Original Paper

Learning Objectives for a Telemedicine Curriculum in Medical Education: Group Concept Mapping Study

Tobias Martin[1*], MS, MD; Lina Vogt[2*], MD; Martin Klasen[2], PhD; Sarah Veldeman[1], MD; Andreas Follmann[1], MhBA, MD; Sasa Sopka[2], MD

[1]Acute Care Innovation Hub, Department of Anesthesiology, Faculty of Medicine, RWTH Aachen University, Aachen, North Rhine-Westphalia, Germany

[2]AIXTRA - Competence Center for Training and Patient Safety, Department of Anesthesiology, Faculty of Medicine, RWTH Aachen University, Aachen, North Rhine-Westphalia, Germany

*these authors contributed equally

Corresponding Author:

Tobias Martin, MS, MD
Acute Care Innovation Hub, Department of Anesthesiology
Faculty of Medicine, RWTH Aachen University
Pauwelsstraße 30
Aachen, North Rhine-Westphalia 52074
Germany
Phone: 49 241 80-87124
Email: tmartin@ukaachen.de

Abstract

Background: The implementation of telemedicine in the health care sector continues and has now surpassed the levels seen during the 2021 coronavirus pandemic. However, there is currently no consensus in the field of medical education on which specific learning objectives and content should be included in targeted telemedicine training programs and curricula.

Objective: This study aims to address the following questions: what are the potential learning objectives for a telemedicine curriculum in medical education, which thematic fields can these learning objectives be grouped into, and how do experts rate the importance and the implementation-effort levels of each learning objective?

Methods: An online group concept mapping tool was used to organize a collective brainstorming session within an expert group and to group and rate the evoked ideas. Ninety-seven clinicians, technical experts, and educationalists working with telemedicine were invited to participate in the study. Data acquisition took place from October 2022 to March 2023. Data collection and analysis were performed using the groupwisdom software.

Results: Of the 97 invited experts, 34 (35.0%) took part in the brainstorming phase, 10 (10.3%) in the sorting phase, and 12 (12.3%) and 10 (10.3%) in the subsequent importance and implementation-effort ratings, respectively. A total of 47 final statements were included for sorting and rating. Multidimensional scaling produced a 2D concept map with a stress value of 0.242 after 20 iterations. After hierarchical clustering of the statements, the number of clusters could be reduced to 6: “Fundamentals of telemedicine,” “Implementation of telemedicine,” “Legal principles,” “Communication in telemedicine,” “Practical use of the technology,” and “Technical knowledge.” Participants considered the statements in the “Practical use of the technology” cluster to be the most important (mean rating 4.92, SD 0.26), followed by those in the “Communication in telemedicine” (mean 4.56, SD 0.47) and “Legal principles” (mean 4.54, SD 0.44) clusters. A significant negative correlation was observed between the importance and implementation-effort ratings of the statements (r=–0.57; P<.001), with statements that were considered more important also being considered easier to implement. At the cluster level, the correlation was also negative but did not reach statistical significance (r=–0.79; P=.06; n=6 clusters).

Conclusions: The expert ratings of importance and implementation effort suggest that a telemedicine curriculum may primarily focus on practical competencies and training, as well as on legal issues.

JMIR Form Res 2026;10:e91748; doi: 10.2196/91748

Keywords: telemedicine; video consultation; telehealth; eHealth; curriculum; learning objectives; group concept mapping; medical education; graduate education; undergraduate education; medical students; teaching

Introduction

Background

Digital technology is driving the transformation of the health care sector [1-4]. Mobile health apps, electronic health records, telemedicine, remote monitoring systems, robotic systems for health care, and AI solutions are being adopted at a rapid pace. Collectively referred to as *digital health* [5], these technologies are very promising for improving the quality and efficiency of health care delivery. Telehealth is a subset of digital health that specifically refers to the provision of health-related services and information over long distances using telecommunications technologies. According to the World Health Organization, this encompasses clinical health care for the diagnosis and treatment of diseases and injuries, as well as the continuing education of health care professionals (HCPs) [6]. Other definitions also include public health activities, such as screening measures, when performed remotely [7].

Telemedicine represents the clinical care component of telehealth and is understood as the provision of remote health care services designed to diagnose, treat, or prevent diseases or injuries using digital technologies when patients and HCPs are separated by distance [8]. While different modalities of telemedicine exist, video consultations, defined as videoconferencing between a physician and a patient, are the most common [9]. The implementation of telemedicine has accelerated considerably in recent years, particularly for sanitary reasons during the COVID-19 pandemic, during which telemedicine made it possible to minimize health risks for individuals and HCPs by avoiding viral transmission [10,11].

