the blood pressure, it may result in undertreatment, and an opportunity to prevent avoidable potential cardiovascular events may be missed.[224] Consequently, the accuracy of blood pressure measurement depicts a relevant issue of patient safety.[224]

Table 1-2: Examples of Potential Sources of Inaccuracies

Potential source of inaccuracy	Range of reported mean effect on systolic blood pressure [mm Hg]	Range of reported mean effect on diastolic blood pressure [mm Hg]
Acute meal ingestion	−6	−5 to −1.9
Acute alcohol use	−23.6 to +24	−14 to +16
Acute caffeine use	+3 to +14	+2.1 to +13
Acute nicotine use or exposure	+2.81 to +25	+2 to +18
Bladder distension	+4.2 to +33	+2.8 to +18.5
Insufficient rest period	+4.2 to +11.6	+1.8 to +4.3
Legs crossed at knees	+2.5 to +14.89	+1.4 to +10.81
Unsupported back	No significant effects reported	+6.5
Unsupported arm	+4.87	+2.7 to +4.81
Arm lower than heart level	+3.7 to +23	+2.8 to +12

[Continuation of Table 1-2]

Incorrect choice of cuff size		
• Smaller cuff	+2.08 to +11.2	+1.61 to +6.6
• Larger cuff	−3.7 to −1.45	−4.7 to −0.96
Talking during measurement	+4 to +19	+5 to +14.3
Reliance on a single measurement	+3.3 to +10.4	−2.4 to +0.6
Interarm variability	|3.3| to |6.32|	|2.7| to |5.06|

The table was shortened and modified with permission from Kallioinen N, Hill A, Horswill MS, Ward HE, Watson MO. Sources of inaccuracy in the measurement of adult patients' resting blood pressure in clinical settings: A systematic review. *J Hypertens*. 2017;35(3):421-441. doi:10.1097/HJH.0000000000001197.

Investigations have found room for improvement in blood pressure measurement skills in health care professions students as well as in health care professionals.[222,225,226] For example, Rakotz et al evaluated medical students' ability to perform adequate blood pressure measurement with an automated device.[225] With the participating students having confirmed to had received previous blood pressure measurement training, it was found that the mean number of elements the participants fulfilled correctly was 4.1 out of a predefined 11-element skillset.[225] Levy et al assessed the adherence of physicians and nurses or technicians to recommended guidelines for blood pressure measurement. In their investigation, 76.6% of 64 patients who had their blood pressure measured by a physician, and 96.3% of 54 patients who had their blood pressure measured by a nurse or technician reported that the respective observer measured the blood pressure without waiting a 5-minute rest period.[226] Due to the findings of these studies in health care professionals and health care professions students, it is fair to assume that pharmacy students' and

pharmacists' blood pressure measurement skills might also have room for improvement. This proposal is also indicated by a survey applied in German community pharmacies, which revealed that only 5 of 17 surveyed pharmacies apply repeated blood pressure measurements.[208]

Neither the 2018 ESC/ESH guidelines nor the 2017 ACC/AHA guideline express specific recommendations about which type of blood pressure measurement device should be used in the community pharmacy. For the blood pressure measurement in the doctor's office, the ESC/ESH guidelines recommend auscultatory or oscillometric semiautomatic or automatic sphygmomanometers equally.[123] The Policy Statement from the World Hypertension League recommends semi-automated (manual inflation) or fully automated (automated inflation) oscillometric blood pressure devices for community screening settings and also prefers them in the clinical setting and recommends manual blood pressure measurement only "where automated measures are not feasible for technical reasons."[227] Therefore, this dissertation focuses on oscillometric blood pressure measurement. Moreover, recently, the use of automated blood pressure measurement devices over manual auscultatory devices in routine community and clinical setting with the premise of the devices being properly validated for measurement accuracy has been further reinforced by other organizations such as the WHO.[214,216,219] The WHO recommends the use of validated automatic blood pressure measurement devices with upper arm cuff in the routine clinical and community screening.[214] Reasons for the rising advocacy for automated oscillometric devices include simplifying the blood pressure measurement procedure, reducing observer bias compared to the auscultatory technique, and decreasing additional training requirements.[216] Finally, the recent "2021

European Society of Hypertension practice guidelines for office and out-of-office blood pressure measurement" in particular gives some recommendations regarding the blood pressure measurement in a community pharmacy and recommend a validated electronic upper-arm cuff device (preferring devices that take automatically triplicate readings).[219] It is important to consider that automated devices still require attention, knowledge, capability to follow proper directions, and the correct conduction of sequential activities,[214,228] and consequently, require appropriate training.[214]

Many potential sources of inaccuracy can be addressed by using a proper, standardized blood pressure measurement technique and validated equipment.[182,214,220] Furthermore, international organizations such as the WHO, the World Hypertension League, and the Lancet Commission on Hypertension Group place major emphasis on appropriate training, assessment, and certification of health care professionals for accurate blood pressure measurement, even if automated blood pressure measurement devices are used.[214,229,216] Additionally, periodic retraining of staff to maintain the skills over the long term is reinforced.[214,216,229] Given the lack of accurate blood pressure measurement in practice,[225,226] blood pressure measurement skills should be taught appropriately, and the observer's performance should be tested at an early stage, namely in health care professionals schools.[216] In this context, the Lancet Commission on Hypertension Group demands research to "identify the best methods of delivering training."[216]

1.3 Blood Pressure Measurement Teaching Approaches in Pharmacy Education

Because accurate blood pressure measurement is essential for correct and successful hypertension screening and management,[214] blood pressure measurement skills should be conveyed already to health care professions students[216] including pharmacy students in an appropriate manner. Some innovative approaches for pharmacy students are described in the literature.[16,230,231] For example, Prescott et al investigated a blended learning model consisting of a flipped classroom format with online videos as out-of-class material for pharmacy students in a patient assessment course, in which blood pressure assessment was 1 of the topics. The authors found that the blended learning model group performed better in blood pressure assessment than the traditional classroom group.[16] This finding shows the potential of the flipped classroom approach for conveying blood pressure measurement skills to pharmacy students. Turgon et al described the integration of a blood pressure screening clinic at a tertiary-care cardiac center as part of a second-year pharmacy curriculum after comprehensive training including educational videos, a quiz, practical laboratory, and lectures.[231] However, because this real-life setting approach requires adequate space and sufficient devices,[231] it might not be applicable for every pharmacy faculty everywhere. Furthermore, simulation-based training is an option used for pharmacy students to train blood pressure measurement skills.[230] For example, Seybert et al analyzed the impact of simulation-based learning on doctor of pharmacy students' ability to perform accurate blood pressure assessment.[230] Their simulation-based learning approach included didactic lectures on blood pressure assessment with practical sessions using a high-fidelity computerized patient simulator. The authors found

that students' knowledge and their ability to accurately determine blood pressure improved following simulation sessions.[230] However, because of the potential high expenditures for a simulator, such approaches might not be feasible in low-resource settings and on a large scale.

1.4 Aims

There are many potential obstacles to adequate blood pressure measurement.[220] Furthermore, there is a lack of proficiency for accurate blood pressure measurement among health care professionals and health professions students,[222,225,226] whereas accurate blood pressure measurement is of great importance for the screening and management of hypertension.[214] Given the need for appropriate teaching approaches for blood pressure measurement[216] and the ongoing digitalization in health professions education,[232] the aim of this work was to develop a modern video-based approach to successfully convey blood pressure measurement skills to pharmacy students, focusing on oscillometric upper arm blood pressure measurement devices. Furthermore, because the impact of changes in education practice should be evaluated in educational research and the adoption of new teaching methods should be evidence-based[17,18] this work additionally aimed to evaluate the efficacy and students' perception of these teaching approaches.

In particular, the present work aimed to:

1. Develop a self-instruction video for conveying blood pressure measurement skills in pharmacy students (Chapter 2).[233]
2. Evaluate the impact of the self-instruction video compared to face-to-face instruction in the scope of a non-inferiority study ("SIV Versus FTFI Study," Chapter 3).[234]
3. Evaluate the impact of a blended learning approach in a flipped classroom–like setting in the scope of a study ("Flipped Classroom–Like Approach Study," Chapter 4).[235]

2. Development of a Self-Instruction Video

2.1 Background

High blood pressure is an important worldwide health issue.[116] According to the Global Burden of Disease Study, high systolic blood pressure was the leading risk factor, when ranked by risk-attributable DALYs accounting for 10.4 million deaths and 218 million DALYs in 2017.[176] This makes the importance of proper detection, treatment, and control of hypertension clear.[116] The beneficial impact of a pharmacist's intervention alone or in collaboration with other health care professionals in improving blood pressure control is described in the literature.[181] Pharmacists can perform multifaceted tasks in hypertension management such as measuring blood pressure and educating patients on self-blood pressure measurement.[186]

Accurate blood pressure measurement plays a vital role in detecting hypertension and in managing patients with hypertension appropriately.[214] Inaccurate blood pressure measurement can cause diagnostic errors and inadequate decision-making and risk assessment.[214] Many sources of inaccuracy can be addressed by proper, standardized blood pressure measurement technique and validated equipment.[216,220,236] Currently, the scientific environment and health institutions have made major efforts to optimize blood pressure measurement skills.[214-216,236] In this context, the WHO places major emphasis on proper training of the respective personnel, even if automated blood pressure measurement devices are used.[214] Consequently, this competence should be taught appropriately already to students of diverse health care professions[216] including pharmacy students.

In a time where the use of educational videos in health professions education has increased,[10,237] an educational video might be an option for teaching blood pressure measurement skills to pharmacy students. Clinical teaching videos are used for several purposes, such as to deliver lectures,[27] to demonstrate clinical skills,[28,29] to show cases,[30] and to provide feedback and evaluation.[31-35] In this chapter, it was aimed to develop an instructional video in the German language tailored to teach pharmacy students oscillometric upper arm blood pressure measurement in a community pharmacy setting in the form of a role-play that can be used as a self-instruction tool.

2.2 Methods

The video production was divided into 3 main phases: pre-production, production, and post-production similar to video productions described in the literature.[238,239] The pre-production phase included all planning activities prior to the actual filming as defined in the literature,[238,240] whereas the production phase covered all activities involving the recording of audio-visual material.[238] The post-production phase consisted of the activities following the initial film recording such as editing.[240] The steps applied in this project in each of the 3 phases are summarized in Table 2-1.

Table 2-1: Summarized Steps of the Video Production

Pre-production	Production	Post-production
• Definition of the purpose/goal of the video • Identification of target audience • Selection of video style • Scriptwriting • Decision about self-production or cooperation with professional production company • Recruitment of actors • Selection and organization of filming location, required material, and other staff (such as the camera operator) • Testing feasibility and clarity of script and, where necessary, revising the script • Rehearsal of the script and scenes with the actors • Coordination of shooting schedule and personnel	• Setup the filming location and lighting • Filming the video • Recording the sound	• Screening of the video footage • Rough cut • Re-recording sound, where necessary • Sound editing • Fine cut • Insertion of slides, pictures, animations, and transition effects • Evaluating and reviewing the video and, where necessary, revising • Rendering final product into the desired and eligible format

In this table, the steps conducted for this project are summarized. The content is based on the experience of the present video project and complies with the literature.[42,239-241] Depending on the video project other steps such as taking voice-overs might be necessary.

2.2.1 Pre-Production

Before starting the production of the video, many theoretical considerations and fundamental decisions were made. Among these, the purpose and target audience of the educational video were identified, and the video style was selected, as recommended in the literature.[239,241] The target audience of this educational video was pharmacy students in the eighth and final semester of their university studies and the video was purposed at conveying oscillometric upper arm blood pressure measurement skills for a community pharmacy setting in a self-directed manner.

Another step before the actual video production was the scriptwriting, as proposed by the literature.[240] Two pharmacists (faculty members) developed the script, based on a literature search that included, but was not limited to the standard operating procedure on blood pressure measurement in the community pharmacy of the "Federal Union of German Associations of Pharmacists" (*Bundesvereinigung Deutscher Apothekerverbände e. V.*, ABDA) as of 2017,[242] the 2018 ESC/ESH guidelines for the management of arterial hypertension,[123] and 2017 ACC/AHA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults.[125] The script was revised in several rounds and comprised an introduction—describing the storyline of the film in short, the roles, and the locations—and 2 scenes. The first scene was the greeting in the community pharmacy, and the second was the actual blood pressure measurement in the community pharmacy. The script included written dialogue between the patient and the pharmacist, described further behavior and actions the actors were meant to perform, and indicated some technical instructions on shot size. Furthermore, the script already noted some elements

for post-production, such as where the chapter slides should be inserted in the video.

Another step in the pre-production phase was the recruitment of actors.[240] For that purpose, 2 pharmacy students in their final year of pharmacy studies in the scope of their scientific elective course were asked and gave voluntary and written consent. One actor took on the role of a patient whose blood pressure was to be measured, and the other actor depicted the pharmacist who performed the blood pressure measurement. To ensure correct and seamless blood pressure measurement on the day of recording, the actors trained extensively to measure each other's blood pressure adequately and rehearsed the script. The feasibility and clarity of the script were tested in the scope of the rehearsals with the actors.

Moreover, the filming location, materials, and other staff were selected and organized in this phase as suggested in the literature.[240] The video project, described in this dissertation, was supported by the multimedia center of the university (Heinrich Heine University Duesseldorf). Therefore, 1 internal staff member and 1 external via the multimedia center organized professional camera operator were included in the team of this video project. The video was filmed in a real community pharmacy to generate an authentic community pharmacy setting. The community pharmacy was arranged by the multimedia center, and the faculty members arranged the missing requisites such as a white coat and different cuff sizes suitable for the available blood pressure monitor (OMRON M5 Professional HEM-7001-D).

2.2.2 Production

The video was filmed in 1 day by 1 professional camera operator with 1 camera in a community pharmacy in Germany. The sound was recorded via the microphone of the camera and by external microphones attached to each actor. Besides the recording, the camera operator also set up the lighting. Every scene was recorded in several pieces, with almost every piece being filmed from 2 perspectives: from the pharmacist's perspective, and from the patient's perspective. During the filming process, the camera operator conferred with the 2 faculty members over the shot size and what should be in the center of the frame in order to record the blood pressure measurement appropriately. Thus, depending on the content of the respective section, some sections were filmed close-up and/or from a distance. Generally, during the production phase, the 2 faculty members' function was to ensure that the recorded material is authentic and correct with respect to the content, as suggested in the literature.[239]

2.2.3 Post-Production

In this phase, the footage was edited using the software Adobe Premiere Pro CS 6 to generate an educational video. This included first assembling a rough cut. For that purpose, the video footage was screened, suitable recordings were selected, assembled, and cut. Then, the respective audio tracks recorded by the camera were allocated and selected. Moreover, where necessary, audio tracks were re-recorded in the sound recording studio of the multimedia center. Intro slides, chapter slides, explanatory slides with written explanations and/or pictures or other illustrations, and final credit slides were

incorporated in the video. The chapter slides, displaying the heading of the respective segment, were intended at separating the segments and announcing the particular segment, to be demonstrated. After chapter slides, the explanatory slides were inserted where appropriate with the purpose of providing an additional written and/or pictorial summary about the steps of the blood pressure measurement to be demonstrated. The pictures demonstrated, among others, possible mistakes during the blood pressure measurement (eg, incorrect placement of the cuff), for improving understanding. Afterward, the video recording cutting and sound synchronization were refined. Moreover, transition effects were embedded, and the display duration of the slides and pictures were adjusted.

During editing, the video as a whole was reviewed by the 2 faculty members and the multimedia staff member several times, and it was determined that the camera audio track was partly impaired by loud background noises. Therefore, the majority of the camera audio tracks were exchanged with audio tracks recorded by the microphones attached to the actors. Subsequently, the synchronization of audio and video was refined again, and the sound volume was adapted. Afterward, the video sequence was rendered. In a second and final editing process after the video was once applied in the scope of a study (SIV Versus FTFI Study, chapter 3), the sound of the video and a few slides were further optimized and added.

The task of microphone audio track allocation, as well as the compiling of slides and additional pictures, was performed by the faculty members. The illustrations, pictures, and slides were prepared in Microsoft PowerPoint by the faculty members. The remaining editing was performed by the multimedia staff member,

whereby the process was accompanied and guided regarding content by the 2 faculty members to ensure the blood pressure measurement was depicted correctly.

2.2.4 Personnel and Facilities

A 6-person team was involved in creating this educational video: 2 faculty members (pharmacists), 2 pharmacy students, 1 staff member from the university's multimedia center, and 1 external via the multimedia center organized professional camera operator. The multimedia center staff member supported the project as a media expert, and the faculty members served mainly as content experts as suggested in the literature.[239] Except for the ongoing personnel expenses for the 2 faculty members, no additional costs related to the video development were incurred for the Institute of Clinical Pharmacy and Pharmacotherapy. An oscillometric upper arm device (OMRON M5 Professional HEM-7001-D) was used in the video. Professional filming equipment was used. The video was filmed in 1 day in a community pharmacy in Germany during the day-to-day business to generate an authentic community pharmacy setting. The video project was approved by the ethics committee of the medical faculty of the Heinrich Heine University Duesseldorf (Study Number 2018-164_1-ProspDEuA).

2.3 Results

Given the aim of providing pharmacy students a guide in the form of a self-instruction tool on how to measure blood pressure with an oscillometric upper arm device appropriately in a community pharmacy setting, the video not only demonstrated the necessary steps but also delineated the blood pressure measurement process via role-play to support the students in communicating with the patient, along with descriptive slides. The video also considers factors that can potentially influence the accuracy of blood pressure measurements, implemented as pharmacist–patient interaction. The finalized video (after second editing) had a duration of 11 minutes and 33 seconds and presents oscillometric blood pressure measurement at the upper arm in a real community pharmacy setting in the German language. Table 2-2 describes the content and structure of the video.

Table 2-2: Description of the Structure and Content of the Video

Segment	Short description of the segment
Introduction	• Slides showing the title of the video and information on copyright
Greeting	• Recording showing the patient entering the community pharmacy • Recording showing the patient and pharmacist greeting and the patient asking for blood pressure measurement
Facilities	• Slides describing the required spatial and technical equipment • Recording showing the spatiality for the blood pressure measurement
Preparation of blood pressure measurement	• Slides describing the preparation for blood pressure measurement, such as: ○ Questions that the pharmacist should ask the patient during a patient interview ○ How clothing is removed properly from the arm (or arms, respectively, if both arms are intended to be measured) ○ How to choose the correct cuff size • Recording showing: ○ The pharmacist conducting the patient interview ○ The pharmacist giving the patient instructions on how to expose arm/arms appropriately ○ The patient exposing their arm/arms properly ○ The pharmacist measuring the arm circumference/s of the patient properly for choosing the correct cuff size

[Continuation of Table 2-2]

Rest period	• Slides describing:
	  ○ The proper duration of the rest period
	  ○ The instructions the pharmacist should give to the patient regarding the patient's posture and behavior during the rest period
	• Recording showing:
	  ○ The pharmacist informing the patient about the required rest period
	  ○ The pharmacist giving the patient proper instructions regarding the patient's posture and behavior during the rest period and the patient executing these instructions accordingly
	• Slide simulating the rest period
	• Recording showing the pharmacist attaching the chosen cuff with the correct size to the device after the rest period

Process of blood pressure measurement	• Slides describing the process of blood pressure measurement, such as:
	  ○ How to put on the cuff properly
	  ○ The instructions the pharmacist should give to the patient regarding the patient's posture and behavior for the blood pressure measurement
	  ○ Other important aspects of appropriate blood pressure measurement in a community pharmacy
	• Recording showing the pharmacist put on the cuff properly and measuring the patient's blood pressure accurately

[Continuation of Table 2-2]

Documentation of the blood pressure measurement	• Slides depicting the correct documentation of the blood pressure measurement • Recording showing: ○ The pharmacist documenting and informing the patient about his/her blood pressure ○ The closing of the consultation
Acknowledgments	• Slides listing the names and roles of the involved persons and expression of thanks to the community pharmacy, the video was filmed at

2.4 Discussion

An educational video in the German language on the proper oscillometric upper arm blood pressure measurement tailored for pharmacy students was created. The design of the video was in the form of a role-play to promote students' communication skills. Furthermore, the video was designed as a self-learning tool in the form of a self-instruction video. To facilitate video production for inexperienced educators in pharmacy and medical education, some technical and pedagogical aspects, which are considered to be important for developing educational videos, are discussed in the following.

Defining the target audience is of great importance, as the necessity and helpfulness of certain information may vary depending on the experience level of the audience (novice versus expert status).[239,243] The main target audience for this video was pharmacy students of the eighth semester. At the Heinrich Heine University Duesseldorf, by whom students the video was intended to be used, students attend clinical pharmacy teaching in the seventh semester for the first time. Therefore, the content of the video was aligned to a rather novice audience. It was decided to do so in the form of a role-play, along with written and pictorial explanations, rather than a narrative demonstration, to also facilitate the impartation of communication skills. Nevertheless, the created video can also be valuable for pharmacists to refresh their blood pressure measurement skills.

The popular video-sharing platform YouTube hosts myriad educational videos from various sources on clinical skills, including blood pressure measurement skills,[244-247] with some of these videos having received millions of views. However, videos on clinical skills education available on YouTube show a highly heterogeneous range of educational usefulness and/or quality.[248-254]

Nevertheless, health-related organizations[247,255,256] and The New England Journal of Medicine[257] also have published educational videos on auscultatory or oscillometric blood pressure measurement, mainly in the English language.

When developing an educational video, the literature recommends considering cognitive load, student engagement, and active learning to maximize the utility of the video,[243] which was also endeavored during the development process in the present work. For example, Brame has suggested creating educational videos in a way giving the impression that the video is specifically for the respective students in the respective class to promote student engagement.[243] Therefore, for the present video project, students of the current semester were recruited as actors. This effect might not be sustained, as at some point the respective future class would not recognize the acting students anymore. Nevertheless, the advantage of student actors might be the reduction of production costs, while the students themselves might benefit from this as a learning experience.

An additional aspect to maintain student engagement is keeping educational videos short.[243] However, there are different suggestions regarding the duration of an educational video.[92,237,258-260] For example, Guo et al recommended to "segment videos into short chunks, ideally less than 6 minutes" but simultaneously, they reported that for tutorials the length does not matter as much compared to lecture videos, but it is important to facilitate re-watching and skipping.[258] However, the analysis focused on math and science courses[258] while the instruction video of this dissertation focuses on a clinical skill. Chauvet et al recommended regarding surgical teaching videos that they should not be longer than 10 to 15 minutes for more complex procedures.[260] Based on these arguments the video length of the blood pressure measurement video appears

adequate. The practical application in the following studies might deliver more information.

For this video, it was decided to insert chapter slides for 2 reasons. First, it was aimed to reduce cognitive overload by segmenting the video.[243,261] Second, it was sought to promote active learning by facilitating the student-controlled movement through the video by chapter slides.[243] Furthermore, the conscious decision was made to add background music neither during the pharmacist–patient interaction nor to the descriptive slides to manage cognitive load.[261]

.

2.5 Conclusion

This chapter provides insight into pedagogical aspects and steps undertaken to create an instructional video designed to teach a clinical skill using the example of oscillometric upper arm blood pressure measurement for pharmacy students produced in a community pharmacy setting. This work is a valuable support for faculty members who want to develop educational videos. This might be of interest especially during the COVID-19 pandemic, where distance learning has become highly relevant.[44-46] The actual value of the developed educational video needs to be evaluated in studies regarding efficacy and students' perceptions of this educational tool. In the following 2 chapters, the evaluation of the developed instructional video in different educational settings is presented.

2.6 Disclosure

Parts of this chapter were previously published as: Farahani S, Farahani I, Burckhardt BB, Monser K, Laeer S. The development of an educational video on blood pressure measurement for pharmacy students. *Adv Med Educ Pract*. 2021;12:655-663. doi:10.2147/AMEP.S302728. The author of this dissertation had a lead role in and substantially contributed to the conceptualization, investigation, methodology, project administration, writing - original draft, writing - review and editing.

3. Self-Instruction Video Versus Face-to-Face Instruction for Conveying Blood Pressure Measurement Skills in Pharmacy Students (SIV Versus FTFI Study)

3.1 Background

High blood pressure is a global health issue.[116] In 2010, the estimated worldwide number of adults ≥ 20 years with hypertension was 1.39 billion.[178] In the same year, an estimated 46.5% of adults with hypertension were aware of their disease, while 36.9% among those with hypertension were treated with antihypertensive medication, globally.[178] However, blood pressure was controlled in only 13.8% of adults with hypertension.[178] Early detection, treatment, and control of hypertension are crucial for decreasing hypertension-associated morbidity and mortality.[116,262]

Pharmacists are well positioned to support the management of hypertension. They are not only one of the most accessible health care professionals,[184,185] but can also perform multifaceted activities such as blood pressure measurements and teaching patients about blood pressure self-measurement.[186] Moreover, in 2018, the updated ESC/ESH guidelines for the management of arterial hypertension emphasized “[a] key role for nurses and pharmacists in the longer-term management of hypertension.”[123]

Although blood pressure measurement is a common procedure,[211,220] various factors can affect the accuracy of blood pressure measurement and health care providers should be knowledgeable of these factors.[220] Inaccurate blood pressure measurement, bears the risk of misclassification and subsequent inadequate pharmacotherapy.[222,223] With this being said, regardless of who is performing the

blood pressure measurement and which measurement method is used, standardized measurement, staff training, and validated devices are key for accurate blood pressure measurement.[183,214] Consequently, blood pressure measurement skills should be taught at an early stage[216] in the pharmacy profession, namely during pharmacy studies.

Traditional teaching approaches, such as face-to-face teaching approaches, have been used for hands-on clinical skill education for decades.[7] However, it may be influenced by the instructors' ability to assure that all students are engaged in learning.[22] The quality and content of face-to-face teaching tend to vary between different instructors.[23] Modern approaches, such as educational videos, might be a promising alternative. In a face-to-face environment, students have the opportunity to interact with the instructor and peers,[13] whereas the advantage of educational videos is that learners can be taught in a standardized manner, which contributes to the reduction of procedural and methodological inconsistencies in skills teaching.[23,40,42,43] The advantage of making an educational video available online is that it can reach many geographically dispersed learners.[51,63] Particularly in the current COVID-19 pandemic, when many educational institutions have been temporarily closed,[263] the vital role of educational videos as a tool for distance education[41] has become apparent. The literature describes several types of educational videos, such as video lectures,[27] clinical skill demonstration videos,[28,29] and video cases.[30] Moreover, clinical education videos, can be used to provide feedback and evaluation.[31-35] Instructional videos are studied in addition to traditional instructor-led teaching[29,36,37] or as a replacement for traditional instructor-led teaching as self-directed learning. [13-15,22,47,48]

However, there is a shortage of literature investigating the effect of self-instruction videos for clinical skills in pharmacy students compared to a control group. Therefore, the aim of this study was to investigate whether a self-instruction video (SIV) is non-inferior to face-to-face instruction (FTFI) for conveying blood pressure measurement skills.

.

3.2 Methods

3.2.1 Operational Definitions

For the purpose of this dissertation,

- the term self-instruction video (SIV) was used to refer to a video recording that demonstrates and explains a skill and that aims to teach the skill without any facilitator or instructor present.[38]
- the term face-to-face instruction (FTFI) was used to refer to an instruction performed by an instructor, whereby the learner and instructor are in the same location and participate in the instruction at the same time.[20]

3.2.2 Objectives

The primary objective of this study was to investigate whether a self-instruction video is non-inferior to face-to-face instruction in terms of acquiring blood pressure measurement skills as measured by objective structured clinical examinations. A secondary objective was to determine whether the SIV is non-inferior in terms of participants' self-confidence and self-perceived proficiency as measured by a self-assessment survey. A further secondary objective was to explore the participants' perception and satisfaction as measured by a perception and satisfaction survey.

3.2.3 Study Design

Approval for this study was granted by the ethics committee of the medical faculty of Heinrich Heine University Duesseldorf (Study Number 2018-164_2-ProspDEuA). The participants were pharmacy students in the eighth

and final semester of their university studies at Heinrich Heine University Duesseldorf, Germany. This study was conducted in the scope of the clinical pharmacy course. Neither participation nor non-participation in the study had an impact on passing this course. For recruitment, students were informed about the study and were provided with written participant information. The students were included in the study when they had granted voluntary, written informed consent. The investigation was conducted as a randomized controlled non-inferiority trial using a pre-post design. The study evaluated the efficacy of an SIV (intervention group) as an alternative to FTFI (control group). Figure 3-1 illustrates the study design.

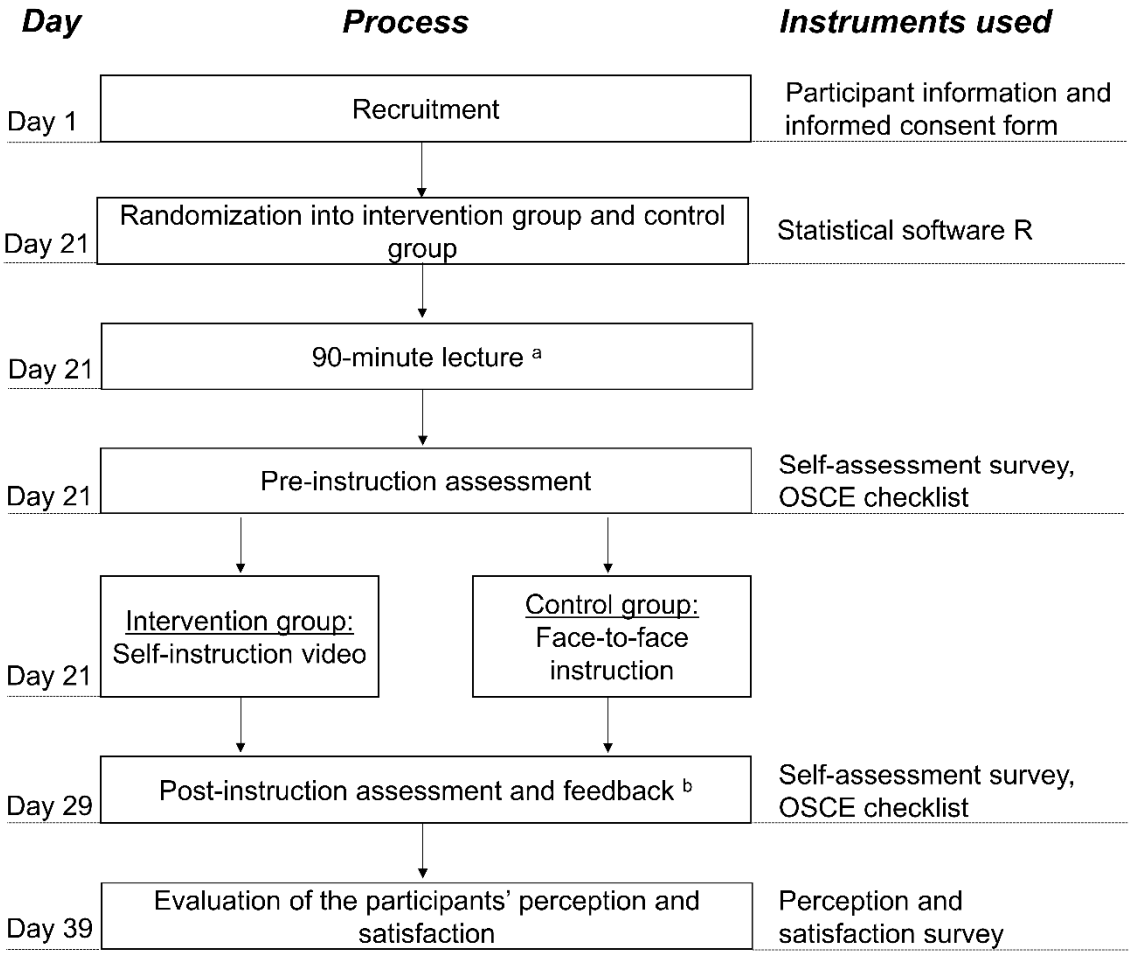

Figure 3-1: Overview of the Study Design of the SIV Versus FTFI Study

OSCE = objective structured clinical examination.
[a] The lecture dealt with the basic knowledge of hypertension and vital parameters, without describing the actual procedure of the oscillometric blood pressure measurement. [b] Immediately after the post-instruction OSCE encounter, each participant received feedback from the rater.

On day 21, the participants of both groups attended a 90-minute lecture regarding basic knowledge on hypertension and vital parameters, without describing the actual procedure of oscillometric blood pressure measurement. On the same day, the participants accomplished a pre-instruction assessment which comprised a self-assessment survey and an OSCE on blood pressure measurement. Afterward, on the same day, the intervention group was trained by watching a self-instruction video on oscillometric upper arm blood pressure measurement

while the control group received face-to-face instruction on oscillometric upper arm blood pressure measurement. On day 29, the post-instruction assessment was conducted, which also consisted of a self-assessment survey and an OSCE on blood pressure measurement. At the post-instruction OSCE, each participant additionally received feedback from the rater immediately after the OSCE encounter. Finally, on day 39, the participants' perception and satisfaction were ascertained anonymously by a survey.

3.2.4 Instruction

3.2.4.1 Self-Instruction Video

The SIV was developed by 2 pharmacists with the support of the university's multimedia center, as described in chapter 2. It depicted the stepwise process of blood pressure measurement with the same oscillometric upper arm blood pressure monitor applied in the OSCEs and was structured with the following sections: "introduction," "greeting," "facilities," "preparation of blood pressure measurement," "rest period," "process of blood pressure measurement," "documentation of the blood pressure measurement," and "acknowledgments." The video was in the local language German. Each participant watched the 11-minute and 11-second video on an individual computer with headphones in one room at the university (Heinrich Heine University Duesseldorf). The participants were allowed to watch the video for up to approximately 15 minutes. In this timeframe, the participants could pause and rewind the video according to their preferences. The video was temporarily available for the SIV group on the computers in a computer room of the university. The teaching was done without the input of an instructor and was self-directed. Nevertheless, for coordination a

faculty member was available. The participants were instructed not to make notes or other recordings such as video or audio recordings of the SIV. Typically, taking notes during teaching activities appears to be a regular part of students' behavior. However, in the scope of the study, the participants were instructed to refrain from that to avoid information exchange between the groups and potentially correlated confounders.

3.2.4.2 Face-to-Face Instruction

The participants in the FTFI group received FTFI for approximately 15 to 20 minutes by an instructor. The role of the instructors was performed by 3 faculty members (pharmacists). Also, students who did not sign the informed consent form, attended the FTFI, leading to an instructor-to-participant ratio of 1:11. In the FTFI, the process of blood pressure measurement was explained and demonstrated. The participants of the FTFI group were also instructed not to make notes of the instruction for the same reasons as described in section 3.2.4.1.

3.2.5 Instruments

3.2.5.1 Objective Structured Clinical Examination

Clinical skill performance was measured by pre- and post-instruction OSCEs. Both the pre- and post-instruction OSCEs comprised 1 station that was limited to a maximum of 10 minutes, with the rest period being simulated (due to time restrictions) if the participant recommended it. In both the pre- and post-instruction OSCEs, the participants were required to pretend they were in a

community pharmacy and measure the blood pressure of an adult with an oscillometric upper-arm blood pressure monitor (OMRON M5 Professional HEM-7001-D, the device did not have the function to perform automatically multiple readings with 1 activation). In the OSCEs, 1 blood pressure monitor, 1 measuring tape, 3 different cuff sizes, writing utensils, and the participant instruction (Appendix 1) were provided. In each OSCE encounter, 1 participant took over the role of the pharmacist, and in addition, 1 SP, and 1 rater were involved. The SPs were played by a pool of faculty members or volunteer pharmacy students of the eighth and final semester of university pharmacy studies who did not participate in the study. Moreover, the SPs had been prepared for their role. In total, 4 raters supported the study. The rater assessed the participant's OSCE performance by filling in the OSCE checklist. Each participant was rated by the same rater in the pre- and post-instruction OSCE. The role of the raters was performed by 2 previously trained pharmacists of the institute of clinical pharmacy and pharmacotherapy and 2 pharmacy students who had been trained beforehand in the scope of their scientific elective course in their final year of university pharmacy studies.

3.2.5.2 OSCE Checklist

For the development of the checklist, a literature search was conducted. The developed checklist was based among others on the standard operating procedure on blood pressure measurement in the community pharmacy of the ABDA as of 2017,[242] the 2018 ESC/ESH guidelines for the management of arterial hypertension,[123] and the 2017 American guideline for the prevention, detection, evaluation, and management of high blood pressure in adults.[125] The

original OSCE checklist encompassed 39 items (Appendix 2). For subsequent analysis, 2 items of the checklist had to be excluded because these 2 aspects could not be performed by every standardized patient or in every OSCE encounter, respectively. Consequently, a maximum of 37 points was achievable, which were divided into the sections “general preparation of blood pressure measurement,” “rest period,” “steps of blood pressure measurement,” and “documentation.” The summarized content of the checklist is presented in Table 3-1. Every item was weighted equally. If an item was fulfilled correctly, 1 point was awarded, whereas 0 points were awarded if the participant did not comply with an item. The OSCE score was used to assess the blood pressure measurement performance and consequently to evaluate the acquisition of skill through the respective instruction.

Table 3-1: Summarized Content of the Checklist for Blood Pressure Measurement of the SIV Versus FTFI Study

Section	Number of items in the respective section	Content
General preparation of blood pressure measurement	9	• Examinee asks questions about factors that potentially could affect BP (6 items) • Examinee inquires whether the measuring arm is known to the patient (1 item) • Examinee asks the patient to remove clothing from arm (or arms respectively, if both arms are intended to be measured) without rolling up sleeves (1 item) • Examinee measures arm circumference/s (1 item)
Rest period	4	• Examinee gives instructions to the patient regarding the patient's position during the rest period (2 items) • Examinee gives instructions to the patient regarding the patient's behavior during the rest period (ie, to not speak) (1 item) • Examinee has the patient relax (rest) for 5 minutes in seated position (prior to measurement) (1 item)
Steps of the blood pressure measurement	18	• Examinee selects correct cuff size (1 item) • Examinee places the cuff correctly (5 items) • Examinee gives instructions to the patient regarding the patient's body position, arm position, and behavior during BP measurement (5 items) • Examinee measures BP correctly (5 items) • Examinee communicates the measured BP appropriately and asks for open questions (2 items)
Documentation	6	• Examinee documents properly (6 items)

BP = blood pressure measurement.
Summarized content of the 37-item checklist (without considering the 2 items excluded as described in 3.2.5.2.

3.2.5.3 Self-Assessment Survey

To evaluate the impact of the 2 instruction approaches on the participants' self-confidence and self-perceived proficiency in their blood pressure measurement skills, the participants completed a self-assessment survey (Appendix 3) immediately before each OSCE session. The self-assessment survey encompassed 5 items. A 6-point Likert scale (0 = strongly disagree, 1 = disagree, 2 = rather disagree, 3 = rather agree, 4 = agree, 5 = strongly agree) was used. The self-assessment survey was developed for this study. The participants' demographics, such as age, gender, additional education as a pharmaceutical technician assistant, current or former work in a community pharmacy, former experience in blood pressure measurement, and preparation for the blood pressure measurement, were collected along with the self-assessment survey.

3.2.5.4 Perception and Satisfaction Survey

The participants were asked to fill out a perception and satisfaction survey about OSCEs, the respective instructional approach, and the entire OSCE seminar on blood pressure measurement. The survey consisted of 13 items rated by a 6-point Likert scale ["strongly disagree" (*trifft gar nicht zu*); "disagree" (*trifft nicht zu*); "rather disagree" (*trifft eher nicht zu*); "rather agree" (*trifft eher zu*); "agree" (*trifft zu*)"strongly agree" (*trifft voll zu*)]. One of these items was solely applicable to the SIV group and another item was solely applicable to the FTFI group. Additionally to the 13 items, for each group, 1 question was included where the participants were required to rate the respective instructional approach they received, based on the German school grading scale, ranging from 1 = very good (*sehr gut*) to

6 = insufficient (*ungenügend*). In free-text items (open-ended questions), they also had the possibility to comment on what they liked in particular regarding the respective instruction they received and what they would suggest changing regarding the respective instruction they received. For analysis, the comments on the free-text items were categorized into topics.

3.2.6 Statistical Analysis

All data, except for the perception and satisfaction survey, were collected in a pseudonymized way, and rendered anonymous after data analysis. The perception and satisfaction survey was collected anonymously. The participants were randomized to the SIV group or FTFI group using R.[264] The non-inferiority of the SIV compared to the FTFI was examined with a two-sided 95% confidence interval (CI) for the difference in the mean change (from pre- to post-instruction assessment) of OSCE score between the 2 groups in terms of the primary outcome, and for the difference in the mean change (from pre- to post-instruction assessment) of self-assessment score between the 2 groups in terms of the secondary outcome. The difference in the mean change of the respective score between the 2 groups was calculated by: “mean change of the respective score of the SIV group” minus “mean change of the respective score of the FTFI group.” Thereby, the mean change of the respective score for each group was determined by calculating the post-instruction score minus the pre-instruction score for each included participant and subsequently calculating the mean.