During the COVID-19 pandemic, the use of telemedicine increased substantially in many countries, while numerous barriers to its implementation were successfully overcome [12]. Evidence from France [13,14], Germany [15,16], and the United States [17-19] shows that telemedicine utilization remained markedly above prepandemic levels, with many practices having access to telemedicine. Thus, telemedicine is not a temporary innovation but is likely to become a permanent component of health care delivery. This is why training in telemedicine is essential for preparing medical students for their future careers [20-22]. It is therefore important to educate and train HCPs in its use and to define learning objectives and competencies for HCPs that can be incorporated into a structured telemedicine curriculum.

Telemedicine in Medical Education

In addition to organizational and cultural barriers, the transformation process also gave rise to important educational challenges [23-26]. This is why structured training in telemedicine is essential for preparing medical students for their future careers [20-22]. During the COVID-19 pandemic, HCPs adopted telemedicine mainly out of acute necessity, but education and training beforehand were often insufficient, and the professionals learned according to the "trial-and-error" principle [27]. Accelerated by the COVID-19 pandemic, medical schools and medical program directors, mainly in the United States, have evaluated various concepts for teaching telehealth in undergraduate, graduate, and postgraduate medical education [28-39].

Despite the growing integration of telemedicine into routine health care delivery, structured training programs remain scarce in Germany. In the specific field of prehospital emergency care, postgraduate training with a defined curriculum prepares emergency physicians to work in emergency medical systems that use telemedical technologies to support paramedics during field missions [40]. In the outpatient sector, another curriculum has specifically been designed to provide general practitioner assistants with digital competencies covering, among other topics, telemedical care [41]. In graduate medical education in Germany, however, there is still no consensus on how and to what extent medical students should be trained in telemedicine.

The need to train medical students in telemedicine and to integrate telemedicine into the medical curriculum had, however, been identified before the pandemic. Although several American Medical Associations had already recommended the implementation of telemedicine education [28], adoption into existing curricula was limited. In a 2021 survey of US medical schools, almost half had not integrated telehealth into their curricula [42]. Moreover, existing curricula vary widely between institutions [42]. The situation is similar in Europe. In France, telemedicine has been part of the official curriculum since 2009, yet students still had limited knowledge and practical skills related to telemedicine in 2019 [43]. In Germany, the Society for Medical Informatics defined telemedicine as one of the digital learning objectives for medical students in 2012, but most of the schools had not integrated telemedicine into their curricula in 2020 [44,45]. In a 2021 study, 87% of participating faculty representatives agreed that "digitization should be given higher priority in teaching content" [46]. The current status of telemedicine education in German medical schools is hard to estimate, as more recent data are not available.

Learning Objectives for Telemedicine

Although the need for a telemedicine curriculum is generally recognized, it is still unclear which learning objectives should specifically be addressed [47]. Budakoğlu et al [48] concluded that there was "no well-established telemedicine curriculum in the undergraduate years" and that "the effectiveness of the educational programs did [tense adjusted] not have a robust evidence base."

Recently, first steps have been made to solve the issue of defining learning objectives for telemedicine empirically. In a modified Delphi process, Hart et al [49] identified a total of 34 competencies for a telemedicine curriculum for graduate medical education. Bajra et al [28] followed

Kern's six-step framework [50] for graduate and undergraduate medical education to develop and implement a telehealth curriculum with a total of 20 learning objectives. These studies provide valuable information about learning objectives and competencies; however, for a sustainable curriculum that remains adaptable to future technological developments and innovations, we consider it appropriate to go even further and identify overarching thematic fields. The reason for this is 2-fold. First, lists of learning objectives and competencies are not necessarily exhaustive; experts may miss some points, and overarching thematic fields can be helpful for identifying them. Second, telemedicine is a rapidly changing field. The need for new competencies may quickly arise, and defined thematic fields can be useful for evaluating whether the curricular framework is still up to date without having to reassess the entire set of learning objectives. Thus, there is a substantial need for a comprehensive classification of relevant content.

Group concept mapping (GCM) is a mixed methods approach to organizing the collective ideas of a group on a specific topic, which makes it particularly well-suited to addressing this need. A key strength of GCM is its ability to integrate the perspectives of participants with diverse professional backgrounds to generate a multiperspective view of a topic and classify learning objectives without relying on predefined categories or prior assumptions. Unlike Delphi processes, all participants contribute their ideas and later review all the statements generated by the group independently of other participants' perspectives. The initial input of the team organizing the process is minimal. Consequently, the results are largely driven by expert data and only minimally influenced by the researchers' or other participants' assumptions about potentially relevant categories. Furthermore, this approach provides a holistic starting point for curriculum development, as GCM aims to identify overarching thematic fields rather than merely compiling lists of individual learning objectives. GCM also allows participants to rate learning goals according to specific dimensions such as ease of implementation and importance. This can generate additional information for prioritizing educational content.

In line with the above, this investigation aims to answer the following research questions using the GCM methodology:

- RQ1: What are the potential learning objectives for a telemedicine curriculum in medical education?
- RQ2: Which thematic fields can these learning objectives be grouped into?
- RQ3: How do experts rate the importance and implementation-effort levels of each learning objective?