A non-inferiority margin of −10% was defined to be educationally meaningful. This decision, made before collecting the data, and was based on the non-inferiority

margin applied in a study by Platz et al, who compared different educational methods in emergency medicine and surgery residents.[265] In the present study of this dissertation, −10% corresponds to −3.7 points regarding the OSCE score and −2.5 points regarding the self-assessment score. If the two-sided 95% confidence interval lay entirely to the right of the non-inferiority margin, non-inferiority for the respective objective was claimed. This analysis approach was based on guidelines.[266-268] If the condition of non-inferiority was fulfilled for the respective score, it was assessed whether the increase in the respective score from pre- to post-instruction was higher in the SIV group than in the FTFI group. This was tested using a one-sided Mann–Whitney test with a significance level of alpha = 0.05.

The change in the OSCE score and self-assessment score from pre- to post-instruction assessment for each group was analyzed using a one-sided Wilcoxon signed rank test, applied to the differences between pre- and post-instruction scores, with a significance level of alpha = 0.05. The difference between the 2 groups in the baseline (pre-instruction assessment) scores was analyzed using a two-sided Mann-Whitney test with a significance level of alpha = 0.05. The item of the perception and satisfaction survey, on participants' German school grade ratings on the respective instruction, was analyzed using a two-sided Mann-Whitney test with a significance level of alpha = 0.05. Asymptotic *p*-values are considered in the following. The *p*-values were not adjusted for multiple testing. Microsoft Excel[269] was used for data entry, and Microsoft Excel[269] and OriginPro[270] were used for analysis.

3.3 Results

Of 58 students who were in their final semester of pharmacy university studies, 10 did not provide informed consent before randomization and 2 were trained as raters before the participant recruitment. Consequently, 46 students participated in the study. A total of 23 participants were randomized to the FTFI group, and 23 participants to the SIV group. All 46 participants completed the pre- and post-instruction assessment. One participant of the FTFI group was excluded from the analysis due to the SP's non-compliance with the predefined setting, and 1 participant of the SIV group was excluded from the analysis because of incomplete self-assessment survey data. Consequently, 22 participants of the FTFI group and 22 participants of the SIV group were included in the analysis. The 2 excluded participants could not be excluded from the analysis of the perception and satisfaction survey due to its anonymous form. Forty-one participants took part in the perception and satisfaction survey.

Out of the 22 participants of the FTFI group included in the analysis, 21 participants filled out the items regarding demographics at pre-instruction assessment. Out of these 21 participants of the FTFI group, 71.43% were female, 9.52% had training as a pharmaceutical technical assistant, and 28.57% had measured the blood pressure with an oscillometric upper arm device for the first time in their lives. Out of 22 participants of the SIV group, 72.73% were female, 13.64% had training as a pharmaceutical technical assistant, and 45.45% had measured the blood pressure with an oscillometric upper arm device for the first time in their lives. As 1 demographic item regarding experience in blood pressure measurement had been worded ambiguously, it was excluded from the analysis. Table 3-2 provides further details regarding the demographics.

Table 3-2: Demographics of Participants and Participants' Preparation for OSCEs in the SIV Versus FTFI Study

	Face-to-face instruction group (n = 21 [a])	Self-instruction video group (n = 22)
Age in years		
Median (IQR)	22 (3)	24.5 (6)
Mean (SD)	23.86 (3.17)	27.14 (7.91)
Gender		
Female, n (%)	15 (71.43)	16 (72.73)
Male, n (%)	6 (28.57)	6 (27.27)
Training as a pharmaceutical technical assistant		
Yes, n (%)	2 (9.52)	3 (13.64)
No, n (%)	19 (90.48)	19 (86.36)
Currently working or formerly worked in a community pharmacy		
Yes, n (%)	6 (28.57)	3 (13.64)
No, n (%)	15 (71.43)	19 (86.36)
I have performed BP measurement with an oscillometric upper arm device by myself for the first time in my life		
Yes, n (%)	6 (28.57)	10 (45.45)
No, n (%)	15 (71.43)	12 (54.55)
Did you prepare yourself for BP measurement? (at pre-instruction assessment)		
Yes, n (%)	0 (0)	1 (4.55)
No, n (%)	21 (100)	21 (95.45)
Did you prepare yourself for BP, excluding the respective received instruction? (at post-instruction assessment) [b, c]		
Yes, n (%)	0 (0)	3 (13.64)
No, n (%)	22 (100)	19 (86.36)

IQR = interquartile range; SD = standard deviation; BP = blood pressure.
[a] One participant of the FTFI group did not fill in the demographic section in the self-assessment survey at pre-instruction assessment, resulting in n = 21. [b] At post-instruction assessment, 22 participants of the FTFI group filled out the preparation section and 22 participants of the SIV group. [c] Regarding this item in the FTFI group the number was corrected (counted as no) by 2 participants who crossed yes as they stated the FTFI instruction as preparation.

3.3.1 OSCE Score

At baseline (pre-instruction assessment), the OSCE score did not differ significantly between the 2 groups ($p = 0.620$). Both the FTFI group ($p < 0.001$) and SIV group ($p < 0.001$) demonstrated a significant improvement in the OSCE score from pre- to post-instruction assessment after the respective instruction. The detailed results for the OSCE score are depicted in Table 3-3. Furthermore, in Appendix 4, box plots for the OSCE score at pre-instruction assessment per rater are depicted which indicates that 1 of the 4 raters might had been less strict when evaluating participants' performance. However, it should be considered that all raters evaluated different participants.

Table 3-3: OSCE Score and Self-Assessment Score of the SIV Group and FTFI Group in the SIV Versus FTFI Study

Group	Instrument	Pre-instruction assessment score in points		Post-instruction assessment score in points		*p*-value [a]	Change in points	
		Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)		Mean (SD)	Median (IQR)
FTFI	OSCE checklist (n = 22)	7.95 (3.91)	8 (4)	20.32 (3.20)	20 (4)	$p < 0.001$	12.36 (4.51)	11.5 (7)
	Self-assessment survey (n = 22)	12.91 (3.48)	14 (4)	18.05 (2.66)	18 (2)	$p < 0.001$	5.14 (2.62)	4.5 (4)
SIV	OSCE checklist (n = 22)	7.41 (3.85)	6 (7)	20.77 (4.28)	20.5 (5)	$p < 0.001$	13.36 (5.01)	13.5 (8)
	Self-assessment survey (n = 22)	14.14 (4.38)	14.5 (7)	17.5 (2.43)	17.5 (3)	$p = 0.001$	3.36 (4.17)	3 (7)

OSCE = objective structured clinical examination; FTFI = face-to-face instruction; SIV = self-instruction video; SD = standard deviation; IQR = interquartile range.
[a] One-sided Wilcoxon signed rank test was applied to analyze the change in the respective score from pre- to post-instruction assessment for each group. A significance level of alpha = 0.05 was used.

Regarding the non-inferiority analysis of the primary objective, there was a 1-point difference in the mean OSCE score change (from pre- to post-instruction assessment) between the 2 groups, with a 95% confidence interval (CI) of −1.82 points to +3.82 points (Figure 3-2). The two-sided 95% CI of the difference in the mean change in OSCE score between the 2 groups lay entirely to the right of the non-inferiority margin of −3.7 points (≙ −10%). Therefore, it was concluded that the SIV is non-inferior to FTFI for acquiring blood pressure measurement skills (primary outcome). When comparing the OSCE score changes (from pre- to post-instruction OSCE) between the 2 groups, the OSCE score in the SIV group did not show a significantly greater increase (from pre- to post-instruction OSCE) compared to the FTFI group (p = 0.262).

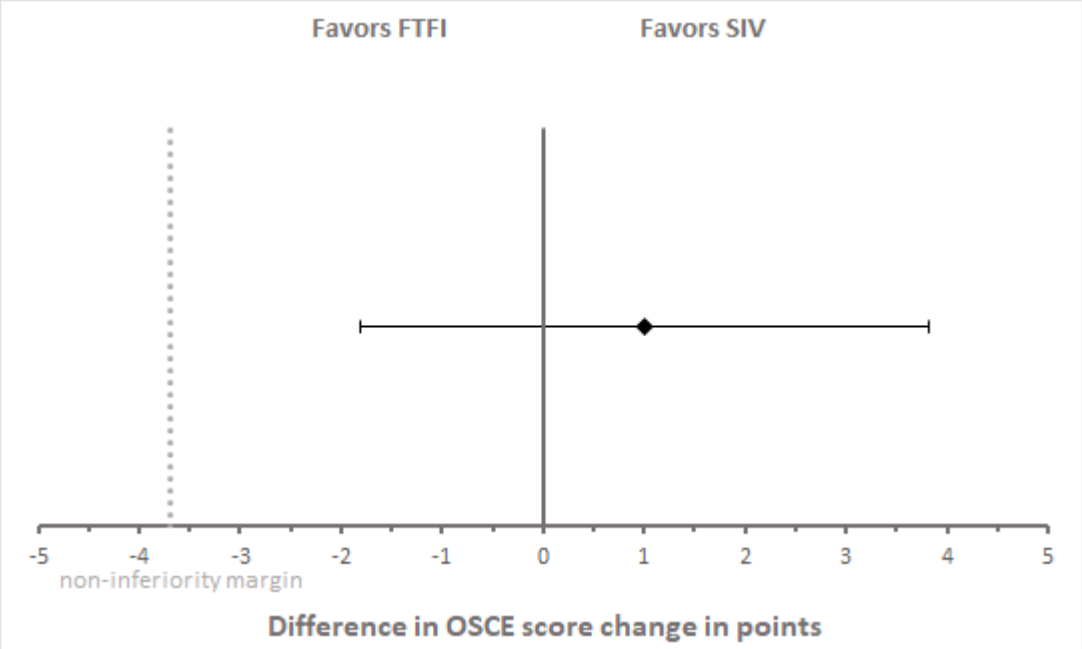

Figure 3-2: Non-Inferiority Analysis of the OSCE Score in the SIV Versus FTFI Study

OSCE = objective structured clinical examination; FTFI = face-to-face instruction; SIV = self-instruction video.
The diamond represents the difference in mean change of OSCE score between the 2 groups and was calculated as follows: “mean change of OSCE score of the SIV group” minus “mean change of OSCE score of the FTFI group.” Error bars indicate the two-sided 95% confidence interval. The dashed line represents the non-inferiority margin of −3.7 points.

3.3.2 Self-Assessment Score

At baseline (pre-instruction assessment), the self-assessment score did not differ significantly between the 2 groups ($p = 0.407$). In both the FTFI group ($p < 0.001$) and SIV group ($p = 0.001$), the self-assessment score representing the participants’ self-confidence and self-perceived proficiency showed a significant increase from pre- to post-instruction assessment. The detailed results of the self-assessment score are depicted in Table 3-3.

Regarding the non-inferiority analysis of the secondary outcome of the self-assessment score, the difference in the mean self-assessment score change

(from pre- to post-instruction assessment) between the 2 groups was −1.77 points, with a 95% confidence interval of −3.83 points to +0.29 points (Figure 3-3). Thus, the 95% CI of the difference in the mean change in self-assessment score between the 2 groups included the non-inferiority margin of −2.5 points (≙ −10%); consequently, the result regarding non-inferiority was inconclusive for the self-assessment score.

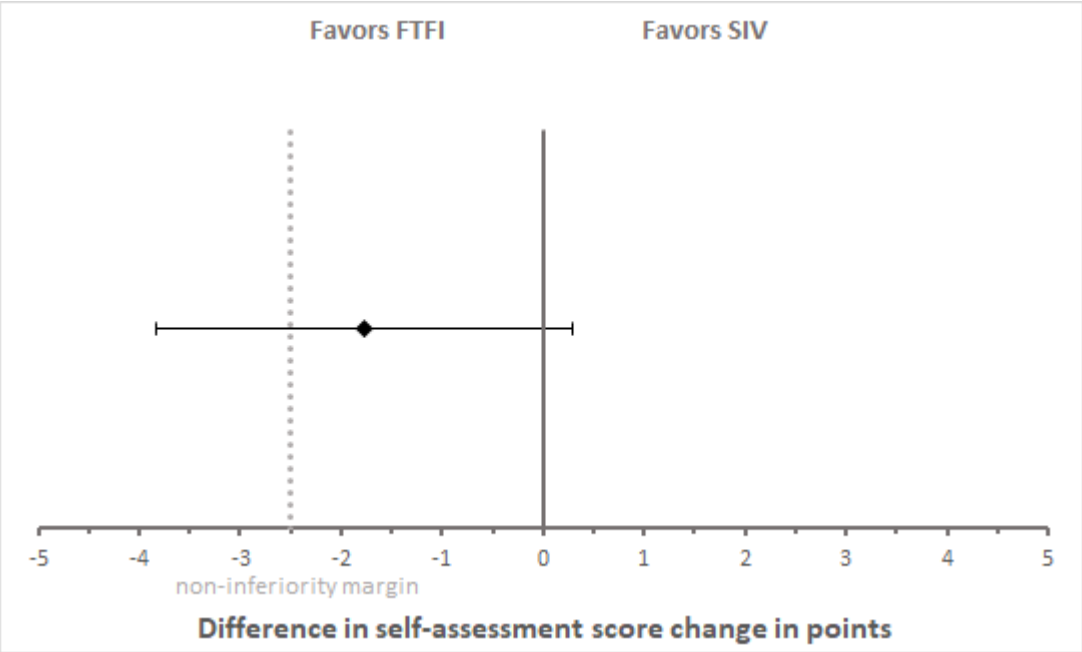

Figure 3-3: Non-Inferiority Analysis of the Self-Assessment Score of the SIV Versus FTFI Study

FTFI = face-to-face instruction; SIV = self-instruction video.
The diamond represents the difference in mean change of self-assessment score between the 2 groups and was calculated as follows: “mean change of self-assessment score of the SIV group” minus “mean change of self-assessment score of the FTFI group”. Error bars indicate the two-sided 95% confidence interval. The dashed line represents the non-inferiority margin of −2.5 points.

3.3.3 Perception and Satisfaction Survey

Out of 46 randomized participants, 41 (20 from the FTFI group, 21 from the SIV group) took part in the perception and satisfaction survey. However, not all participants filled out the survey entirely. Therefore, the total number of responses

differed depending on the item. Only the responses to items filled in unambiguously were included in the evaluation. The results regarding the items are depicted in Table 3-4. The face-to-face instruction was rated with a mean German school grade of 2.32 (n = 19, standard deviation (SD) = 0.89) and a median of 2 (n = 19, first quartile = 2, third quartile = 3). The self-instruction video was awarded a mean German school grade of 1.71 (n = 21, SD = 0.64) and a median of 2 (n = 21, first quartile = 1, third quartile = 2); the grades between the 2 groups differed significantly (p = 0.026). The German school grade result indicates that the SIV was more appreciated than the FTFI. Regarding the free-text items, the 3 most frequent topics of each item per group are shown in Table 3-5.

Table 3-4: Results of the Perception and Satisfaction Survey in the SIV Versus FTFI Study

	Proportion of Responses, n (%)					
	Strongly Disagree	**Disagree**	**Rather Disagree**	**Rather Agree**	**Agree**	**Strongly Agree**
1. I enjoyed the OSCE seminar on BP measurement.						
FTFI group; n = 20	0 (0)	2 (10)	2 (10)	7 (35)	8 (40)	1 (5)
SIV group; n = 21	0 (0)	1 (4.76)	3 (14.29)	4 (19.05)	12 (57.14)	1 (4.76)
2. During the OSCEs/simulations, I was able to determine my strengths and weaknesses in BP measurement.						
FTFI group; n = 20	0 (0)	0 (0)	0 (0)	2 (10)	8 (40)	10 (50)
SIV group; n = 21	0 (0)	1 (4.76)	0 (0)	6 (28.57)	9 (42.86)	5 (23.81)
3. The level of difficulty of the OSCE case was appropriate.						
FTFI group; n = 20	0 (0)	0 (0)	0 (0)	4 (20)	7 (35)	9 (45)
SIV group; n = 20	0 (0)	1 (5)	1 (5)	1 (5)	9 (45)	8 (40)
4. Ten minutes were an appropriate timeframe to perform the OSCE case.						
FTFI group; n = 20	0 (0)	1 (5)	1 (5)	4 (20)	6 (30)	8 (40)
SIV group; n = 21	1 (4.76)	1 (4.76)	1 (4.76)	2 (9.52)	10 (47.62)	6 (28.57)

[Continuation of Table 3-4]

5. The instruction (FTFI or SIV) should take place on a different day than the OSCEs/simulations.						
FTFI group; n = 20	4 (20)	6 (30)	1 (5)	4 (20)	3 (15)	2 (10)
SIV group; n = 20	4 (20)	10 (50)	2 (10)	0 (0)	2 (10)	2 (10)
6. The OSCEs/simulations enabled me to apply the knowledge and skills that I acquired during the instruction.						
FTFI group; n = 20	0 (0)	0 (0)	0 (0)	3 (15)	10 (50)	7 (35)
SIV group; n = 21	0 (0)	0 (0)	1 (4.76)	6 (28.57)	9 (42.86)	5 (23.81)
7. After this seminar, I feel better prepared for the correct BP measurement in the community pharmacy.						
FTFI group; n = 20	0 (0)	0 (0)	0 (0)	4 (20)	7 (35)	9 (45)
SIV group; n = 21	0 (0)	0 (0)	0 (0)	4 (19.05)	12 (57.14)	5 (23.81)
8. Carrying out the OSCEs/simulations increased my self-confidence in performing BP measurements on real patients in the community pharmacy.						
FTFI group; n = 20	0 (0)	0 (0)	2 (10)	6 (30)	5 (25)	7 (35)
SIV group; n = 21	0 (0)	0 (0)	0 (0)	4 (19.05)	13 (61.90)	4 (19.05)

[Continuation of Table 3-4]

9. The instructional video was helpful for the preparation for the OSCEs/simulations.						
FTFI group; n = NA	Not applicable					
SIV group; n = 21	0 (0)	0 (0)	2 (9.52)	3 (14.29)	7 (33.33)	9 (42.86)
10. The FTFI was helpful for the preparation for the OSCEs/simulations.						
FTFI group; n = 20	0 (0)	0 (0)	2 (10)	5 (25)	7 (35)	6 (30)
SIV group; n = NA	Not applicable					
11. In the future, instructional videos should be included in the teaching of clinical pharmacy.						
FTFI group; n = 11	0 (0)	0 (0)	0 (0)	2 (18.18)	4 (36.36)	5 (45.45)
SIV group; n = 20	0 (0)	0 (0)	2 (10)	4 (20)	7 (35)	7 (35)
12. OSCEs/simulations about BP measurement are superfluous because one can do nothing wrong with the BP measurement.						
FTFI group; n = 18	11 (61.11)	7 (38.89)	0 (0)	0 (0)	0 (0)	0 (0)
SIV group; n = 20	14 (70)	5 (25)	1 (5)	0 (0)	0 (0)	0 (0)

[Continuation of Table 3-4]

13. In the future, OSCEs/simulations should be included as a firm part of the clinical pharmacy course [a] for training practical skills (such as BP measurement).						
FTFI group; n = 16	0 (0)	0 (0)	0 (0)	3 (18.75)	9 (56.25)	4 (25)
SIV group; n = 21	0 (0)	1 (4.76)	1 (4.76)	3 (14.29)	8 (38.10)	8 (38.10)

BP = blood pressure; OSCE = objective structured clinical examination; FTFI = face-to-face instruction; SIV = self-instruction video; NA = not applicable.
[a] Clinical pharmacy Course = *Seminar Klinische Pharmazie*

Table 3-5: Examples of Topics of Comments on Free-Text Items of the Perception and Satisfaction Survey in the SIV Versus FTFI Study

Group	Free-text item	Topics
Face-to-face instruction group	What did you particularly like about the face-to-face instruction?	• The possibility to ask questions • Demonstration of procedure • The detailed instruction
	I would change the following about the face-to-face instruction:	• The fast pace of speech or demonstration • Information should be put into writing (eg, handout, slides, or flipchart) • The duration of the instruction was too short
Self-instruction video group	What did you particularly like about the self-instruction video?	• The combination of text and video • The actors • The descriptive explanation
	I would change the following about the self-instruction video:	• Taking notes should be allowed • Narrative voice for the written slides should be implemented • Summary in bullet point form should be added to the end of the video

The 3 most frequent topics of comments are presented for each item per group. If topics appeared with equal frequency, 1 topic was chosen. In Appendix 5 further topics are depicted.

3.4 Discussion

In this randomized controlled study, both educational approaches (ie, FTFI and SIV) were aimed at conveying the necessary knowledge and skills for performing correct and accurate blood pressure measurement. In this study, the SIV was non-inferior to FTFI in the acquisition of blood pressure measurement skills in pharmacy students (primary outcome). Participants' self-confidence/self-perceived proficiency improved in both groups. However, the analysis of self-confidence/self-perceived proficiency yielded an inconclusive result regarding the non-inferiority (secondary outcome). Finally, the students' perception and satisfaction (secondary outcome) indicated that the seminar as a whole, the integrated OSCEs, and both instruction approaches were predominately well received.

The findings of this study imply that an SIV, as a replacement for instructor-led teaching on oscillometric blood pressure measurement, achieves a similar effect on students' performance compared to FTFI. This corresponds to the findings of George et al, who demonstrated non-inferiority of video demonstration as a replacement for bedside teaching for teaching pediatric clinical skills in medical students. In line with the "SIV Versus FTFI Study," they applied a non-inferiority margin of 10%.[13] The setting of an SIV can influence the results of such investigations. De Vries et al, for example, revealed that self-directed video-based training with a shorter duration compared to instructor-led training was insufficient to achieve comparable results in laypeople.[271] In the present study of this dissertation and that of George et al,[13] the video-based instructions had a rather similar duration compared to the traditional instructor-led instructions. Furthermore, it should be considered that de Vries et al showed the

video to laypeople,[271] while in the “SIV Versus FTFI Study” and the study of George et al,[13] the video was viewed by health care professions students.

Although there was improved participants’ self-confidence/self-perceived proficiency from pre- to post-instruction in both groups of the “SIV Versus FTFI Study,” the findings on the participants’ self-confidence/self-perceived proficiency were inconclusive regarding non-inferiority. Lee et al found that the frequency of viewing an instructional video was positively correlated with confidence in practice.[272] As the participants of the SIV group had a limited time frame of approximately 15 minutes access to the video, it might be speculated that the limited video access provided in the “SIV Versus FTFI Study” setting was insufficient for building up enough confidence. It can only be assumed that unlimited video access with more frequent viewing of the instructional video would have resulted in a more strengthened data set regarding self-confidence/self-perceived proficiency so that non-inferiority could have been statistically demonstrated.

The instructional video on blood pressure measurement was highly accepted by the students. In particular, the responses of both groups implied that the students appreciated the implementation of instructional videos in clinical pharmacy education. However, the survey did not ask whether pharmacy students would accept the use of self-instruction videos as a replacement for face-to-face instruction. Interestingly, the literature indicates that students are critical of instructional videos as a standalone approach.[13,48] For example, Bazyk et al reported that, although students in their study considered the learning experience with the video good, they preferred live instruction over videotaped instruction.[48] They appreciated the interaction with the instructor and the possibility of asking

questions immediately in case of uncertainty, during live instruction.[48] Lwin et al, on the other hand, reported high overall satisfaction among participants with self-directed interactive video-based instruction. However, it should be considered that their approach included unsupervised practice, and satisfaction was surveyed only among participants of the video group.[23]

In the “SIV Versus FTFI Study,” although both instructional approaches led to a significant increase in the participants’ blood pressure measurement skills and self-confidence/self-perceived proficiency, there still remained potential for further improvement in both groups. It may be assumed that enhanced skill performance and confidence might be achieved by a more extensive teaching approach than that applied in the present study. For example, combining the respective instructional approach with other teaching activities such as practice time and instructor feedback may be more beneficial to performance and self-confidence/self-perceived proficiency. The beneficial impact of practice on the blood pressure measurement performance is supported by the results in the study of Padmavathi et al who analyzed the effectiveness of video demonstration (intervention group) on blood pressure performance to traditional practical instruction (control group).[273] In contrast to the present study, they found that the objective structured practical examination score, which was a measure for students' blood pressure measurement performance, was significantly higher in the video demonstration group compared to the control group. However, in the study by Padmavathi et al performance was measured after practice time.[273] In the “SIV Versus FTFI Study,” neither group had practice time. However, the pre-instruction OSCE in the “SIV Versus FTFI Study” may have induced a learning effect.[274]

In general, depending on the skill intended to be taught, a combination of a self-instruction video with instructor-led teaching may be necessary. In that context, van Dujin et al analyzed the difference in student performance after receiving a single mode of instruction versus receiving both modes (ie, face-to-face instruction and video instruction) for learning cervical psychomotor skills.[7] The authors found improved student performance after students received both modes of instruction compared to receiving one method of instruction, with no significant impact in the order of instruction.[7] This observation suggests that a combination of SIV and FTFI might be more beneficial. However, it should be considered that van Dujn and colleagues investigated teaching cervical examination and intervention skills,[7] which appear to be more complex than oscillometric blood pressure measurement. Bauer et al found in their study on auscultatory blood pressure measurement with first-year nursing students that a video instruction resulted in a poorer adherence to predefined steps of blood pressure measurement procedure than the group with the conventional form of instruction and another group that received the combination of both.[275] However, it should be noted that each group in the study of Bauer et al was supplemented with additional teaching activities, such as practice time, with the video instruction seeming to have received the shortest practice time;[275] this difference in practice time might have influenced the results. Furthermore, auscultatory blood pressure measurement, which was the subject of the study by Bauer et al,[275] is considered to require more training than oscillometric blood pressure measurement.[214,227] It may be speculated that the combination of SIV with some form of instructor-guided practice might be the most effective and simultaneously resource-efficient approach.

Finally, in the “SIV Versus FTFI Study,” the conveying of blood pressure measurement skills was investigated. The next step is to counsel and advise the patient appropriately regarding their obtained blood pressure. Future research on blood pressure measurement skills should extend the investigation on this step.

There are some limitations to the present study. First, there is a potential for inter- and intra-rater variability. It was intended to mitigate these variabilities by training the raters beforehand. As there can be still variabilities a further measure to take them into account was to have each participant being assessed by the same rater for the pre- and post-instruction OSCE. Moreover, the FTFI was performed by 3 different instructors, which may have led to inconsistency in the information and techniques taught.[25] To reduce the inter-instructor variability, the lead instructor trained the 2 other instructors, and the 3 instructors were provided with a script for the FTFI. Another aspect that should be considered is that the pre- and post-instruction OSCEs were the same OSCE case. This was done to create a standardized study environment with comparable pre- and post-instruction assessment. To minimize the possibility that participants across the groups shared information (“contamination” between groups),[276] participants were instructed not to disclose information on the instruction method and the OSCEs. To reduce the possibility of information on the SIV being shared, the video was not made available online. Additionally, the intervention of both groups took place on the same day and the same timeframe to reduce cross-communication between the groups.

3.5 Conclusion

This study demonstrates that, based on the OSCE score and a non-inferiority margin of −10%, the developed SIV was non-inferior to FTFI for acquiring blood pressure measurement skills with an oscillometric device in pharmacy students. The result for the self-assessment score was inconclusive regarding non-inferiority. Considering the advantages of instructional videos and the findings of the present study, SIVs might be considered as a valuable option for teaching blood pressure measurement skills. However, depending on the skill intended to be taught, a combination of an SIV with other teaching activities may be necessary to reach higher skill competencies. In this regard, as the results of this study indicate room for improvement in students' blood pressure measurement performance after the respective standalone instructions, a combination of a self-instruction video with hands-on exercise for teaching blood pressure measurement might derive the maximum benefit out of the developed SIV. A modern strategy to implement this approach might be the use of a blended learning approach in the format of a flipped classroom–like setting, which is presented in chapter 4.

3.6 Disclosure

Parts of this chapter were previously published as: Farahani S, Farahani I, Burckhardt BB, Schwender H, Laeer S. Self-Instruction Video Versus Face-to-Face Instruction of Pharmacy Students' Skills in Blood Pressure Measurement. *Pharmacy (Basel)*. 2020;8(4):217. doi:10.3390/pharmacy8040217. The author of this dissertation had a lead role in and substantially contributed to the conceptualization, investigation, methodology, project administration, formal analysis, visualization, writing - original draft, writing - review and editing.

4. Blended Learning on Blood Pressure Measurement: Investigating Two in-Class Strategies in a Flipped Classroom–Like Setting to Teach Pharmacy Students' Blood Pressure Measurement Skills (Flipped Classroom–Like Approach Study)

4.1 Background

High systolic blood pressure depicted the leading risk factor worldwide, when ranked by risk-attributable DALYs, accounting for 10.4 million deaths and 218 million DALYs in 2017,[176] making proper detection, treatment, and control of hypertension crucial.[116] Pharmacists are well-accessible health care professionals[277] and the literature indicates that pharmacist's intervention has a positive impact on the management of arterial hypertension.[181,192,195] The guidelines on the pharmacy-based hypertension management model, developed by EuroPharm Forum and the WHO CINDI Programme, include blood pressure measurement as 1 part of the pharmacist's intervention strategy.[186] Although, at first sight, blood pressure measurement appears to be a simple procedure,[216] there are various potential sources of inaccuracies[220] and inaccurate blood pressure measurement can lead to "diagnostic errors and incorrect decision-making and risk assessment."[214] Consequently, staff training and retraining on proper blood pressure measurement, also with automatic devices, are of great importance to assure accurate blood pressure measurement, which has been underlined by the WHO.[214] Recently in 2019, the Lancet Commission on Hypertension Group highlighted the importance of standardized training and performance assessment of blood pressure measurement skills during health care professions education. Furthermore, they emphasized the need for research to "identify the best methods of delivering training."[216] For proper blood pressure

measurement, pharmacy students should have knowledge on the aspects regarding proper equipment and environment for the blood pressure measurement, proper patient preparation, proper blood pressure measurement technique, and proper documentation and providing of blood pressure measurement readings to the patient.[278] Due to the importance of accurate blood pressure measurement for the identification and proper management of hypertension,[214] pharmacy students should be sensitized and taught the skill appropriately. A modern strategy to teach students blood pressure measurement skills might be the use of a blended learning approach.

Blended learning is considered as “the thoughtful integration of classroom face-to-face learning experiences with online learning experiences.”[54] One benefit of the blended learning approach is that the online component in the form of internet information and communication tools can offer flexibility in terms of place and time.[54] With the development of information technology, blended learning approaches have been increasingly studied in health care professions students education and indicating a positive impact on students' knowledge and skills.[56-61] A meta-analysis by Li et al analyzed the impact of blended learning on nursing students’ knowledge, skills, and satisfaction. They found that compared to traditional teaching, blended learning significantly improved nursing students' knowledge and satisfaction.[62] Regarding the analysis of skills, there was no significant difference between blended learning and traditional teaching.[62] However, Li et al found high heterogeneity in the included studies.[62] Regarding students’ confidence in their ability in the respective studied clinical skill, a controlled study by Berga et al found that the effect on confidence (that was measured by a self-efficacy scale) was not significantly different from traditional

teaching although both groups showed a significant increase of confidence from pre- to post-survey.[279] A blended learning approach can be implemented in various formats.[55,63,64] A format to realize blended learning is the flipped classroom.[64,65]

Jensen et al describe that in a flipped classroom the students are responsible for content attainment before the class and in-class the instructor guides and facilitates concept application.[70] The literature indicates the beneficial effect of flipped classroom approaches on blood pressure measurement skills.[16,280] However, there is no universal flipped classroom approach.[71] Furthermore, it appears that the design of the flipped classroom influences the differences in the effect of the flipped classroom[101,102] dependent on the learning domain and learning objective.[101] Therefore, research evaluating which elements contribute to the efficacy of a flipped classroom approach is needed.[100] However, there is a shortage of comparative studies on the adequate extent or elements of in-class activities of a blended learning approach in a flipped classroom setting for practical clinical skills.

Given the importance of accurate blood pressure measurement,[214,216] the purpose of this study was to compare a brief in-class session against an extended in-class session in order to develop an effective blended learning approach in a flipped classroom–like setting for conveying blood pressure measurement skills to pharmacy students. In particular, it was hypothesized that a self-instruction video (as out-of-class material) combined with an extended in-class session would lead to better blood pressure measurement performance as well as to greater self-confidence/self-perceived proficiency compared to the self-instruction video (as out-of-class material) combined with a brief in-class session.

4.2 Methods

4.2.1 Objectives

The primary objective of the “Flipped-Classroom–Like Approach Study” was to evaluate whether a self-instruction video in combination with an extended in-class session comprising an OSCE with feedback plus additional in-class activities (group B) would lead to better blood pressure measurement performance as compared to SIV in combination with a brief in-class session comprising an OSCE with feedback only (group A). The blood pressure measurement performances were quantified using an OSCE.

The secondary objectives were to analyze whether an SIV in combination with an extended in-class session comprising an OSCE with feedback plus additional in-class activities (group B) would lead to greater student self-confidence/self-perceived proficiency in blood pressure measurement skills as compared to SIV in combination with a brief in-class session comprising an OSCE with feedback only (group A). This was measured by a self-assessment survey. Moreover, the perception and satisfaction of the 2 different groups were assessed using a perception and satisfaction survey.

4.2.2 Study Design

This study was approved by the responsible ethics committee of the medical faculty (Study Number: 2019-729-andere Forschung erstvotierend) and was conducted in the scope of the clinical pharmacy course at Heinrich Heine University Duesseldorf, Germany. Pharmacy students in the final (eighth) semester of their pharmacy university studies were invited to participate in the

study. For recruitment, students were informed about the study and were provided with written participant information. The students were informed that neither participation nor non-participation in the study would influence students' passing of this course. The inclusion criterion was the students' voluntary, written informed consent. Students who had participated in an elective scientific course the semester before, in which the contents and results of a previous study on blood pressure measurement and blood pressure measurement educational approaches were presented and discussed, were excluded to reduce potential bias. The impact of 2 different flipped classroom–like approaches with different extents of in-class session in the scope of blended learning was investigated in a randomized controlled manner in a 2-group study. The control group (group A) participated in an in-class session consisting of an OSCE and feedback ("brief" in-class session), whereas the intervention group's (group B) in-class session consisted of an OSCE and feedback plus additional in-class activities ("extended" in-class session).

The study design and procedure are illustrated in Figure 4-1. After recruitment, the participants were randomized into 2 groups —A and B—differing in the extent of in-class activities. On day 23, both groups attended a 60-minute lecture on the basic knowledge of hypertension and vital parameters, without presenting the actual procedure of the oscillometric blood pressure measurement. The lecture is routinely presented every semester during the clinical pharmacy course and was not considered as an actual part of the flipped classroom–like approach as it did not address content regarding the procedure of the oscillometric blood pressure measurement. On the same day, the participants of both groups completed a baseline assessment comprising a self-assessment survey and a

subsequent OSCE on blood pressure measurement (assessment 1). Subsequently on day 25, unlimited access to an SIV as out-of-class material was activated for both groups. On day 37, the participants of both groups completed a second self-assessment survey and a subsequent OSCE (assessment 2) to assess the impact of the out-of-class activity (SIV). After completing OSCE 2, each participant of both groups received immediate rater feedback that informed the participants about which steps were missing and/or executed incorrectly using the OSCE checklist (approximately 2 minutes). The second OSCE and the rater feedback constituted the in-class session of group A. In contrast, group B received additional in-class activities on sources of potential inaccuracies in blood pressure measurement immediately after the second OSCE-session (including feedback) on the same day. In this study setting, OSCE 2 served as a study measurement instrument and as a hands-on exercise for training purposes. The in-class session of each group is detailed in section 4.2.3.2. On day 64, both groups participated in a third self-assessment survey and a subsequent OSCE with subsequent rater feedback to assess the impact of the respective in-class session (assessment 3). At the end of this seminar (day 64), a perception and satisfaction evaluation survey was distributed to the participants.

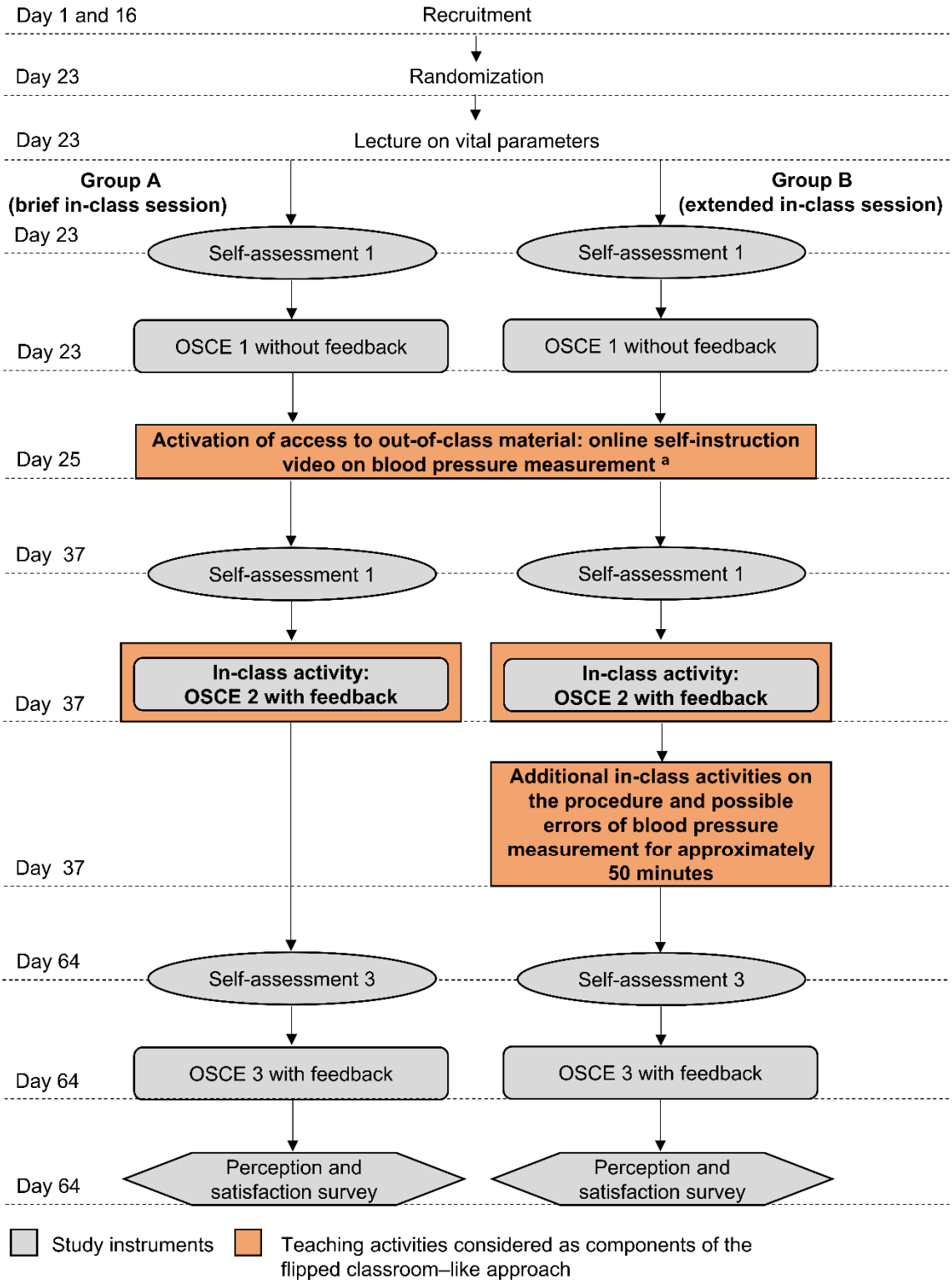

Figure 4-1: Overview of the Study Design of the Flipped Classroom–Like Approach Study

OSCE = objective structured clinical examination. [a] The video access was activated on day 25 and was accessible from this time onward during the complete study for both groups.

4.2.3 Flipped Classroom Approach

The blended learning approach in the format of a flipped classroom–like setting was developed and aimed to convey blood pressure measurement skills to pharmacy students. It was composed of an out-of-class activity, in which a self-instruction video was used for both groups, and an in-class session of an extent dependent on the group.

4.2.3.1 Out-of-Class Activity

In both study groups, the self-made self-instruction video (development described in chapter 2), customized for pharmacy students, with a total length of 11 minutes and 33 seconds was provided to the participants. The duration minimally deviates from that used in the “SIV Versus FTFI Study” (chapter 3), as the video was slightly modified for this study. The video was meant to give pharmacy students a guide on how to measure the patient’s blood pressure accurately with an oscillometric upper arm device in a community pharmacy setting using a role-play format along with descriptive slides as a self-learning tool.[233] The video was provided on the university’s video platform “hhu mediathek.” The students of both groups were provided with a link and could access the video via student identification data on-demand. The video access was activated after assessment 1 on day 25 and was accessible from this time onward during the complete study for both groups. Consequently, the SIV could be used as preparation for assessment 2 as well as for assessment 3. The participants had the possibility to watch the SIV multiple times, at any time, and pause, replay, and rewind the video according to their preferences. Data regarding participants’ video access was recorded by the university’s multimedia center.

4.2.3.2 In-Class Session

Group with Brief in-Class Session (Group A)

The in-class session of group A consisted of a single hands-on exercise in the form of OSCE 2 (further described in section 4.2.4.1) at assessment 2 and immediate rater feedback.