Methods

GCM

GCM effectively combines qualitative data collection with quantitative analysis [51-53]. Briefly, GCM first gathers an expert group's ideas on a certain topic (here, learning objectives for a telemedicine curriculum). This initial *brainstorming phase* involves individual brainstorming, where each expert independently contributes their ideas without having access to other participants' ideas. Subsequently, the ideas of all experts are pooled, and each expert receives the pooled ideas. Every expert then individually sorts the pool of ideas into thematic groups (*sorting phase*). All experts are free to sort completely independently; they are not given any instructions on how many groups they should sort into or which concepts or themes to use for clustering. After completing the sorting phase, the experts once again receive the deck of pooled ideas. Now they are asked to rate these ideas on one or more scales such as importance or estimated implementation effort (rating phase).

For analysis, multivariate statistical techniques such as multidimensional scaling and hierarchical cluster analysis are applied to the data. This allows the grouping of all participants' contributions into thematic fields and visualizing the relationships between the different groups in the form of cluster maps. Statistical analysis also allows us to quantify the relationships between the rating dimensions (to check whether an idea rated as important by many experts is also considered easy to implement). This quantified information on the rating dimensions provides important insights into the groups' perspectives on a specific idea and can be used to draw conclusions (eg, to start the implementation process of a telemedicine curriculum with the dimensions that are important and can be easily implemented). Data collection and analysis were performed online using the Concept System groupwisdom software (Build 2022.30.10; Concept Systems Inc).

Timeline

The participants were contacted at 2 different time points. They first received an email invitation to participate in a brainstorming phase, conducted in October and November 2022. They were contacted again for a subsequent sorting and rating phase, from January to March 2023. Participants could provide input in both phases or in only one of the 2 phases. Data analysis was conducted from April to May 2023.

Ethical Considerations

The study protocol was reviewed and approved by the Ethics Committee of the Medical Faculty of the University Hospital RWTH (Rheinisch-Westfälische Technische Hochschule) Aachen (EK 477/20) and was designed in accordance with the ethical principles of the World Medical Association Declaration of Helsinki [54].

Participant Recruitment

A purposive sampling strategy was used to recruit participants. Experts with relevant expertise in telemedicine from Germany and Switzerland were identified through the authors' professional networks and were invited to participate via email. Of the 97 experts invited to participate in the study, 93 were based in Germany, including 83 from the federal state of North Rhine-Westphalia and 10 from other German states. The remaining 4 experts were based in Switzerland. Among the invited experts, 18 (18.5%) were technical experts and developers working in the field of telemedicine, 19

(19.5%) had a background in medical education, 46 (47.4%) were nursing professionals, and 14 (14.4%) were physicians. They received an invitation email containing background information on the study's purpose and the methods of data collection and analysis, along with a link to the online platform and detailed instructions for study participation. To ensure that all participants used the same definition of telemedicine, they received a link to a video explaining the differences between video consultations, tele-expertise, and televisits [55]. In addition to the brainstorming, sorting, and rating tasks (described in the following section), participants were asked to provide information about their professional background and their experience with telemedicine. All data collection was conducted online and anonymously.

Brainstorming Phase

Participants were asked to generate possible learning objectives for a telemedicine curriculum, completing the following focus prompt: "Learning content and learning objectives of a curriculum on telemedicine in Germany should be in your opinion..." Reminders were sent after 2 and 4 weeks.

Idea Synthesis

Once the initial brainstorming phase was completed, the statements made by the participants were revised and synthesized by the study team. The aim of this phase was to obtain a list of unique ideas, with one idea per statement that was relevant to the focus prompt. Specifically, any statement that was not related to the focus prompt was deleted. The remaining statements were then scanned for thematic duplication and synthesized into single statements by the authors LV and MK. If necessary, statements were rephrased to match the grammar of the focus prompt. At a consensus meeting, an Excel spreadsheet (Microsoft Corporation) containing all initial statements, proposed deletions for duplication, and proposed changes to synthesize the statements was presented to all authors. All changes had to be voted on unanimously; therefore, the synthesis had to be adapted until all the authors agreed. The revised and synthesized statements were uploaded into the software for sorting and rating.

Sorting Phase

In this step, participants were contacted again via email and asked to sort the final statements into thematic groups. Participants were asked to group the statements into thematically coherent groups. The total number of groups was not determined in advance, but left up to the participants. Participants were also told that the sorting should be performed according to their subjective perception, and that there were no "right" or "wrong" ways to sort the statements. Finally, the participants were asked to label each group according to its content.

Rating Phase

After sorting, participants were asked to individually rate all statements using two 6-point Likert scales for importance ("How important is this learning objective in your opinion?," with ratings from "very unimportant" to "very important") and implementation effort ("How easily can this learning objective be implemented in your opinion?," with ratings from "very easy to implement" to "very hard to implement"). The order in which statements were presented to individual participants during the sorting and rating phase was automatically randomized by the system.