Group with Extended in-Class Session (Group B)

The extended in-class session of group B (intervention group) consisted of OSCE 2 with immediate rater feedback, equivalent to that of group A (control group). However, group B received additional instructor-guided in-class activities for approximately 50 minutes following assessment 2. For that purpose, 2 instructors and the participants of the intervention group met in a lecture hall. The additional in-class activities started with an assignment in the "thinking-pairing-sharing" format followed by a video case. The thinking-pairing-sharing assignment was based on Frank Lyman's concept and is a cooperative discussion strategy.[281] The topic of this assignment was potential sources of inaccuracies for the oscillometric as well as auscultatory upper arm blood pressure measurement. At first, each participant was supposed to think about the question individually for approximately 10 minutes. Thereafter, the participants were told to form groups of 2 and discuss the question with their partner for approximately 5 minutes. Finally, the participants were required to share their assumptions with the plenum by raising their hands. During the approximately 20-minute sharing phase, an instructor corrected and/or discussed the participants' solutions, if necessary, and recorded them on the chalkboard. As a

second assignment, the participants of group B watched a video (via 1 screen in the lecture hall), made for this study, of oscillometric upper arm blood pressure measurement in a community pharmacy, with intentional mistakes in the procedure. The participants were asked to identify mistakes in the measurement procedure and share them with the plenum. The video case had a duration of approximately 10 minutes and the subsequent discussion lasted approximately 5 minutes.

4.2.4 Instruments

For the 2 flipped classroom–like approaches, comprehensive evaluation methods to assess the usefulness and perception were applied. In addition to an OSCE checklist on the OSCE performance of the participants, a self-assessment survey and a perception and satisfaction survey were used.

4.2.4.1 Objective Structured Clinical Examination

Participants' blood pressure measurement skills were evaluated by OSCEs. In all 3 assessments (A1 to A3), the OSCE consisted of 1 station with the same case at each assessment, in which each participant was required to take over the role of a pharmacist and perform proper blood pressure measurement for an adult SP with an oscillometric upper arm device, pretending to be located in a community pharmacy. During the OSCE encounter, 1 blood pressure monitor (OMRON M5-Professional HEM-7001-D; the device did not have the function to perform automatically multiple readings with 1 activation), 1 measuring tape, 3 different cuff sizes, and writing utensils were provided. The OSCE encounter started with

a pre-encounter phase, in which the participants had the possibility to read the participant instruction (Appendix 6), describing the task, followed by an encounter phase of a maximum of 12 minutes in which the participants were required to perform the task of blood pressure measurement. If the participant recommended a rest period to the patient, this period was simulated due to time restrictions. In each OSCE encounter, 1 participant, 1 SP, and 1 rater attended. The roles of SPs were performed voluntarily by a pool of 8 students of their final semester of pharmacy studies, who did not participate in the study, and 5 faculty members. The SPs were provided with a script to standardize the role of the SP and were briefed on their task. Four other faculty members assumed the role of raters and assessed students' blood pressure measurement performances by an OSCE checklist. Before the first assessment, 1 of the raters had trained the other raters on their task.

4.2.4.2 OSCE Checklist

The participants' performance of blood pressure measurement was assessed by OSCE 1, OSCE 2, and OSCE 3, with each participant being assessed by a rater filling in a checklist. The OSCE checklist, taken from the previous "SIV Versus FTFI Study" (chapter 3), was slightly modified and still consisted of 37 items divided into the sections "general preparation of blood pressure measurement," "rest period," "steps of blood pressure measurement," and "documentation." The checklist is depicted in Appendix 7. The checklist items were weighted equally with 1 point being awarded if the respective item was fulfilled correctly by the participant and 0 points if not, thus a maximum OSCE score of 37 points was achievable. The checklist was based on literature that included, but was not

limited to, the standard operating procedure on blood pressure measurement in the community pharmacy of the ABDA as of 2017,[242] 2018 ESC/ESH guidelines for the management of arterial hypertension,[123] and the 2017 ACC/AHA guideline for the prevention, detection, evaluation, and management of high blood pressure in adults.[125]

4.2.4.3 Self-Assessment Survey

The participants' self-confidence and self-perceived proficiency in their blood pressure measurement skills were assessed by a self-assessment survey (Appendix 8). The self-assessment survey was filled in by each participant shortly before OSCE 1, OSCE 2, and OSCE 3 and consisted of 5 items using a 6-point Likert scale (0 = strongly disagree, 1 = disagree, 2 = rather disagree, 3 = rather agree, 4 = agree, 5 = strongly agree), with a maximum of 25 points. Along with the self-assessment survey, participants' preparation for the blood pressure measurement was collected in each assessment (A1 to A3). Additionally, at assessment 1, participants' demographics including age, gender, additional education as a pharmaceutical technician assistant, and current or former work in a community pharmacy, and data on former experience in blood pressure measurement were collected along with the self-assessment survey.

4.2.4.4 Perception and Satisfaction Survey

Participants' perception of and satisfaction with the seminar were evaluated by a survey in which the participants were asked to rate 16 items concerning the seminar by a 6-point Likert scale ["strongly disagree" (*trifft gar nicht zu*);

“disagree” (*trifft nicht zu*); “rather disagree” (*trifft eher nicht zu*); “rather agree” (*trifft eher zu*); “agree” (*trifft zu*)“strongly agree” (*trifft voll zu*). The participants were also asked to rate the seminar series in the flipped classroom format and the self-instruction video based on the German school grading scale from 1 = very good (*sehr gut*) to 6 = insufficient (*ungenügend*). Further, the survey included 4 free-text items (open-ended questions). In the free-text items, they had the option to comment on the aspects they particularly liked regarding the instructional video, what they would suggest changing about the instructional video, the aspects they particularly liked about the seminar series conducted in a flipped classroom format, and what they would suggest changing about seminar series conducted in a flipped classroom format. The comments the students gave on the free-text items were grouped into categories, for analysis.

4.2.5 Statistical Analysis

Data from the OSCE checklist and self-assessment survey including demographics were collected in a pseudonymized way and were anonymized after data analysis. The perception and satisfaction survey was anonymous. Data on participants’ video access was collected by students’ user IDs and was anonymized after analysis. Microsoft Excel[269] was used for data entry, and OriginPro[270] and Microsoft Excel[269] were used for analyses. The participants were randomized to group A or group B using R.[264] A two-sided Mann–Whitney test was applied for baseline comparison of the respective score between the 2 groups. The between-group comparison for the score change from assessment 1 to assessment 2 was likewise conducted using a two-sided Mann–Whitney test for the respective score. A one-sided Mann–Whitney test was

applied to assess whether the increase in the respective score from assessment 2 to assessment 3 was significantly higher in group B (group with extended in-class session) than in group A (group with brief in-class session). A one-sided Mann–Whitney test was applied to assess whether the respective score at assessment 3 was significantly higher in group B than in group A. One-sided Wilcoxon signed-rank tests were used for within-group comparisons. For that purpose the one-sided Wilcoxon signed rank test was applied either to the differences between the assessmet 1 and assessment 2 scores or to the differences between the assessmet 2 and assessment 3 scores for the respective score. Regarding the perception and satisfaction survey, participants' German School grade ratings were analyzed using a two-sided Mann–Whitney test. A significance level of alpha = 0.05 was used and asymptotic *p*-values were considered in the following. The *p*-values were not adjusted for multiple testing.

4.3 Results

Forty-six pharmacy students, who were eligible according to the inclusion criterion and exclusion criterion and who signed the informed consent form, participated in the study, 23 of them were randomized into the group with the brief in-class session (group A) and 23 into the group with the extended in-class session (group B). Of these 46 participants, 5 students from group A and 2 from group B were excluded from analyses due to non-compliance with the predefined standardized setting, incomplete self-assessment survey data, or absence from an assessment time point. Thus, 18 participants in group A and 21 participants in group B were included in the analysis of all data except the perception and satisfaction survey. The perception and satisfaction survey was distributed to participants who attended all 3 assessment time points. Participants who attended all 3 assessments but were excluded from the other analyses due to reasons other than the omission of an assessment time point, could not be excluded due to the anonymous character of the perception and satisfaction survey. Participants' demographics and preparation for OSCE 1, OSCE 2, and OSCE 3 are depicted in Table 4-1.

Table 4-1: Demographics of Participants and Participants' Preparation for OSCEs in the Flipped Classroom–Like Approach Study

	Group A (brief in-class session) (n = 18)	Group B (extended in-class session) (n = 21)
OSCE 1		
1.1 Age in years [a]		
Median (IQR)	24 (4)	23 (3)
Mean (SD)	25.72 (4.53)	24.4 (3.19)
1.2. Gender		
Female, n (%)	12 (66.67)	16 (76.19)
Male, n (%)	6 (33.33)	5 (23.81)
1.3. Training as a pharmaceutical technical assistant		
Yes, n (%)	3 (16.67)	2 (9.52)
No, n (%)	15 (83.33)	19 (90.48)
1.4. Currently working or formerly worked in a community pharmacy [b]		
Yes, n (%)	8 (44.44)	4 (19.05)
No, n (%)	10 (55.56)	17 (80.95)
1.5. Have measured BP by myself for the first time in my life		
Yes, n (%)	3 (16.67)	6 (28.57)
No, n (%)	15 (83.33)	15 (71.43)
1.6. If answered item 1.5 with no: What kind of blood pressure measurement device/s have you already used to measure the BP? [c]		
Upper arm blood pressure measurement device	11 (73.33)	13 (92.86)
Wrist blood pressure measurement device	10 (66.67)	8 (57.14)
Blood pressure measurement device with stethoscope	5 (33.33)	3 (21.43)
1.7. Did you prepare yourself for the BP measurement? [d]		
Yes, n (%)	0 (0)	0 (0)
No, n (%)	18 (100)	20 (100)

[Continuation of Table 4-1]

OSCE2		
2.1. Did you prepare yourself for the BP measurement?		
Yes, n (%)	18 (100)	21 (100)
No, n (%)	0 (0)	0 (0)
2.2. If item 2.1 was answered yes: Did you prepare yourself with the self-instruction video from the university's video platform?		
Yes, n (%)	18 (100)	21 (100)
No, n (%)	0 (0)	0 (0)
2.3. If item 2.1 was answered yes: Did you use any other materials for preparation in addition to the video? [e]		
Yes, n (%)	0 (0)	0 (0)
No, n (%)	18 (100)	21 (100)
OSCE 3		
3.1. Did you prepare yourself for the BP measurement? [f]		
Yes, n (%)	15 (83.33)	19 (90.48)
No, n (%)	3 (16.67)	2 (9.52)
3.2. If item 3.1 was answered yes: Did you prepare yourself with the self-instruction video from the university's video platform? [g]		
Yes, n (%)	15 (100)	18 (94.74)
No, n (%)	0 (0)	1 (5.26)
3.3. If item 3.1 was answered yes: Did you use any other materials for preparation in addition to the video? [e, h]		
Yes, n (%)	0 (0)	0 (0)
No, n (%)	15 (100)	19 (100)

OSCE = objective structured clinical examination; IQR = interquartile range; SD= standard deviation; BP = blood pressure.

[a] Out of n = 20 in group B, as 1 participant of group B did not fill in the item for age. [b] Excluding mandatory traineeship (*Famulatur*) during the pharmacy studies. [c] Although 15 participants of group B answered item 1.5 with "no," only 14 participants of group B responded to item 1.6. In group A, n = 15 for item 1.6. [d] One participant in group B did not respond to item 1.7, resulting in 20 responses in group B for item 1.7. The survey also included item 1.8: "If item 1.7 is answered with yes: How and how long did you prepare for the blood pressure measurement?" As no participant of either group responded "yes," this item is not listed here. [e] The survey at assessment 2 and assessment 3 also included item 2.4 or 3.4, respectively "If item 2.3/3.3 is answered "yes": Which additional materials did you use?" One participant of group A commented on that item for both assessment 2 and assessment 3, that he/she read his/her notes on the video, while

responding to items 2.3 and 3.3 with “no.” [f] In group B, 1 participant responded to item 3.1 with “yes,” while responding to item 3.2 and 3.3 with “no.” [g] For item 3.2, 15 responses were received in group A and 19 responses in group B. [h] In group B, the number of participants for item 3.3 was corrected by the participants, who crossed yes and commented that their additional preparation was the seminar (counted as no).

4.3.1 OSCE Score

At baseline (OSCE 1) the OSCE score did not show a significant difference ($p = 0.380$) between the 2 groups. From A1 (OSCE 1) to A2 (OSCE 2), the OSCE score increased significantly in both groups (group A: $p < 0.001$; group B: $p < 0.001$). Regarding the increase in OSCE score from A1 to A2, there was no significant difference between the 2 groups ($p = 0.213$). The OSCE score increased significantly from OSCE 2 (A2) to OSCE 3 (A3) in both groups (group A: $p = 0.005$; group B: $p < 0.001$). Regarding the change in OSCE score from A2 to A3, there was no significantly higher improvement in group B compared to group A ($p = 0.202$). Finally, after the respective teaching approaches, group A achieved at A3 a median OSCE score of 27.5 points (IQR = 9 points) and a mean OSCE score of 28.06 points (SD = 5.29 points), and group B achieved a median OSCE score of 30 points (IQR = 2 points) and a mean OSCE score of 29.14 points (SD = 3.65 points) out of a maximum of 37 achievable points of the checklist. At A3 the OSCE score in group B was not significantly higher than the OSCE score in group A ($p = 0.351$). Results regarding the OSCE score are detailed in Figure 4-2, Table 4-2, and Table 4-3.

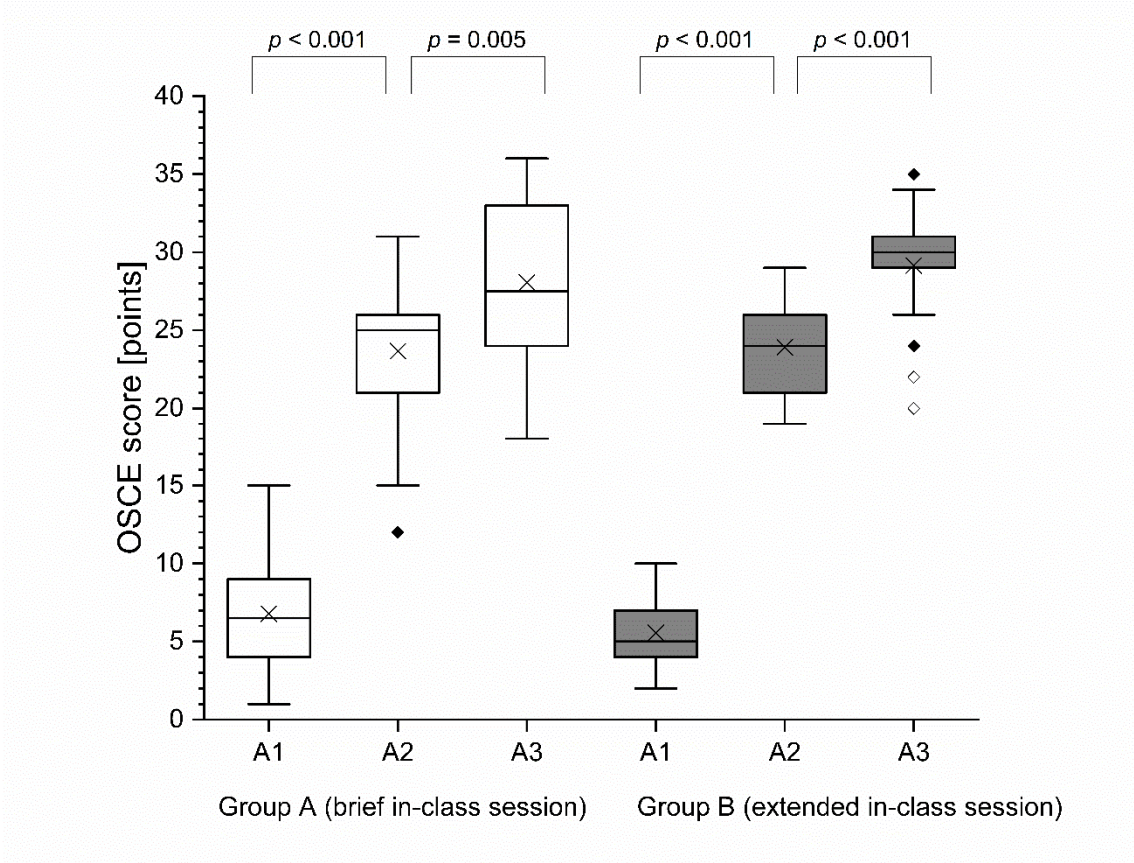

Figure 4-2: OSCE Score of Group A and Group B in the Flipped Classroom–Like Approach Study

Results are depictes as box plots.
black cross (×) = mean; horizontal line = median; black diamond (♦) = outlier; white diamond (◊) = extreme value; OSCE = objective structures clinical examination; A1 = assessment 1; A2 = assessment 2; A3 = assessment 3.

4.3.2 Self-Assessment Score

At baseline (self-assessment survey 1) the self-assessment score between the 2 groups did not show a significant difference (p = 0.488). From A1 (self-assessment survey 1) to A2 (self-assessment survey 2), the self-assessment score increased significantly in both groups (group A: p = 0.002; group B: p < 0.001). Regarding the increase in self-assessment score from A1 to A2, there was no significant difference between the 2 groups (p = 0.178). The

self-assessment score increased significantly from A2 to A3 in both groups (group A: $p = 0.020$; group B: $p < 0.001$). Regarding the change in self-assessment score from A2 to A3, there was no significantly higher increase in group B compared to group A ($p = 0.113$). Finally, after the respective teaching approach, group A achieved at A3 a median self-assessment score of 18.5 points (IQR = 3 points) and a mean self-assessment score of 18.72 points (SD = 2.91 points), and group B achieved a median self-assessment score of 20 points (IQR = 2 points) and a mean self-assessment score of 19.43 points (SD = 2.77 points) out of a maximum of 25 achievable points of the self-assessment survey. At A3 the self-assessment score in group B was not significantly higher than the self-assessment score in group A ($p = 0.261$). Results regarding the self-assessment score are detailed in Figure 4-3, Tables 4-2, and Table 4-3.

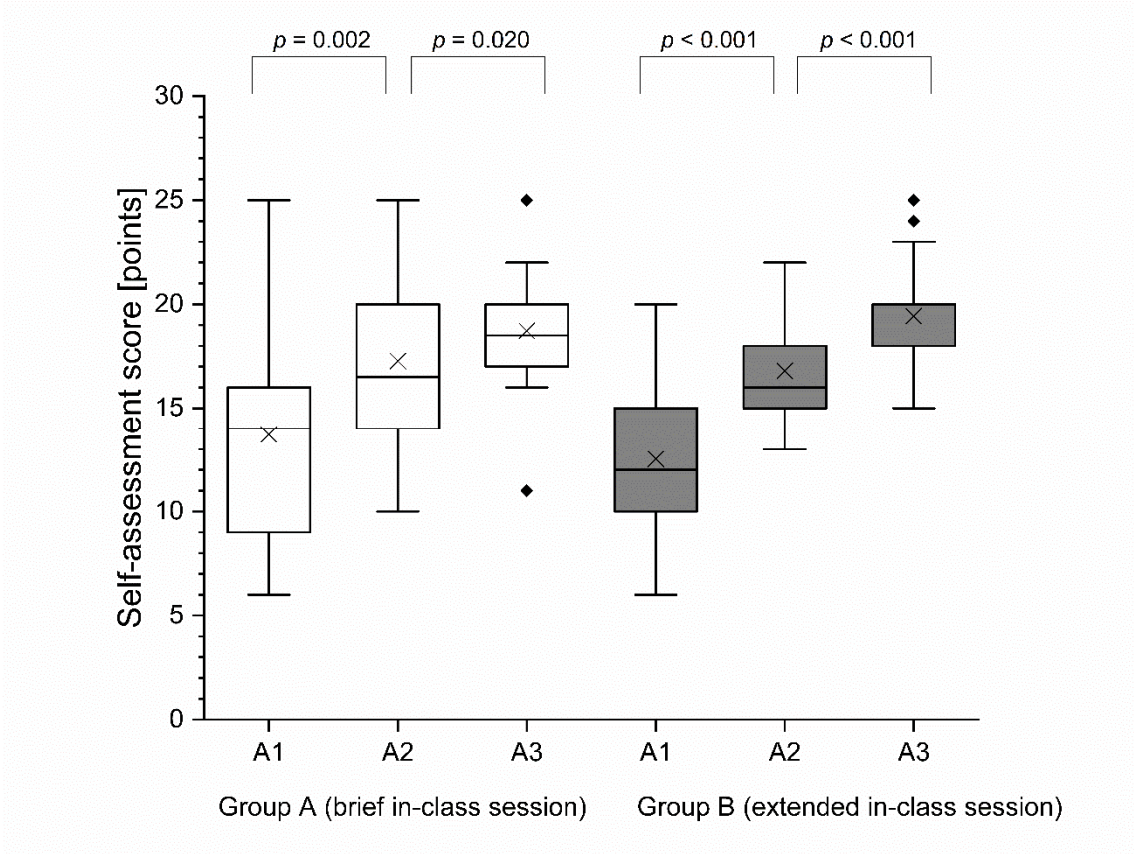

Figure 4-3: Self-Assessment Score of Group A and Group B in the Flipped Classroom–Like Approach Study

Results are depicted as box plots.
black square (×) = mean; horizontal line = median; black diamond (♦) = outlier; A1 = assessment 1; A2 = assessment 2; A3 = assessment 3.