Analysis

GCM Analysis

The participants' sorting results were transferred into a binary similarity matrix, in which each cell represented whether a pair of statements had or had not been sorted into the same group by a participant. Then multidimensional scaling was applied to map the position of each statement in relation to the others within a 2D space. In the resulting 2D point map, each point represents a statement, while the distance between 2 points reflects the frequency with which statements were sorted together by participants. Statements that are located closer to one another were more frequently grouped together and therefore exhibit greater conceptual relatedness than statements located farther apart.

In a final step, the statements were grouped into thematic clusters using the method proposed by Ward [56] for agglomerative hierarchical cluster analysis. This approach, recommended for identifying a previously unknown structure of content categories [57], was applied to the statements' 2D coordinates to generate a series of nested cluster solutions with varying numbers of clusters.

In the last step, the number of clusters was progressively reduced to determine the final cluster solution presenting the smallest number of clusters while still being conceptually interpretable. Following the 15-5 heuristic [53], cluster solutions ranging from 15 to 5 clusters were reviewed in a joint session involving all authors. Beginning with the 15-cluster solution, the number of clusters was reduced by one at each step, in accordance with the hierarchical clustering structure, by merging the 2 nearest clusters into one. At every step of this iterative process, the authors discussed the suggested merger. If the resulting cluster remained conceptually coherent and the remaining clusters retained their conceptual distinctiveness, the process moved to the next step. The termination criterion for dimensional reduction was defined as the step when further merging of 2 clusters would compromise either the conceptual coherence of the merged cluster or the conceptual distinctiveness of the remaining clusters. During cluster reduction, coherence was always checked manually at every single step as the underlying data were quantitative and conveyed a specific meaning. However, from a mathematical standpoint, any hierarchical cluster solution can be further reduced by merging the nearest neighboring clusters.

Statistical Analysis

The characteristics of the participants were summarized as numbers and percentages for categorical data. A 2-sided chi-square test of homogeneity was used to compare the

distribution of professional backgrounds between invited experts and respondents. Statistical significance was assessed at an α level of .05. The analysis was conducted in Python (version 3.9.7) using the scipy.stats module. Following multidimensional scaling, a stress value (SV) was calculated according to Kruskal [58]. Briefly, the SV reflects the degree to which the 2D point map reproduces the similarities observed in the original similarity matrix, with lower SVs indicating a better fit. The SV is primarily determined by 2 factors: the number of sorters and the consensus among them regarding the sorting results [52,53].

To assess conceptual coherence within the concept map, bridging values (BVs) were calculated for each statement and cluster. At the statement level, the BV indicates how often a statement was grouped with other statements that were thematically close to it (low BV="often" and high BV="rarely"). At the cluster level, the BV, calculated as the average of the statement-level BVs within a cluster, reflects the thematic homogeneity (low BV) vs heterogeneity (high BV) of the cluster.

Correlations between importance and implementation-effort ratings were calculated at both the statement and cluster levels. Correlations at the statement level were calculated using IBM SPSS Statistics (version 29.0; IBM Corp). For the cluster level, the routine implemented in groupwisdom was used. Significance for correlations was defined as $P<.05$.

Results

Study Participation

The study participation and response rates varied across the different phases of the study. Of the 97 invited experts, 39 (40.2%) opened the initial invitation link and entered baseline data. The response rate then dropped, with 34 (35.0%) experts participating in the brainstorming phase. Twenty-four experts participated in the second part, which involved sorting and rating, following the second invitation. However, only the results of 10 (10.3%) experts could be included for sorting, and only 12 (12.3%) and 10 (10.3%) experts could be included in the importance and implementation-effort ratings, respectively (Table 1).

Table 1. Participant flow across the group concept mapping process.

Study phase	Invited (n)	Participated (n)	Excluded (n)	Included in analysis and response rate, n/N (%)
Baseline data (professional background)	97	39	• 58 experts who did not respond to the survey	39/97 (40.2)
Baseline data (experience with telemedicine)	97	36	• 58 experts who did not respond to the survey • 3 experts who provided baseline information only for the professional background	36/97 (37.1)
Brainstorming	97	34	• 58 experts who did not respond to the survey • 5 experts who entered baseline data but did not participate in the brainstorming phase	34/97 (35.0)
Idea synthesis	—[a]	73 statements	• 17 not related to the focus prompt • 9 similar/overlapping statements	47/73 (64.3)
Sorting	97	24	• 73 experts who did not respond to the invitation for the second phase • 13 experts who only sorted parts of the data • 1 participant misunderstood the sorting task	10/97 (10.3)
Rating (importance)	97	12	• 85 experts who did not participate in the importance rating	12/97 (12.3)

Study phase	Invited (n)	Participated (n)	Excluded (n)	Included in analysis and response rate, n/N (%)
Rating (implementation effort)	97	10	• 87 experts who did not participate in the rating of the implementation effort	10/97 (10.3)

[a]Not applicable.

Participant Characteristics

Out of the 97 invited people, 39 participants provided information about their professional background. Among these, 9 (23.0%) were physicians working in patient care, 14 (35.8%) were nurses in patient care, 4 (10.2%) worked in medical education or medical didactics, 7 (17.9%) worked in technical development, and 5 (12.8%) chose to answer "Other/miscellaneous." Excluding the miscellaneous category, the distribution of professional backgrounds among respondents did not differ significantly from that of the invited experts (χ^2_3=4.8; *P*=.19). Thirty-six participants provided information about their prior professional experience with telemedicine. Of these, 8 (22.2%) reported less than 1 year of experience with telemedicine, 8 (22.2%) 1 to 2 years, 9 (25%) 3 to 5 years, 7 (19.4%) 6 to 10 years, and 4 (11.1%) had more than 10 years of experience.

RQ 1: Brainstorming and Idea Synthesis

A total of 73 statements were collected from 34 of the invited experts who participated in the brainstorming phase. Seventeen of these were deleted because they were not related to the focus prompt. The remaining 56 raw statements were synthesized, meaning that statements with similar content were summarized and overlaps were removed. The 47 final statements were then uploaded for sorting (Multimedia Appendix 1).

RQ 2: Sorting

Twenty-four of the invited experts participated in the sorting step; however, 13 of them sorted only part of the statements, and only the remaining 11 provided sorting sets that were sufficiently complete to be used. One additional participant had to be excluded due to an obvious misunderstanding of the sorting instructions, resulting in a final sample of 10 participants for this step.

The analysis of the sorting data resulted in a 2D concept map with an SV of 0.242 after 20 iterations. This value was well below the average SV of 0.28 (SD 0.04) from a pooled analysis across 69 concept mapping studies by Rosas and Kane [52]. Thus, the SV indicated a good fit of the final representation to the raw data and an interpretable dataset.

Applying the 15-5 heuristic, the study team decided on a 6-cluster solution, which was considered to optimally reflect the content of the statements.

Based on the thematic fields covered, the six clusters were labeled as follows:

1. Fundamentals of telemedicine (9 statements, average BV: 0.11)
2. Implementation of telemedicine (7 statements, average BV: 0.26)
3. Legal principles (7 statements, average BV: 0.35)
4. Communication in telemedicine (10 statements, average BV: 0.24)
5. Practical use of the technology (5 statements, average BV: 0.11)
6. Technical knowledge (9 statements, average BV: 0.16)

Figure 1 depicts the map for the 6-cluster solution. A full list of statements (learning objectives) and their BVs is given in Table 2.

Figure 1. Cluster map. Each point represents one statement; spatial distances between points indicate how frequently they were sorted together (the closer the points, the more often they were sorted together).