Table 4-2: OSCE Score and Self-Assessment Score per Assessment Time Point of Group A and Group B in the Flipped Classroom–Like Approach Study

Instrument	Group	Score in points at A1		Score in points at A2		Score in points at A3	
		Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)	Mean (SD)	Median (IQR)
OSCE checklist	Group A (brief in-class session) (n = 18)	6.78 (3.92)	6.5 (5)	23.67 (5.22)	25 (5)	28.06 (5.29)	27.5 (9)
	Group B (extended in-class session) (n = 21)	5.57 (2.46)	5 (3)	23.90 (3.46)	24 (5)	29.14 (3.65)	30 (2)
Self-assessment survey	Group A (brief in-class session) (n = 18)	13.72 (5.12)	14 (7)	17.28 (4.16)	16.5 (6)	18.72 (2.91)	18.5 (3)
	Group B (extended in-class session) (n = 21)	12.52 (3.74)	12 (5)	16.81 (2.48)	16 (3)	19.43 (2.77)	20 (2)

OSCE = objective structured clinical examination; A1 = Assessment 1; A2 = Assessment 2; A3 = Assessment 3; SD = standard deviation; IQR = interquartile range.

Table 4-3: Changes in OSCE Score and Self-Assessment Score of Group A and Group B in the Flipped Classroom–Like Approach Study

Instrument	Group	Change in score between A1 and A2 in points		*p*-value [a]	Change in score between A2 and A3 in points		*p*-value [b]
		Mean (SD)	Median (IQR)		Mean (SD)	Median (IQR)	
OSCE checklist	**Group A (n = 18)**	16.89 (3.88)	16.5 (5)	*p* = 0.213	4.39 (5.74)	2 (7)	*p* = 0.202
	Group B (n = 21)	18.33 (4.27)	19 (5)		5.24 (4.07)	5 (6)	
Self-assessment survey	**Group A (n = 18)**	3.56 (4.93)	3 (6)	*p* = 0.178	1.44 (2.64)	1 (4)	*p* = 0.113
	Group B (n =21)	4.29 (3.26)	5 (3)		2.62 (2.50)	2 (3)	

[a] A two-sided Mann–Whitney test with alpha = 0.05 was used to assess whether there is a significant difference in the score change (from A1 to A2) between the 2 groups. [b] A one-sided Mann–Whitney test with alpha = 0.05 was used to assess whether the increase (from A2 to A3) in group B (extended in-class session) is significantly higher as compared to group A (brief in-class session).
A1 = assessment 1; A2 = assessment 2; A3 = assessment 3; Group A = brief in-class session; Group B = extended in-class session; OSCE = objective structured clinical examination; SD = standard deviation; IQR = interquartile range.

4.3.3 Perception and Satisfaction Survey

In total, 38 participants returned the perception and satisfaction survey. One survey was excluded because its group allocation was not clearly evident. Thus, 21 surveys from the group with brief in-class session (group A) and 16 from the group with extended in-class session (group B) were included in the analysis. As not all of these participants filled in the survey completely, the total number of responses varied depending on the item. Generally, the majority of both groups indicated to some extent interest (rather agree, agree, or strongly agree) in the seminar series on blood pressure measurement (item 1). All participants of both groups agreed to some extent (rather agree, agree, or strongly agree) that they feel better prepared for performing correct blood pressure measurement on a real patient in the community pharmacy after the seminar series. The SIV was rated with a mean German school grade of 1.90 (SD = 0.89) and a median of 2 (IQR = 1) by group A (n = 21); and a mean German school grade of 1.88 (SD = 0.72) and a median of 2 (IQR = 0.5) by group B (n = 16) with no significant difference between the 2 groups (p = 1). The seminar series in the format of flipped classroom model was rated with a mean German school grade of 2.3 (SD = 1.22) and a median of 2 (IQR = 1.5) by the group with the brief in-class session (n = 20); and a mean German school grade of 2.44 (SD = 1.03) and a median of 2 (IQR = 1) by the group with the extended in-class session (n = 16), with no significant difference between the 2 groups (p = 0.519). Further results regarding the perception and satisfaction survey are depicted in Tables 4-4 and 4-5.

Table 4-4: Results of the Perception and Satisfaction Survey of the Flipped Classroom–Like Approach Study

	Proportion of responses, n (%)					
	Strongly disagree	**Disagree**	**Rather disagree**	**Rather agree**	**Agree**	**Strongly agree**
1. I found the seminar series on BP measurement interesting.						
Group A; n = 21	0 (0)	1 (4.76)	2 (9.52)	6 (28.57)	7 (33.33)	5 (23.81)
Group B; n = 16	0 (0)	0 (0)	2 (12.5)	5 (31.25)	6 (37.5)	3 (18.75)
2. During the OSCEs/simulations, I was able to determine my strengths and weaknesses in BP measurement.						
Group A; n = 21	0 (0)	0 (0)	1 (4.76)	3 (14.29)	6 (28.57)	11 (52.38)
Group B; n = 16	0 (0)	0 (0)	0 (0)	0 (0)	9 (56.25)	7 (43.75)
3. The OSCEs/simulations enabled me to apply my knowledge and skills that I gained during the instructional video and the in-class phase.						
Group A; n = 21	0 (0)	0 (0)	0 (0)	2 (9.52)	13 (61.90)	6 (28.57)
Group B; n = 16	0 (0)	0 (0)	0 (0)	0 (0)	10 (62.5)	6 (37.5)
4. After this seminar series, I feel better prepared for the correct BP measurement in the community pharmacy on real patients.						
Group A; n = 21	0 (0)	0 (0)	0 (0)	0 (0)	11 (52.38)	10 (47.62)
Group B; n = 16	0 (0)	0 (0)	0 (0)	3 (18.75)	5 (31.25)	8 (50)

Flipped Classroom–Like Approach Study
–Results–

[Continuation of Table 4-4]

5. The instructional video was helpful in conveying knowledge about measuring BP.						
Group A; n = 21	0 (0)	0 (0)	1 (4.76)	3 (14.29)	8 (38.10)	9 (42.86)
Group B; n = 16	0 (0)	0 (0)	0 (0)	2 (12.5)	7 (43.75)	7 (43.75)
6. The instructional video was helpful in improving my practical BP measurement skills.						
Group A; n = 21	0 (0)	0 (0)	0 (0)	6 (28.57)	5 (23.81)	10 (47.62)
Group B; n = 16	0 (0)	0 (0)	0 (0)	4 (25)	6 (37.5)	6 (37.5)
7. I had technical problems accessing or playing the instructional video.						
Group A; n = 20	17 (85)	1 (5)	0 (0)	1 (5)	1 (5)	0 (0)
Group B; n = 16	14 (87.5)	2 (12.5)	0 (0)	0 (0)	0 (0)	0 (0)
8. The in-class phase was helpful to improve my understanding of BP measurement.						
Group A; n = 20	0 (0)	0 (0)	1 (5)	3 (15)	10 (50)	6 (30)
Group B; n = 16	0 (0)	2 (12.5)	1 (6.25)	5 (31.25)	6 (37.5)	2 (12.5)
9. The in-class phase was helpful in improving my practical BP measurement skills.						
Group A; n = 21	0 (0)	0 (0)	1 (4.76)	3 (14.29)	8 (38.10)	9 (42.86)
Group B; n = 16	0 (0)	3 (18.75)	1 (6.25)	3 (18.75)	6 (37.5)	3 (18.75)

Flipped Classroom–Like Approach Study
–Results–

[Continuation of Table 4-4]

10. I prefer the instructional video on its own to train the competence of BP measurement.						
Group A; n = 21	3 (14.29)	6 (28.57)	4 (19.05)	4 (19.05)	2 (9.52)	2 (9.52)
Group B; n = 16	1 (6.25)	2 (12.5)	6 (37.5)	2 (12.5)	3 (18.75)	2 (12.5)
11. I prefer the active in-class phase on its own to train the competence of BP measurement.						
Group A; n = 21	3 (14.29)	6 (28.57)	4 (19.05)	6 (28.57)	2 (9.52)	0 (0)
Group B; n = 16	2 (12.5)	4 (25)	6 (37.5)	3 (18.75)	1 (6.25)	0 (0)
12. I prefer the combination of instructional video with the active in-class phase undertaken in this study to train the competence of measuring BP.						
Group A; n = 21	0 (0)	1 (4.76)	2 (9.52)	3 (14.29)	10 (47.62)	5 (23.81)
Group B; n = 16	0 (0)	1 (6.25)	1 (6.25)	5 (31.25)	4 (25)	5 (31.25)
13. In the future, instructional videos should be included in pharmacy teaching.						
Group A; n = 21	0 (0)	1 (4.76)	1 (4.76)	2 (9.52)	9 (42.86)	8 (38.10)
Group B; n = 16	0 (0)	0 (0)	0 (0)	2 (12.5)	9 (56.25)	5 (31.25)
14. OSCEs/simulations about BP measurement are superfluous because one can do nothing wrong with the BP measurement.						
Group A; n = 21	13 (61.90)	5 (23.81)	3 (14.29)	0 (0)	0 (0)	0 (0)
Group B; n = 16	13 (81.25)	3 (18.75)	0 (0)	0 (0)	0 (0)	0 (0)

Flipped Classroom–Like Approach Study
–Results–

[Continuation of Table 4-4]

15. In the future, OSCEs/simulations should be included as a firm part of the clinical pharmacy course to train practical skills (such as BP measurement).						
Group A; n = 21	0 (0)	1 (4.76)	1 (4.76)	4 (19.05)	11 (52.38)	4 (19.05)
Group B; n = 16	0 (0)	0 (0)	0 (0)	5 (31.25)	4 (25)	7 (43.75)
16. In the future, the “flipped classroom model” should be included in pharmacy teaching.						
Group A; n = 21	1 (4.76)	2 (9.52)	3 (14.29)	9 (42.86)	5 (23.81)	1 (4.76)
Group B; n = 15	0 (0)	0 (0)	3 (20)	5 (33.33)	4 (26.67)	3 (20)

BP = blood pressure, OSCE = objective structured clinical examination; Group A = brief in-class session; Group B = extended in-class session.

Table 4-5: Examples of Topics of Comments on Free-Text Items of the Perception and Satisfaction Survey in the Flipped Classroom–Like Study

Free-text item	Group	Topics
What did you particularly like about the instructional video?	Group A (brief in-class session)	• Comprehensible and/or clear and/or detailed video • Realistic depiction • The actors
	Group B (extended in-class session)	• Combination of video and slides • Comprehensible and/or clear and/or structured video • Depiction of pharmacist interacting with patient
I would change the following about the instructional video:	Group A (brief in-class session)	• The written slides should be narrated • A "problem patient" should be additionally depicted • Shortening the video
	Group B (extended in-class session)	• The video had too many hiatuses • The sound quality should be improved • A "problematic patient should be additionally depicted"
What did you particularly like about the seminar series in the "flipped classroom model"?	Group A (brief in-class session)	• Practical application • Repeating several times to consolidate knowledge • Possibility to watch the video at your own pace
	Group B (extended in-class session)	• Practical application • Linking of theory and practice • No required attendance during the self-learning phase (out-of-class activities)
I would change the following about the seminar series in the "flipped classroom model":	Group A (brief in-class session)	• Better time management for in-class activities • General request for more practical OSCEs like that for training purposes (without grading) • Too fast
	Group B (extended in-class session)	• Better time management • Smaller group size and room size during the additional in-class activities regarding the potential mistakes • Additional in-class activities regarding the potential mistakes were not particularly helpful

The 3 most frequent topics of comments are presented for each item per group. If topics appeared with equal frequency, one topic was chosen. In Appendix 9 further topics are depicted.

4.3.4 Video Access

Data regarding the video access provided by the multimedia center were inconsistent. Nevertheless, for analysis, a total of 103 video hits was used, which was most traceable by additional details provided in the report. Thus, the analysis was carried out based on 103 video hits. Subsequent excluding of the 7 excluded participants and access by website administrator resulted in 83 video accesses. Before the second OSCE (A2), each participant had accessed the video at least 1 time (video access mean = 1.69; SD = 0.77) (video access median = 2; IQR = 1). For the third OSCE (A3), the video was not accessed by every participant, leading to a mean video access of 0.44 (SD = 0.60) (median video access = 0; IQR = 1). In particular, for the third OSCE, 5 students of group A had accessed the video once, and 1 student of group A twice. In group B, 8 students had accessed the video once and 1 student of group B twice. These numbers should be taken with caution as they could include for example instances of participants only clicking on the video without watching it and/or watching parts of the video multiple times. Furthermore, students might have taken notes on the video and read their notes instead of rewatching the video or several students might have watched the video via one student user ID. These aspects might also be a reason why the counts of video views self-reported by the students (Table 4-1) do not comply with this video access data. A further reason for the deviation between the access data in Table 4-1 and the data collected by the multimedia center might be that in Table 4.1 data is based on self-reported data by the students, which might be subject to bias.

4.4 Discussion

This study developed an effective teaching approach for conveying blood pressure measurement skills to pharmacy students. This study contributes to the literature by providing data on effective and adequate teaching approaches for blood pressure measurement, as suggested in the literature.[216] A blended learning approach that combines a valuable self-instruction video with a hands-on exercise in the form of an OSCE and subsequent rater feedback in a flipped classroom–like setting allowed students to acquire comprehensive blood pressure measurement skills. However, the hypothesis proposed above in section 4.1, was not supported by the present results, as the additional in-class activities did not result in a significantly higher increase in participants' blood pressure measurement skills or self-confidence/self-perceived proficiency as compared to the group with brief in-class session. The flipped classroom approaches were predominantly well accepted in the surveyed students.

In this study, it was found that the blended learning approach consisting of a self-instruction video and hands-on exercise with feedback in a flipped classroom–like setting was optimal to improve pharmacy students' blood pressure measurement skills. Both the brief and the extended in-class strategy led to a significant increase in blood pressure measurement performance from OSCE 2 to OSCE 3, with no significantly higher improvement in the group with the extended in-class session compared to the group with the brief in-class session. Based on these results, it is suggested that an in-class session comprising a hands-on exercise on blood pressure measurement in the form of an OSCE with feedback, in combination with a self-instruction video as out-of-class activity, in the scope of a flipped classroom–like approach was sufficient to

convey blood pressure measurement skills to pharmacy students. Additional in-class activities on potential sources of inaccuracies in blood pressure measurement did not improve students' performance significantly further. Moreover, this result underlines the importance and benefit of feedback for students to foster clinical skills as described in the literature.[282-287] With the omission of the additional in-class activities, the developed flipped classroom–like approach is efficient, as it leads to saving time and staff while maintaining comparable outcomes.

The "Flipped Classroom–Like Approach Study" contributes to the previous literature regarding flipped classroom–like approaches on blood pressure measurement.[16,280] as in the design of the present study, 2 flipped classroom–like approaches were compared. Prescott et al compared a traditional approach and a blended-learning model consisting of a flipped classroom format for pharmacy students in a patient assessment course, in which blood pressure assessment was 1 of the topics. They found that the blended learning model group performed better in blood pressure assessment than the traditional course group.[16] Bachur et al found that after undergoing a class with active methodologies as a teaching strategy in the scope of an inverted classroom model, the physiotherapy and medical students' knowledge on and performance in blood pressure measurement improved significantly.[280] The focus in Bachur and colleagues' study was on active learning activities in the class rather than the pre-class session. In their study, they applied a single-group design with pre-post-assessment without a control group.[280] In contrast to that, the "Flipped Classroom–Like Approach Study" of this work, aimed to compare 2 in-class strategies in the scope of a flipped-classroom–like approach in pharmacy

students by using 2 groups and in a pre-post-design. The design of the study of this dissertation complements previous approaches in the literature and contributes to research in the context of flipped classroom approaches. A literature search found no study comparing different in-class strategies of a flipped classroom approaches for teaching blood pressure measurement skills in pharmacy students. Both, Bachur and colleagues'[280] and the approaches described in the "Flipped Classroom–Like Approach Study" achieved comparable post-training scores in blood pressure measurement performance (67.48% Bachur et al vs a median of 74.32% or mean of 75.83% in group A of the here presented study). In the "Flipped Classroom–Like Approach Study," the hands-on in-class activity in the form of OSCE 2 was conducted by every student individually, but with instructor–student interaction as the students were provided with feedback by the instructor. Moreover, further interaction was present as the student performed blood pressure measurement on an SP who was either a peer or faculty member. The additional in-class activity in group B of the "Flipped Classroom–Like Approach Study" comprised instructor-guided activities as well as working in pairs. Consequently, the in-class activities of both groups in the present study included active learning and were interactive, which might be a factor contributing to the efficacy of the flipped classroom–like approaches applied in this work, as research indicates that active learning is a pivotal factor for the efficacy of flipped classroom approaches.[70]

It is frequently discussed that 1 important premise for the flipped classroom to be effective is that the students use the provided pre-class activities.[73,96,288,289] In the literature, the use of graded in-class quizzes or graded homework as incentives for engaging with pre-class materials is discussed.[94,288,290] Although the second

OSCE (as well as the first and third OSCE) in the “Flipped Classroom–Like Approach Study” had a low-stakes character with students’ performance having no impact on passing this course, knowing that OSCE 2 would be executed might have incited the participants to engage with the self-instruction video. Finally, it was found that, for OSCE 2, the video was accessed in mean 1.69 times per participant. However, data regarding participants’ video access should be taken with caution, as they could include instances of participants only clicking on the video without watching it and/or watching parts of the video multiple times. Furthermore, students may have taken notes while watching the video the first time and read their notes instead of watching the video again. Moreover, at the time of collection of video access data, this data collection service was no regularly implemented at the multimedia center of Heinrich Heine University.

The extent of the required training time might depend on the complexity of the clinical skill meant to be conveyed and on the experience of the learner (novice or expert). For example, Szyld et al investigated a self-directed video-based teaching approach in groups including practice on mannequins for neonatal resuscitation skills in novice learners compared to the same teaching approach but with an instructor present facilitating te the teaching.[34] Although the self-directed approach was non-inferior to the instructor-facilitated approach they indicated that a 2-hour training (including a 20-minute instruction video) appeared insufficient to appropriately perform basic neonatal resuscitation.[34] Therefore the practice time or sessions appears to be not generalizable for clinical skills.

Regarding the students’ self-confidence and self-perceived proficiency, the self-assessment score increased significantly from OSCE 1 to OSCE 2 as well as from OSCE 2 to OSCE 3 in group A. Also in group B, the self-confidence/self-

perceived proficiency increased significantly from OSCE 1 to OSCE 2 as well as from OSCE 2 to OSCE 3. This indicates that the out-of-class activity, as well as the in-class session of both groups, contributed to the promotion of the students' self-confidence and self-perceived proficiency. However, additional activities on typical errors in blood pressure measurement (in group B, with extended in-class session) did not improve students' self-confidence significantly further when compared to group A. These findings imply that the chosen format of the extended in-class session was not superior in terms of participants' self-confidence/self-perceived proficiency and that the brief in-class session is already effective. This indicates that simulation in the form of OSCEs and feedback are helpful to build up confidence in clinical skills. Generally, the positive impact of the flipped classroom approach on students' self-confidence was also reported in a pre- to post-comparison by Liu and colleagues.[80]

The perception and satisfaction survey revealed that the flipped classroom–like approach applied in the study of this dissertation was predominantly well received among the students. Both, the group with the brief in-class session (71.43%) and the group with the extended in-class session (80%) agreed to some extent (rather agree, agree, or strongly agree) that the flipped classroom model should be incorporated in future pharmacy education. The remaining proportion of participants who seemed to show reluctance might have considered the out-of-class material (SIV) as extra work and increasing their workload. Such an attitude is also indicated in the literature.[83,98,291] Moreover, students might need time to adjust to the new teaching modality.[292]

In the present "Flipped Classroom–Like Approach Study," the participants of both groups had unlimited access to the video during the entire study. That strategy

resulted in the participants accessing the video a mean number of 1.69 times. In contrast, the participants of the SIV group in the “SIV Versus FTFI Study” had a limited time frame of approximately 15 minutes to watch a minimally different video. It can be conjectured that the significant improvement in blood pressure measurement skills from OSCE 1 to OSCE 2 in both groups in the “Flipped Classroom–Like Approach Study” might have been reinforced by the unlimited access to the video that enabled students to learn everywhere, every time, and multiple times. With the limited time to watch the video, the participants in the SIV group of the “SIV Versus FTFI Study” reached a median OSCE score of 55.41% (IQR = 13.51%) of the maximum achievable points in OSCE 2 (post-instruction OSCE), whereas in the “Flipped Classroom–Like Approach Study,” when considering the participants of both groups, a median OSCE score of 67.57% (IQR = 13.51%) of the maximum achievable points was achieved in OSCE 2. This implies that unlimited access to a self-instruction video might be conducive to acquiring practical skills and subsequent student performance and might be necessary to draw the maximum benefit of that tool. Regarding the participants’ self-confidence/self-perceived proficiency, the limited time to watch the video, the participants in the SIV group of the “SIV Versus FTFI Study” reached a median self-assessment score of 70% (IQR = 12%) of the maximum achievable points in OSCE 2 (post-instruction OSCE), whereas in the “Flipped Classroom–Like Approach Study,” when considering the participants of both groups, a median OSCE score of 64% (IQR = 20%) of the maximum achievable points was achieved in OSCE 2. This indicates that unlimited video access might not enhance self-confidence. When interpreting the comparison between the studies

of this dissertation, it should be noted that the video and checklist minimally differed between the 2 studies.