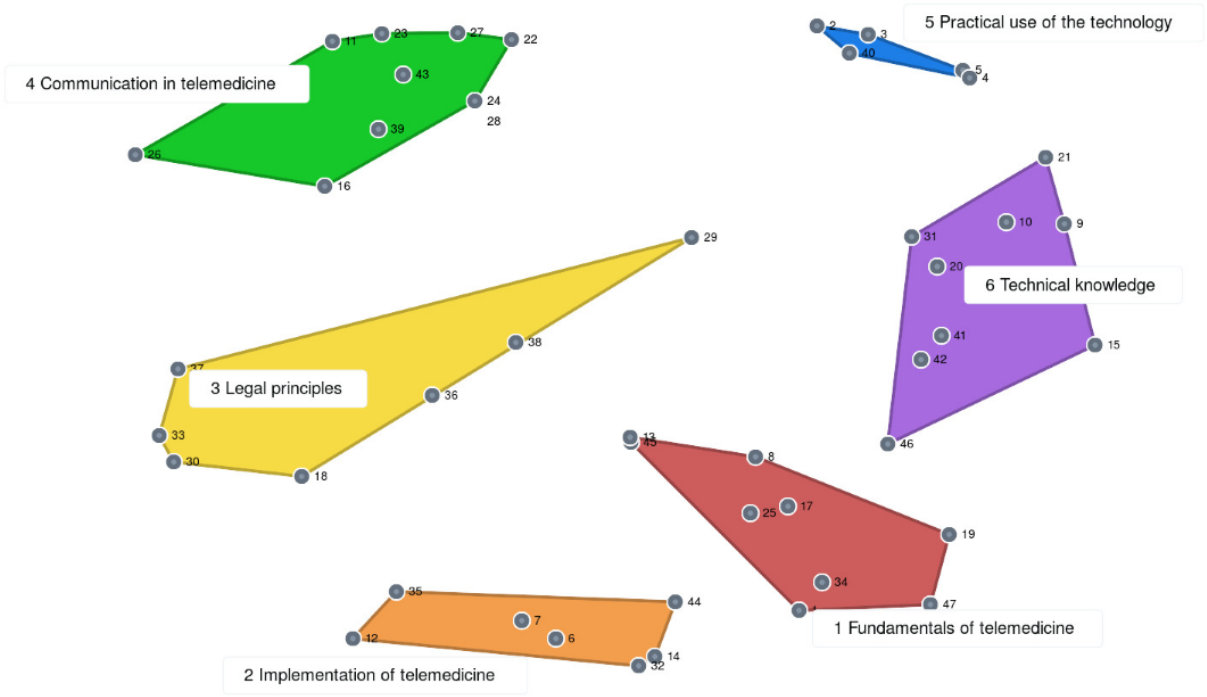


Table 2. Clusters and statements.[a]

Cluster name and statements[b]	Bridging value
Fundamentals of telemedicine	
...to be able to explain basic concepts of public relations in telemedicine.	0.26
...to be able to discuss in which scenarios an approach using telemedicine makes sense.	0.04
...to be able to explain the basic terminology of telemedicine.	0.08
...to be able to name the drawbacks of telemedicine.	0.02
...to be able to explain contemporary concepts and measures that already have been adopted such as electronic prescription, telematic infrastructure, or video consultations.	0.23
...to be able to name the advantages of the use of telemedicine (increased efficiency/effectiveness, less effort for documentation, etc).	0
...to (critically) discuss the limits of telemedicine.	0.06
...to explain areas of competence needed in the field of telemedicine.	0.08
...to explain and critically discuss ways for physicians to actively take part in shaping the digital transformation.	0.26
Implementation of telemedicine	
...to be able to plan how to integrate telemedicine into a normal working day.	0.25
...to be able to discuss how to integrate telemedicine into a normal working day.	0.23
...to be able to explain the billing modalities of telemedicine (including *ICD*[c] coding).	0.56
...to be able to explain areas of application of telemedicine in disaster medicine.	0.14
...to be able to explain how telemedicine can be introduced in the medical practice or hospital.	0.17
...to explain how health data obtained by telemedicine can be made available for research in a legally compliant manner.	0.33
...to explain examples of the clinical use of telemedicine in pandemics.	0.16
Legal principles	
...to be able to explain the basic concepts of telemedicine in the context of general practice.	0.52
...to document use of telemedicine.	0.21
...to name central aspects of data protection and data security regarding use of telemedicine.	0.44
...to explain the modus operandi of delegation and substitution [between physicians and paramedical staff] within telemedical care.	0.47
...to explain what a physician is allowed to prescribe via telemedicine.	0.21

Cluster name and statements[b]	Bridging value
...to explain what tasks a nurse is allowed to perform in telemedical care.	0.43
...to explain what needs to be considered from a professional point of view when communicating with other professional groups via telemedicine.	0.18
Communication in telemedicine	
...to be able to explain the procedure to and to secure informed consent from patients for use of telemedicine.	0.11
...to be able to perform telemedicine [consultations] in practice.	0.43
...to master basic communication and behavioral rules in dealing with impaired people, especially with cognitively impaired people.	0.16
...to be able to take the medical history in a telemedical physician-patient conversation.	0.11
...to show basic skills in creating the telemedical conversation environment.	0.07
...to be able to train nursing staff clinical presentations and conditions.	1.00
...to be able to show basic skills in digital conversations with a patient.	0.15
...to verbalize basic concepts of how trust can be created in the physician-patient conversation despite the [physical] distance.	0.07
...to explain what needs to be considered in telemedical communication with other professional groups regarding interpersonal factors (eg, expression of mutual appreciation).	0.23
...to show basic skills in digital conversation with a patient.	0.06
Practical use of the technology	
...to become proficient in handling the hardware of telemedicine products.	0.10
...to become proficient in handling the software of telemedicine products (including the operating system).	0.07
...to be able to identify the simplest technical problems (eg, no WLAN[d], speaker muted).	0.11
...to be able to solve the simplest technical problems (eg, no WLAN, speaker muted).	0.11
...to explain what needs to be considered when transmitting data with a normal camera (eg, wound analysis, ultrasound "filmed"...).	0.15
Technical knowledge	
...to be able to identify and use available technical support options for telemedicine.	0.18
...to be able to identify and use available assistance measures.	0.14
...to be able to explain the concept of neural networks and their application in telemedicine.	0.33
...to be able to explain how to deal with errors and malfunctions in telemedical applications.	0.21
...to be able to provide immediate help in case of malfunctions caused by ignorance.	0.11
...to explain how vital parameters can be collected by patients themselves using sensor technology.	0.15
...to name medical devices that can be integrated into telemedicine.	0.10
...to name the most important models of telemedical systems on the market.	0.10
...to name and explain the most important clinical applications of telemedicine in nursing.	0.15

[a]English translation of the items by the authors. The original list (in German) is available in Multimedia Appendix 1.
[b]Participants were asked to generate possible learning objectives for a telemedicine curriculum, completing the following focus prompt: "Learning content and learning objectives of a curriculum on telemedicine in Germany should be in your opinion...."
[c]*ICD*: *International Classification of Diseases*.
[d]WLAN: wireless local area network.