The approach investigated in this study required the physical attendance of students and instructors simultaneously during the in-class session. Another possible approach might be to set up this seminar completely in a distance education design, which is highly relevant during the COVID-19 pandemic.[44-46] For that purpose, given that the students are provided with the equipment, each student could record their execution of the respective skill wherever convenient to them and the instructor could evaluate and provide feedback either synchronously or asynchronously. Moreover, this might be an option to retrain pharmacists in their community pharmacy environment. However, the efficacy of the method and the students' satisfaction need to be evaluated before implementation.

Some refinements regarding the educational video made for this dissertation might be done in further educational videos. In terms of an educational video's interactivity, interactive and guiding questions to foster active learning might be integrated,[243] where appropriate. Furthermore, in the self-instruction video of this work, chapter slides were used to positively impact active learning and to reduce cognitive overload. However, it might be more favorable if interactive features, for example, "click-forward pauses,"[243] or "hyperlinked index"[237] had been used to navigate between segments. Moreover, some students who watched the video in the scope of the "SIV Versus FTFI Study" suggested adding a narrative voice to the descriptive slides[234] which was also mentioned by some students of the present "Flipped Classroom–Like Approach Study." Therefore, adding voiceover might enhance such videos further.

In this study as well as in the "SIV Versus FTFI Study," the focus of the investigation was on conveying blood pressure measurement skills. The next step is to counsel and advise the patient appropriately regarding their obtained blood pressure. Regarding community pharmacy blood pressure (CPBP) measurements, the blood pressure threshold for interpretation is highly discussed in the literature.[208,219,293] For example, Albasri et al proposed based on their meta-analysis that "CPBP may be best interpreted using daytime ABPM thresholds for hypertension diagnosis and management," meaning that a threshold of 135/85 mm Hg for blood pressure measurements taken in a community pharmacy may be used for referring a patient to a physician.[293] However, the authors highlight that the primary data used was inconclusive and they call for caution.[293] On the other hand, the blood pressure screening and referral guideline worksheets for the community pharmacy setting published in 2020 by the ABDA are based on the office blood pressure thresholds of the 2018 ESC/ESH guidelines.[208] The lower threshold of 135/85 might however lead to increasing the workload of physicians due to over-referral, further research should investigate the most effective referral approach.[293]

The present "Flipped Classroom–Like Approach Study" has some limitations, including intra- and interrater variability which could potentially have influenced the results bidirectionally. It was intended to reduce these variabilities by training the raters beforehand and having each participant be assessed by the same rater for all OSCE assessments. Moreover, for performance evaluation, the raters used a checklist with items described in detail. Due to these measures, it can be conjectured that the impact of these limitations on the OSCE performance was low. Moreover, variations in the SPs' acting performance may have occurred. It

was aimed to standardize the actors' performance by briefing the SPs and providing a script. Therefore, the impact of this potential bias on the OSCE performance is deemed negligible. It was aimed to reduce a potential "contamination" (exchanging materials or information regarding the study groups) between the study groups[276] by instructing the participants to not disclose information regarding the OSCEs and the activities. Nevertheless, it cannot be completely excluded that information might have been exchanged between the study groups. Moreover, both the "SIV Versus FTFI Study" and "Flipped Classroom–Like Study" were conducted during the clinical pharmacy course, consequently, also other seminars and classes took place that might had an impact. It was intended to control this limitation by a control-group design. Furthermore, it might be that students exchanged information between semesters and consequently between the 2 studies. However, when looking at the OSCE 1 scores between the 2 studies, the scores appear to be rather comparable, which indicates that the occurrence of this limitation might had been low. A possible challenge of educational research discussed in the literature is the Hawthorne effect.[294,295] Schanzenbach outlines that participants might "exert extra effort" due to their knowledge of being evaluated which might affect the measurement outcomes of the study.[294] Boet et al explain that "assessing the impact of the Hawthorne effect on one's research work is difficult, but researchers need to acknowledge its potential presence."[295]

4.5 Conclusion

In this study, the use of both flipped classroom–like approaches improved pharmacy students' blood pressure measurement performance and increased students' self-confidence and self-perceived proficiency in their blood pressure measurement skills. Furthermore, the findings indicate that in the case of acquiring oscillometric blood pressure measurement skills, an SIV combined with a brief in-class session consisting of a hands-on exercise in the form of an OSCE plus feedback was sufficient.

4.6 Disclosure

Parts of this chapter were previously published as: Farahani S, Farahani I, Deters MA, Schwender H, Burckhardt BB, Laeer S. Blended learning on blood pressure measurement: investigating two in-class strategies in a flipped classroom-like setting to teach pharmacy students blood pressure measurement skills. *Healthcare (Basel)*. 2021;9 (7):822. doi:10.3390/healthcare9070822. The author of this dissertation had a lead role in and substantially contributed to the conceptualization, methodology, investigation, project administration, formal analysis, visualization, writing - original draft, writing - review and editing.

and

Farahani S, Farahani I, Burckhardt BB, Monser K, Laeer S. The development of an educational video on blood pressure measurement for pharmacy students. *Adv Med Educ Pract*. 2021;12:655-663. doi:10.2147/AMEP.S302728. The author of this dissertation had a lead role in and substantially contributed to the conceptualization, investigation, methodology, project administration, writing - original draft, writing - review and editing.

5. Overall Discussion and Perspective

This dissertation promotes the thoughtful and evidence-based use of digital tools, in particular video-based approaches for teaching clinical skills in clinical pharmacy education in Germany using the example of teaching blood pressure measurement skills. In this work, an instructional video on oscillometric upper arm blood pressure measurement was developed. The impact of that instructional video applied as a self-instruction video was first evaluated in comparison to face-to-face instruction in a randomized controlled study among pharmacy students. Because the findings indicated that the SIV as a standalone educational approach left room for improvement in pharmacy students' blood pressure measurement skills, the SIV approach was further elaborated into 2 blended learning approaches in a flipped classroom–like setting that varied in the extent of in-class session, and the impact of the 2 flipped classroom–like approaches was evaluated in a randomized 2-group study among pharmacy students. Finally, with the blended learning approach including an SIV and brief in-class session, an effective video-based teaching strategy for conveying blood pressure measurement skills to pharmacy students was developed and evaluated, covering the topics underlined by the WHO, namely “patient preparation, cuff selection, and BP measurement technique.”[214] Furthermore, with the Lancet Commission on Hypertension Group stating “[r]esearch is needed to identify the best methods of delivering training” for blood pressure measurement, this work contributes to closing the gap of investigations regarding proper blood pressure measurement teaching approaches.[216]

A strength of the studies conducted in the scope of this dissertation is that a broad range of outcomes was assessed. In particular, both studies collected data on

students' performance in blood pressure measurement and their self-confidence/self-perceived proficiency before and after the teaching approaches, as well as their perception of and satisfaction with the respective teaching approaches. This broad range of collected outcomes enabled an intensive assessment of the SIV as a standalone teaching tool as well as the flipped classroom–like approaches.

Due to COVID-19 restrictions in terms of in-person classes,[263] the blended learning approach evaluated in the "Flipped Classroom–Like Approach study" could not be offered to the students after completing investigations. However, blood pressure measurement teaching of pharmacy students could be maintained due to the available SIV. As shown by the "SIV Versus FTFI Study," the SIV is a good alternative to FTFI. Nevertheless, this work demonstrated that the flipped classroom-like approach can improve students' blood pressure measurement skills further. Therefore, for upcoming pharmacy education, when in-person teaching is possible again, blood pressure measurement skills should be conveyed in the flipped classroom–like approach including SIV and OSCEs for training purposes as a hands-on training plus immediate feedback to gain maximal learning effect.

Self-instruction videos similar to the one developed in this work can be a flexible learning tool that can be used whenever and wherever most convenient to the learner.[7,28,50] This is not only of great relevance for students but also for registered community pharmacists or pharmacy interns to offer flexibility with regard to continuing pharmacy education.[296] Investigations report that pharmacists of various working sectors (eg, hospital, government, private pharmacy) feel that the lack of personal time is a major barrier to participate in continuing pharmacy

education.[297-299] In this respect, when self-instruction videos are used online or implemented in e-learning units, the participants save time and costs to travel to the locations of education.[296] Furthermore, the educational providers might save expenditures such as for renting the venue if the educational offerings are provided online.[296] The advantages of an SIV, such as helping to reduce procedural and methodological inconsistencies in skills teaching[23,42,43,40] could also be used as a tool for quality assurance in the scope of the quality management of a community pharmacy to assure consistent high quality among pharmacy staff for various services, including blood pressure measurement. Before implementing SIVs for the respective service, the efficacy should be assessed.

This work evaluated the impact of blended learning in a flipped classroom–like setting using the example of blood pressure measurement. The blended learning approach deemed optimal after the investigation of this dissertation was the combination of SIV as out-of-class material and hands-on exercise in the form of an OSCE plus feedback as in-class session. Blended learning approaches with SIVs and hands-on exercises plus feedback on other clinical skills for pharmacy practice can be a valuable strategy to promote patient-oriented and competency-based education in clinical pharmacy. In this context, a pool of SIVs customized for pharmacy students on clinical skills could be created. Further blended learning scenarios including SIV and hands-on exercise plus feedback, similar to the blended learning approach of this dissertation, could be developed on other health tests that can be conducted in a community pharmacy such as blood glucose measurements and blood lipid measurements.[300] Furthermore, screening for atrial fibrillation in a community pharmacy setting, such as the

approach evaluated in a model project in Germany using a hand-held electrocardiogram device,[301] might be a relevant topic. Another objective could be teaching influenza vaccinations. In Germany, pharmacists have recently been allowed to perform influenza vaccinations in the scope of a limited model project.[302] If vaccination is generally legalized for pharmacists, this might be a relevant topic for blended learning scenarios not only for pharmacy students but also for registered pharmacists, in order to efficiently use in-class time for hand-on exercises and feedback and leave knowledge attainment as the responsibility of the learner by provided self-instruction videos. For these new topics, the efficacy should be also studied before broad application.

Although this work was initiated prior to the COVID-19 pandemic before online learning as a possibility for remote teaching and learning gained large awareness, generally, this pandemic with its in-person teaching restrictions can be seen as an accelerator for digital teaching.[303] When face-to-face education is possible again without restrictions, it is important that educators and policymakers leverage the available infrastructure and awareness to sustainably implement digital education in a thoughtful manner to promote competency-based and patient-oriented education in pharmacy.

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2. Farahani I, Farahani S, Deters MA, Schwender H, Laeer S. Efficacy of an objective structured clinical examination training approach for training pharmacy students in diabetes mellitus counseling: a randomized controlled trial. *Pharmacy (Basel)*. 2020;8(4):229. doi:10.3390/pharmacy8040229

3. Farahani I, Farahani S, Deters MA, Schwender H, Laeer S. Training pharmacy students in self-medication counseling using an objective structured clinical examination–based approach. *J Med Educ Curric Dev*. 2021;8:1-9. doi:10.1177/23821205211016484

4. Farahani S, Farahani I, Burckhardt BB, Monser K., Laeer S. The development of an educational video on blood pressure measurement for pharmacy students. *Adv Med Educ Pract*. 2021;12:655-663. doi:10.2147/AMEP.S302728

5. Farahani S, Farahani I, Deters MA, Schwender H, Burckhardt BB, Laeer S. Blended learning on blood pressure measurement: investigating two in-class strategies in a flipped classroom-like setting to teach pharmacy students blood pressure measurement skills. *Healthcare (Basel)*. 2021;9(7):822. doi:10.3390/healthcare9070822

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8. Appendix

Appendix 1: Participant Instruction of the SIV Versus FTFI Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Information für Apotheker	
Aufgabenstellung	Bitte messen Sie den Blutdruck des Patienten/ der Patientin.
Information zum Gerät	Es liegt Ihnen ein validiertes Messgerät mit einem Gütesiegel der Deutschen Hochdruckliga vor, welches vor einem Jahr erfolgreich einer messtechnischen Kontrolle unterzuzogen wurde.
Zeit	Maximal 10 Minuten
Ort	Apotheke
Der Patient	
Alter	28 Jahre

Appendix 2: Checklist of the SIV Versus FTFI Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Checkliste Blutdruckmessung in der Apotheke

Teilnehmercode: _____

Datum: _____

Uhrzeit: von _____ bis _____

Beobachter: _____

Gerätetyp: _____

Zutreffendes bitte ankreuzen. Nichtzutreffendes nicht ankreuzen. Bei Unklarheiten bitte kommentieren.

Auszuführender bzw. zu überprüfender Schritt	Erledigt	Kommentare
Allgemeine Vorbereitungen zur Blutdruckmessung		
Der Prüfling fragt nach **außergewöhnlicher körperlicher Belastung.**		
Der Prüfling fragt nach **außergewöhnlicher psychischer Belastung.**		
Der Prüfling fragt, ob bis ca. 1 Stunde vor der Messung koffeinhaltige Getränke, Alkohol oder Nikotin zugeführt wurden oder ob eine Mahlzeit zu sich genommen wurde. (nur vollständige Nachfrage wird bepunktet)		
Der Prüfling fragt den Patienten nach **Vorerkrankungen und Schwangerschaft** oder namentlich nach potentiell einschränkenden Faktoren der Blutdruckmessung wie: Herzrhythmusstörungen, Vorhofflimmern, Herzschrittmacherträger, fortgeschrittenes Stadium einer Schwangerschaft oder nach Herzerkrankungen, Schwangerschaft**.** (in den letzten beiden Fällen sind alle Umstände vom Prüfling zu nennen. Bitte notieren, was genau gefragt wird).		
Der Prüfling befragt den Patienten nach der **Einnahme von Medikamenten.**		
Der Prüfling informiert den Patienten, dass eine **volle Blase** den Blutdruck erhöhen kann und fragt, ob dies jetzt der Fall ist.		

Auszuführender bzw. zu überprüfender Schritt	Erledigt	Kommentare
Der Prüfling fragt den Patienten, ob bei Ihm eine **Rechts/Links-Seiten-Vergleichsmessung** durchgeführt wurde bzw. ob der **Messarm** vom Arzt festgestellt wurde.		
Der Prüfling bittet den Patienten Uhren und **Schmuckgegenstände am Messarm** bzw. beiden Armen abzunehmen, wenn Messarm nicht bekannt. In diesem simulierten Fall ist der Meassarm nicht bekannt.[a]		
Der Prüfling bittet den Patienten den Messarm bzw. wenn Messarm nicht bekannt beide Arme von Kleidungsstücken zu befreien, wobei zurückgeschobene Kleidung den Arm nicht abschnürt. Im simmulierten Fall sind **beide Arme frei zumachen**.		
Der Oberarmumfang bzw. Oberarmumfänge, wenn Messarm nicht bekannt, wird korrekt gemessen bzw. die Markierung an der Manschette des Gerätes wird genutzt. Im vorliegenden Fall sind beide **Oberarmumfänge zu messen.**		
Ruhephase		
Der Prüfling lässt den Patienten **5 Minuten** in sitzender Position entspannen.		
Der Prüfling weist den Patienten darauf hin, dass er die **Beine nicht überkreuzen** soll.		
Der Prüfling bittet den Patienten sich an **die Stuhllehne** zurück zu lehnen.		
Der Prüfling weist den Patienten darauf hin, während der Ruhephase **nicht zu sprechen.**		
Schritte der Blutdruckmessung		
Der Prüfling wählt eine dem tatsächlichen Armumfang **angepasste Blutdruckmanschette** aus.		
Der Prüfling legt die Manschette **am Oberarm** an.		
Bei einer Messung am **linken Arm**: der Teilnehmer legt Manschette so an, dass der Schlauch in der Mitte der Armbeuge nach unten Richtung Hand verläuft.		
Bei einer Messung am **rechten Arm** muss die Manschette so weit nach links verdreht werden, das der Luftschlauch an seitlich des Ellenbogens verläuft.		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass **der Messarm** während der Messung ruhig auf einer Unterlage zu liegen hat und **nicht bewegt werden darf.**		
Der Prüfling weist den Patienten min. vor der ersten Messung daraufhin, dass **die Handinnenfläche nach oben** zeigen soll.		

Auszuführender bzw. zu überprüfender Schritt	Erledigt	Kommentare
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass während der Blutdruckmessung **nicht gesprochen werden darf.**		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass sich der Patient auch während der Blutdruckmessung an die **Stuhllehne lehnen** soll.		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass sich der Patient auch während der Blutdruckmessung **die Beine nicht überschlagen soll.**		
Der Unterrand der Blutdruckmanschette des Oberarmmessgeräts **endet ca. 2 Querfinger** über der Ellenbeuge, was vom Prüfling kontrolliert wird.		
Der Prüfling bringt die Manschette weder zu fest noch zu locker an. Es sollten **noch 1-2 Finger zwischen** Arm und Manschette passen. Dies wird vom Prüfling kontrolliert. Beim vorliegenden Gerät Zeigefinger.		
Der Luftschlauch ist während der Messungen **nicht geknickt.**[a]		
Der Prüfling führt eine Rechts/Links-Seiten-Vergleichsmessung durch, da bei dem Patienten kein Messarm feststeht. (je eine Messung am rechten und linken Oberarm)		
Der Prüfling deutet das Ergebnis der Rechts/Links-Seiten-Vergleichsmessung korrekt: • bei einer wiederholt auftretenden **Differenz > 10** mmHg an beiden Armen: Messung an dem Arm mit dem höheren Blutdruck. • Bei einer wiederholt auftretenden Seitendifferenz **von > 20 systolisch oder 10 mmHg diastolisch** Patient an den Arzt zur angiologischen Abklärung verweisen. • Treten **keine Messunterschiede** auf, so ist für Oberarmmessungen der Arm zu wählen, der die weniger ausgeprägte Muskelmasse aufweist, d.h. bei Rechtshändern der linke Oberarm.		
Der Prüfling nimmt unverzüglich nach Beendigung jeden Messvorgangs dem Patienten die Blutdruckmanschette ab.		
Im Anschluss an die Rechts/Linksvergleichsmessung, werden **zwei weitere Blutdruckmessungen** am gewählten Messarm durchgeführt.		
Zwischen jeder Wiederholmessung werden min**. 1-2 Minute gewartet.**		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Der **Durchschnitt der letzten 2 Messungen** (2 und 3 Messung) wird als Blutdruck wieder gegeben.		
Der Prüfling fragt den Patienten **nach offenen Fragen**.		
3. Dokumentation		
Zur vollständigen Dokumentation gehören folgende Angaben:		
Systolischer und diastolischer Blutdruckwert [mmHg]		
Puls [min^{-1}]		
Messarm		
Gerätetyp		
Datum		
Uhrzeit		

min. = mindestens. [a] For analysis, these 2 items of the checklist had to be excluded because these 2 aspects could not be performed by every standardized patient or in every OSCE encounter, respectively.

Appendix 3: Self-Assessment Survey of the SIV Versus FTFI Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

Selbsteinschätzungsbogen

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Teilnehmer-Codierung: _____

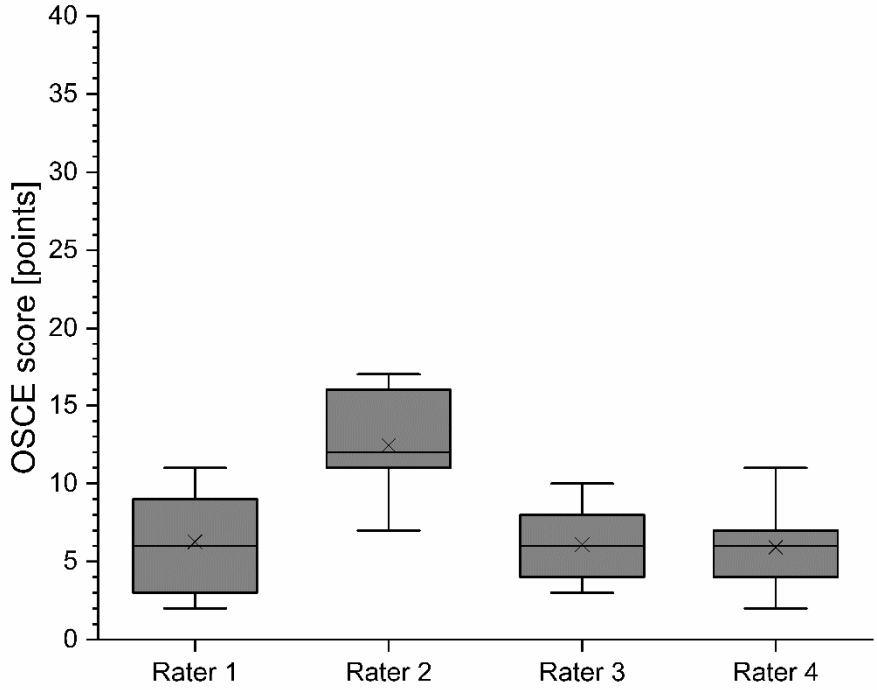
Datum: _____

Wie schätzen Sie Ihre Kompetenz in den folgenden Bereichen ein?
Bitte kreuzen Sie die Kästchen an.

Blutdruckmessung						
1. Ich fühle mich in der Lage die Blutdruckmessung in der Apotheke korrekt durchzuführen.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
2. Ich fühle mich sicher in der Handhabung von oszillometrischen Oberarmblutdruckmessgeräten.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
3. Ich fühle mich sicher in der Auswahl des passenden Blutdruckmessgeräts.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
4. Ich kenne die erforderlichen Arbeitsschritte für eine akkurate Blutdruckmessung mit einem oszillometrischen Oberarmblutdruckmessgerät.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu

5. Wenn mir hypothetisch gesehen in einem Monat wieder die Aufgabe der Blutdruckmessung gestellt wird, bin ich in der Lage den Blutdruck akkurat zu messen.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu

Appendix 4: OSCE Score per Rater and Pre-Instruction Assessment of the SIV Versus FTFI Study



Box plots on the OSCE score at pre-instruction assessment per rater.
black cross (×) = mean; horizontal line = median.
Rater 1, n = 11 participants
Rater 2, n = 11 participants
Rater 3, n = 11 participants
Rater 4, n = 11 participants

Appendix 5: Topics of Comments on Free-Text Items of the Perception and Satisfaction Survey in the SIV Versus FTFI Study

Group	Free-Text item	Topics	Number of comments related to the topic
Face-to-face instruction	What did you particularly like about the face-to-face instruction?	• The possibility to ask questions	15
		• Demonstration of procedure/ able to see how blood pressure measurement is performed properly	3
		• The detailed instruction	3
		• Human interaction	1
		• Real interaction with actor and device	1
		• Practically working through points, which are important and should be considered	1
		• Good refresher to the course	1
		• Receiving personal tips/advice	1
		• Comprehensible and application afterward	1
		• Optimal pace	1
	I would change the following about the face-to-face instruction:	• The fast pace of speech or demonstration	5
		• Information should be put into writing (eg, handout, slides, or flipchart)	4
		• The duration of the instruction was too short	2
		• Instruction should be more structured	2
		• Bigger room size or fewer people in a room	2
		• Taking notes was not possible, consequently, information was quickly forgotten	2
		• Make sure concentration is given	1
		• More practical demonstration	1
		• More face-to-one-face	1
		• Important aspects should be repeated several times	1

[Continuation Appendix 5]

Self-instruction video	What did you particularly like about the self-instruction video?	• The combination of text and video	5
		• The actors	4
		• The descriptive explanation	3
		• The concise information	3
		• Example consultation with patient	2
		• Good memorability	2
		• Step-by-step instruction	2
		• Time for pausing and replaying	1
		• Summary of parameters	1
		• Realistic depiction in a community pharmacy	1
		• Optimal pace	1
		• You could the execution exactly	1
		• Better concentration while watching as you know actors	1
		• Good tool, one can concentrate on the content	1
	I would change the following about self-instruction video:	• Taking notes should be allowed	3
		• A narrative voice for the written slides should be implemented	2
		• Summary in bullet point form should be added to the end of the video	1
		• The video should be available for everyone to clear up ambiguities that may arise after a certain period of time	1
		• Want to see the video again	1
		• Slide with evaluation	1
		• Incorporate the information better into the video	1
		• Explanation on blood pressure measurement for right arm should be more comprehensible	1
		• Powerpoint slides, which are intended to be read do not provide good memorability	1
		• Aspects for women should be also depicted on slides (eg, pregnancy)	1

Appendix 6: Participant Instruction of the Flipped Classroom–Like Approach Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Information für Apotheker	
Aufgabenstellung	Sie sind Apotheker/in in einer Apotheke. Ein Patient betritt die Apotheke und fragt nach einer Blutdruckmessung. Bitte messen Sie den Blutdruck des Patienten/ der Patientin.
Information zum Gerät	Es liegt Ihnen ein validiertes Messgerät mit einem Gütesiegel der Deutschen Hochdruckliga vor, welches vor einem Jahr erfolgreich einer messtechnischen Kontrolle unterzuzogen wurde.
Zeit	Maximal 12 Minuten
Ort	Apotheke
Der Patient	
Alter	28 Jahre

Appendix 7: Checklist of the Flipped Classroom–Like Approach Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Checkliste Blutdruckmessung in der Apotheke

Teilnehmercode: _____

Datum: _____

Uhrzeit: von _____ bis _____

Beobachter: _____

Gerätetyp: OMRON M5 Oberarmmessgerät_____

Zutreffendes bitte abhacken. Nichtzutreffendes mit „ Ø“ versehen. Bei Unklarheiten bitte kommentieren.

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Allgemeine Vorbereitungen zur Blutdruckmessung		
Der Prüfling fragt nach **außergewöhnlicher körperlicher Belastung.**		
Der Prüfling fragt nach **außergewöhnlicher psychischer Belastung.**		
Der Prüfling fragt, ob bis ca. 1 Stunde vor der Messung **koffeinhaltige Getränke, Alkohol oder Nikotin** zugeführt wurden und ob eine **Mahlzeit** zu sich genommen wurde. *(Nur vollständige Nachfrage wird bepunktet).*		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Der Prüfling fragt den Patienten nach **Vorerkrankungen und Schwangerschaft** oder namentlich nach potentiell einschränkenden Faktoren der Blutdruckmessung wie: Herzrhythmusstörungen, Vorhofflimmern, Herzschrittmacherträger, fortgeschrittenes Stadium einer Schwangerschaft oder nach Herzerkrankungen und Schwangerschaft**.** (*In den letzten beiden Fällen sind alle Umstände vom Prüfling zu nennen. Bitte notieren, was genau gefragt wird.*)		
Der Prüfling befragt den Patienten nach der **Einnahme von Medikamenten.**		
Der Prüfling informiert den Patienten, dass eine **volle Blase** den Blutdruck erhöhen kann und fragt, **ob dies jetzt der Fall ist.** (Wenn räumlich möglich, fragt der Prüfling, ob der Patient die Blase entleeren möchte.)		
Der Prüfling fragt den Patienten, ob bei Ihm eine **Rechts/Links-Seiten-Vergleichsmessung** durchgeführt wurde bzw. ob der **Messarm** vom Arzt festgestellt wurde.		
Der Prüfling bittet den Patienten den Messarm bzw. wenn Messarm nicht bekannt **beide Arme von Kleidungsstücken zu befreien**, wobei zurückgeschobene Kleidung den **Arm nicht abschnüren** darf. *(Im simulierten Fall sind beide Arme freizumachen.)*		
Der Oberarmumfang bzw. **Oberarmumfänge,** wenn Messarm nicht bekannt, wird **korrekt gemessen** bzw. die Markierung an der Manschette des Gerätes wird genutzt. *(Im vorliegenden Fall sind beide Oberarmumfänge zu messen).*[a]		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Ruhephase		
Der Prüfling lässt den Patienten **5 Minuten** in sitzender Position entspannen.		
Der Prüfling weist den Patienten darauf hin, dass er die **Beine nicht überkreuzen** soll. *Die Füße des Patienten sollten also flach nebeneinander auf dem Boden stehen.*		
Der Prüfling bittet den Patienten sich an **die Stuhllehne** zurück zu lehnen.		
Der Prüfling weist den Patienten darauf hin, während der Ruhephase **nicht zu sprechen.**		
Schritte der Blutdruckmessung		
Der Prüfling wählt eine dem tatsächlichen Armumfang **angepasste Blutdruckmanschette** aus.		
Der Prüfling legt die Manschette **am Oberarm** an.		
Korrektes Anlegen der Manschette **am linken Arm***: der Teilnehmer legt Manschette so an, dass der Schlauch nach unten zeigt und mittig entlang der Innenseite des Unterarms in Richtung Mittelfinger verläuft.*		
Korrektes Anlegen der Manschette **am rechten Arm:** *die Manschette muss so angelegt werden, dass der Luftschlauch links seitlich des Ellenbogens verläuft und der Luftschlauch nach unten zeigt.*		
Der Unterrand der Blutdruckmanschette des Oberarmmessgeräts **endet ca. 2 Querfinger** über der Ellenbeuge *(Muss vom Prüfling kontrolliert werden.)*		
Der Prüfling bringt die Manschette weder zu fest noch zu locker an. Es sollten **noch 1-2 Finger zwischen** Arm und Manschette passen. (*Dies muss vom Prüfling kontrolliert werden.)*		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass **der Messarm** während der Messung ruhig auf einer Unterlage zu liegen hat und **nicht bewegt werden darf.**		
Der Prüfling weist den Patienten min. vor der ersten Messung daraufhin, dass **die Handinnenfläche nach oben** zeigen soll.		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass während der Blutdruckmessung **nicht gesprochen werden darf.**		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass sich der Patient auch während der Blutdruckmessung an die **Stuhllehne lehnen** soll.		
Der Prüfling weist den Patienten min. vor der ersten Messung darauf hin, dass der Patient auch während der Blutdruckmessung **die Beine nicht überkreuzen soll.** *Die Füße des Patienten sollten also weiterhin flach nebeneinander auf dem Boden stehen.*		
Der Prüfling führt eine Rechts/Links-Seiten-Vergleichsmessung durch *(Je eine Messung am rechten und linken Oberarm, da beim Patient kein Messarm feststeht.)*		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Der Prüfling deutet das Ergebnis der Rechts/Links-Seiten-Vergleichsmessung korrekt: • Wenn ein **Blutdruckunterschied zwischen den beiden Armen** aufgezeichnet wurde, wird für die nachfolgenden Blutdruckmessungen der **Arm mit dem höheren Wert genutzt** • Bei einer Seitendifferenz zwischen beiden Armen von > **15 mmHg systolisch -> Patient zur angiologischen Abklärung an Arzt verweisen**		
Der Prüfling **nimmt** unverzüglich nach Beendigung jeden Messvorgangs dem Patienten die **Blutdruckmanschette ab.**		
Im Anschluss an die Rechts/Linksvergleichsmessung, werden **zwei weitere Blutdruckmessungen** am gewählten Messarm durchgeführt. (zusätzliche Messungen nur falls die letzten beiden um mehr als 10 mmHg differieren.)		
Zwischen jeder Wiederholmessung wird min**. 1 Minute** gewartet.		
Der **Durchschnitt der letzten 2 Messungen** *(für gewöhnlich 2 und 3 Messung)* wird als Blutdruck wiedergegeben.		
Der Prüfling fragt den Patienten **nach offenen Fragen**.		

Auszuführender bzw. zu überprüfender Schritt	**Erledigt**	**Kommentare**
Dokumentation		
Zur vollständigen Dokumentation gehören folgende Angaben:		
Systolischer und diastolischer Blutdruckwert [mmHg] *(Punkte nur mit richtiger Einheit)*		
Puls [min^{-1}] *(Punkte nur mit richtiger Einheit)*		
Messarm		
Gerätetyp		
Datum		
Uhrzeit		

min. = mindestens.

[a] For analysis it was decided to also award 1 point if the arm circumference of only 1 arm was measured. If circumferences of both arms were measured also 1 point was awarded.

Appendix 8: Self-Assessment Survey of the Flipped Classroom–Like Approach Study

KLINISCHE PHARMAZIE & PHARMAKOTHERAPIE

HEINRICH HEINE UNIVERSITÄT DÜSSELDORF

Selbsteinschätzungsbogen

Teilnehmer-Codierung: _____

Datum: _____

Wie schätzen Sie Ihre Kompetenz in den folgenden Bereichen ein?
Bitte kreuzen Sie jeweils das zutreffende Kästchen an (Nur Einfachwahl möglich).

Blutdruckmessung						
1. Ich fühle mich in der Lage die Blutdruckmessung in der Apotheke korrekt durchzuführen.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
2. Ich fühle mich sicher in der Handhabung von oszillometrischen Oberarmblutdruckmessgeräten.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
3. Ich fühle mich sicher in der Auswahl des passenden Blutdruckmessgeräts.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu
4. Ich kenne die erforderlichen Arbeitsschritte für eine akkurate Blutdruckmessung mit einem oszillometrischen Oberarmblutdruckmessgerät.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu

5. Wenn mir hypothetisch gesehen in einem Monat wieder die Aufgabe der Blutdruckmessung gestellt wird, bin ich in der Lage den Blutdruck akkurat zu messen.	☐ Trifft gar nicht zu	☐ Trifft nicht zu	☐ Trifft eher nicht zu	☐ Trifft eher zu	☐ Trifft zu	☐ Trifft voll zu

Appendix 9: Topics of Comments on Free-Text Items of the Perception and Satisfaction Survey in the Flipped Classroom–Like Approach Study

Free-Text Item	Group	Topics	Number of comments related to the topic
What did you particularly like about the instructional video?	Group A (brief in-class session)	• Comprehensible and/or clear and/or detailed video	5
		• Realistic depiction	3
		• The actors	3
		• Stepwise description	2
		• Summarizing slides	2
		• Combination of video and slides	2
		• Consultation plus practical application	1
		• Practical training of blood pressure measurement	1
		• Not just information that you would otherwise find on the Internet	1
	Group B (extended in-class session)	• Combination of video and slides	4
		• Comprehensible and/or clear and/or structured video	3
		• Depiction of pharmacist interacting with patient	2
		• Explanation of important aspects in a short time frame	1
I would change the following on the instructional video:	Group A (brief in-class session)	• The written slides should be narrated	4
		• A "problem patient" should also be depicted	3
		• Shortening the video	3
		• Video and text of the slides should run simultaneously	1
		• Slides or written summary should be provided separately	1
		• The cut and transition should be more attractive	1
		• Medical basics should also be conveyed	1

[Continuation Appendix 9]

I would change the following about the instructional video:	Group B (extended in-class session)	• The video had to many hiatuses	2
		• The sound quality should be improved	2
		• A "problematic patient should be additionally depicted"	1
		• Student mentioned some aspects regarding the consultation with and the instructions to the patient which should be underlined more strongly	1
		• The text should be depicted videographically	1
		• The image quality (especially PowerPoint slides) should be improved	1
		• Too long video	1
What did you particularly like about the seminar series in the "flipped classroom model"?	Group A (brief in-class session)	• Practical application	3
		• Repeating several times to consolidate knowledge	2
		• Possibility to watch video at your own pace	1
		• Individualized feedback	1
		• Close connection between self-learning phase (out of class) and in class phase	1
		• Modern	1
	Group B (extended in-class session)	• Practical application	4
		• Linking of theory and practice	1
		• No required attendance during self-learning phase (out-of-class activities)	1
		• Knowledge of self-learning phase is intensified and supplemented in class	1
		• All questions were answered	1
		• Sufficient preparation time	1
		• Noticeable learning effect	1
		• Identification of own strengths and weaknesses	1
		• Autonomous time management	1

[Continuation of Appendix 9]

I would change the following about the seminar series in the "flipped classroom model":	Group A (brief in-class session)	• better time management for in-class activities	3
		• General request for more practical OSCEs like that for training purposes (without grading)	1
		• Too fast	1
	Group B (extended in-class session)	• Better time management	4
		• Smaller group size and room size during the additional in-class activities regarding the potential mistakes	1
		• Additional in-class activities regarding the potential mistakes was not particularly helpful	1
		• The first OSCE round was superfluous	1

OSCE = objective structured clinical examination.

9. List of Own Publications

Parts of this dissertation were previously published in international peer-reviewed journals beforehand.

Original Publications in Peer-Reviewed Journals

1. Farahani I, Laeer S, Farahani S, Schwender H, Laven A. Blended learning: improving the diabetes mellitus counseling skills of German pharmacy students. *Curr Pharm Teach Learn*. 2020;12(8):963-974. doi:10.1016/j.cptl.2020.04.016
2. Farahani S, Farahani I, Burckhardt BB, Schwender H, Laeer S. Self-instruction video versus face-to-face instruction of pharmacy students' skills in blood pressure measurement. *Pharmacy (Basel)*. 2020;8(4):217. doi:10.3390/pharmacy8040217
3. Farahani I, Farahani S, Deters MA, Schwender H, Laeer S. Efficacy of an objective structured clinical examination training approach for training pharmacy students in diabetes mellitus counseling: a randomized controlled trial. *Pharmacy (Basel)*. 2020;8(4):229. doi:10.3390/pharmacy8040229
4. Farahani I, Farahani S, Deters MA, Schwender H, Laeer S. Training pharmacy students in self-medication counseling using an objective structured clinical examination–based approach. *J Med Educ Curric Dev*. 2021;8:1-9. doi:10.1177/23821205211016484
5. Farahani S, Farahani I, Burckhardt BB, Monser K, Laeer S. The development of an educational video on blood pressure measurement for

pharmacy students. *Adv Med Educ Pract*. 2021;12:655-663. doi:10.2147/AMEP.S302728

6. Farahani S, Farahani I, Deters MA, Schwender H, Burckhardt BB, Laeer S. Blended learning on blood pressure measurement: investigating two in-class strategies in a flipped classroom-like setting to teach pharmacy students blood pressure measurement skills. *Healthcare (Basel)*. 2021;9(7):822. doi:10.3390/healthcare9070822
7. Ali M, Tins J, Burckhardt BB; on behalf of the LENA consortium*. Fit-for-Purpose Quality Control System in Continuous Bioanalysis During Long-Term Pediatric Studies [published correction appears in *AAPS J*. 2020 Jan 29;22(2):37]. AAPS J. 2019;21(6):104. doi:10.1208/s12248-019-0375-1
8. Makowski N, Ciplea AM, Ali M, Burdman I, Bartel A, Burckhardt BB; on behalf of the LENA consortium*. A comprehensive quality control system suitable for academic research: application in a pediatric study. *Bioanalysis*. 2020;12(5):319-333. doi:10.4155/bio-2019-0242
9. Suessenbach FK, Makowski N, Feickert M, Gangnus T, Tins J, Burckhardt BB; on behalf of the LENA consortium*. A quality control system for ligand-binding assay of plasma renin activity: Proof-of-concept within a pharmacodynamic study. *J Pharm Biomed Anal*. 2020;181:113090. doi:10.1016/j.jpba.2019.113090

* The author of this dissertation was part of the LENA consortium.

Conference contributions

1. Farahani S, Feles E, Burckhardt BB, Laeer S; on behalf of the LENA consortium. P32 Depiction of haematological and biochemical laboratory normal reference values in a European multicentre paediatric trial. *Arch Dis Child*. 2019;104(6):e30. doi:10.1136/archdischild-2019-esdppp.70
   17th European Society for Developmental, Perinatal and Paediatric Pharmacology (ESDPPP) congress (May, 2019), Basel, Switzerland
2. Farahani I, Laven A, Farahani S, Deters MA, Feickert M, Suessenbach FK, Schwender H, Laeer S. P33 Effectiveness of OSCEs in training German pharmacy students in consultation on self-medication – a randomised controlled investigation. *Arch Dis Child*. 2019;104(6):e30.2-e31. doi:10.1136/archdischild-2019-esdppp.71
   17th European Society for Developmental, Perinatal and Paediatric Pharmacology (ESDPPP) congress (May, 2019), Basel, Switzerland
3. Feickert M, Burdman I, Makowski N, M Ali, Farahani S, Majid H, Ciplea AM, Bartel A, Burckhardt BB. P34 Reliable results in continuous bioanalysis of paediatric renin samples – comprehensive quality assessment within clinical studies in children. *Arch Dis Child*. 2019;104(6):e31.1-e31. doi:10.1136/archdischild-2019-esdppp.72
   17th European Society for Developmental, Perinatal and Paediatric Pharmacology (ESDPPP) congress (May, 2019), Basel, Switzerland
4. Makowski N, Burdman I, Ali M, Majid H, Farahani S, Ciplea AM, Bartel A, Burckhardt BB. P64 Quality assessment for the continuous bioanalysis of aldosterone: application in an European paediatric study. *Arch Dis Child*. 2019;104(6):e43.3-e44. doi:10.1136/archdischild-2019-esdppp.102

17th European Society for Developmental, Perinatal and Paediatric Pharmacology (ESDPPP) congress (May, 2019), Basel, Switzerland