RQ 3: Ratings

Descriptive Statistics

The final ratings included ratings of importance from 12 participants and ratings of implementation effort from 10 participants. The descriptive statistics from the rating step are listed in Table 3. The participants estimated that learning objectives related to "Practical use of the technology" were the most important in ME, followed by learning objectives from the clusters "Communication in telemedicine" and "Legal principles." The "Implementation of telemedicine" and "Technical knowledge" were considered to be the least important. Interestingly, the 3 most important clusters were also considered to be the easiest to implement, with "Communication in telemedicine" estimated as the easiest, followed by "Practical use of the technology" and "Legal principles." "Implementation of telemedicine" was considered the most difficult to integrate into a curriculum.

Table 3. Importance and implementation-effort ratings for the clusters.

Cluster	Importance, mean (SD)	Implementation effort, mean (SD)
Fundamentals of telemedicine	4.25 (0.72)	2.46 (0.61)
Implementation of telemedicine	3.97 (0.91)	2.87 (0.54)
Legal principles	4.54 (0.44)	2.44 (0.23)

Cluster	Importance, mean (SD)	Implementation effort, mean (SD)
Communication in telemedicine	4.56 (0.47)	2.30 (0.25)
Practical use of the technology	4.92 (0.26)	2.33 (0.45)
Technical knowledge	3.98 (0.80)	2.61 (0.57)

Correlations Between Importance and Implementation-Effort Ratings

At the statement level, we observed a significant negative correlation between importance and implementation-effort ratings (r=–0.57; P<.001). In other words, when a learning objective was perceived as more important, it was also regarded as easier to implement. The relationship is depicted in Figure 2.

At the cluster level, the correlation was also negative but did not reach statistical significance (r=–0.79; P=.06). Given the small number of clusters (n=6), this finding should be interpreted cautiously. The results are depicted in Figure 3.

Figure 2. Correlation between importance and implementation-effort ratings at the statement level.

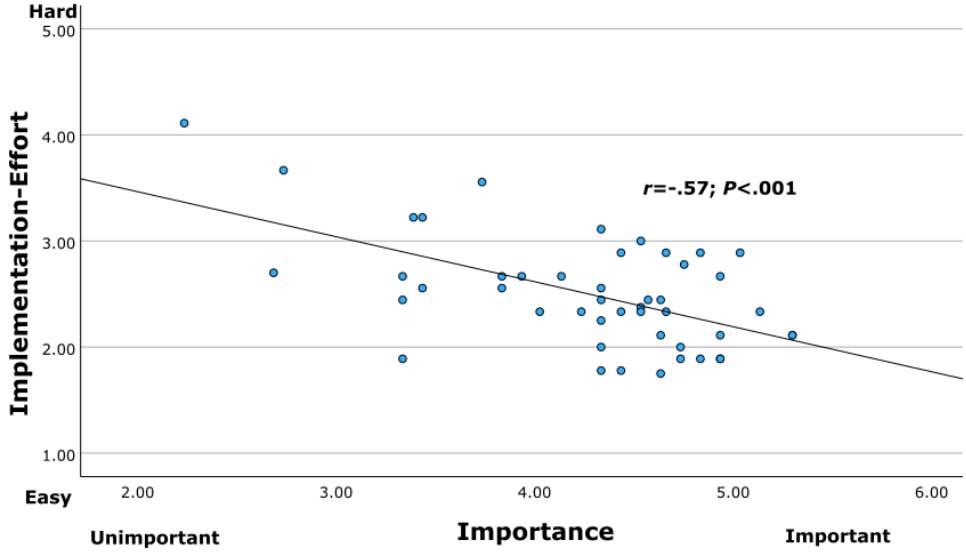
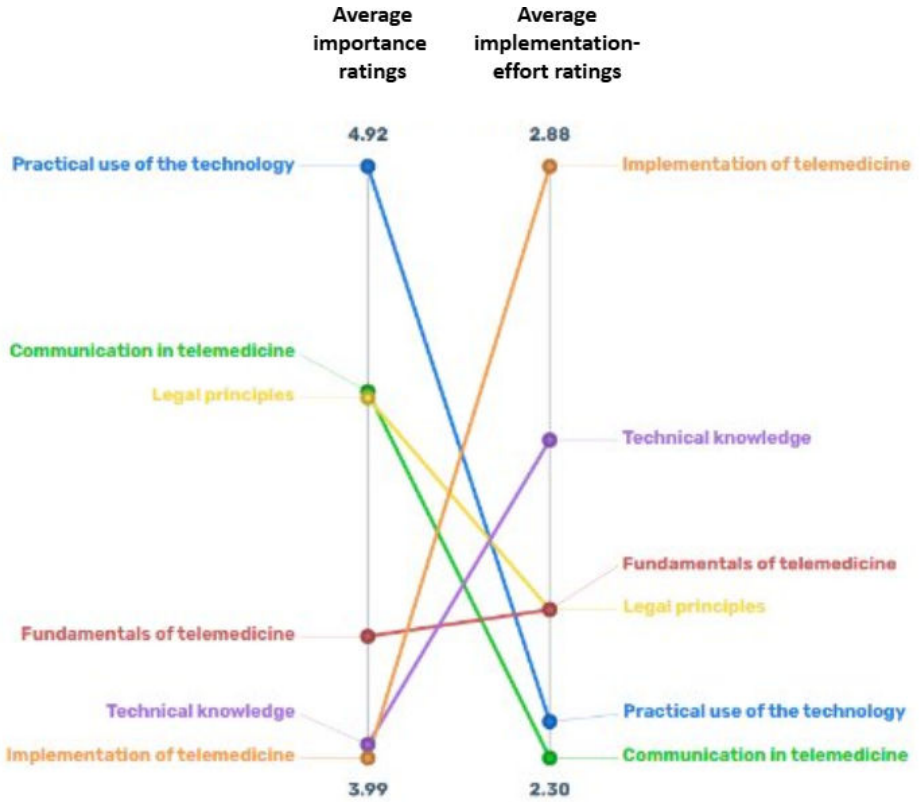


Figure 3. Correlation between importance and implementation-effort ratings at the cluster level.



Discussion

Principal Findings

This study identified a total of 47 potential learning objectives for a telemedicine curriculum, grouped into 6 different thematic clusters and covering a broad range of both practical and theoretical knowledge. The quantitative analysis of the data suggested a negative association between perceived importance and ease of implementation. At the statement level, this association was supported by a statistically significant correlation. This correlation was also negative at the cluster level but did not reach statistical significance and was based on only 6 clusters. Therefore, this finding should be considered exploratory rather than confirmatory. A key finding of this study is the breadth of competencies considered necessary for telemedicine practice. The identified learning objectives extend beyond clinical decision-making to include technical knowledge, communication skills, legal and regulatory aspects, and professional collaboration. This highlights that telemedicine is not a stand-alone technical competence but a rather complex professional activity requiring a broad set of knowledge, skills, and attitudes.

Coherence of Identified Areas of Competency

The clusters identified in this study can be mapped onto the 6 core competencies defined in the framework of the Accreditation Council for Graduate Medical Education (ACGME) [59]: *medical knowledge*, *professionalism*, *patient care and procedural skills*, *practice-based learning and improvement*, *interpersonal and communication skills*, and *systems-based practice* (visualized by Lauer and Lauer [60]). The cluster "Fundamentals of telemedicine" primarily relates to *medical knowledge*, whereas "Legal aspects" aligns with *professionalism*, "Communication in telemedicine" with *interpersonal and communication skills*, and "Implementation of telemedicine" with *systems-based practice*. While parts of the 2 remaining clusters "Practical use of the technology" and "Technical knowledge" are also linked to *systems-based practice*, they primarily align with *patient care and procedural skills*. This alignment is consistent with previously proposed telemedicine competency frameworks. The statement "to be able to perform telemedicine [consultations] in practice" falls under patient care and procedural skills, and is, for example, identical to one of the telemedicine competencies, namely "perform physical assessments...and incorporate vital signs...as appropriate to the patient's care" proposed by Hart et al [49], who also mapped the competencies to the ACGME framework. Similarly, the telemedicine curriculum proposed by the Society of Teachers of Family Medicine in the United States [61] was developed in line with the Association of American Medical Colleges Telehealth competencies [62,63], which can likewise be mapped to the ACGME competency domains [64]. The themes of this curriculum, comprising 20 learning objectives grouped into 5 modules (*Introduction to telehealth*, *The telehealth encounter*, *Requirements for telehealth*, *Access and equity in telehealth*, and *Future of telehealth*) [28], are also, in part, reflected in the findings of this study. There are close similarities with the study results. The learning objectives identified in the "Fundamentals of telemedicine" and "Communication in telemedicine" clusters reflect, for

example, the competencies covered in the *Introduction to telehealth* and *The telehealth encounter* modules, respectively. These findings have 2 important implications: the substantial overlap between the study results and previously published frameworks supports the relevance of these learning objectives and suggests an emerging consensus regarding the core objectives of a telemedicine curriculum. The identification of similar domains across different expert groups and different educational contexts strengthens the validity and generalizability of these competencies.

Furthermore, the fact that all identified clusters can be mapped onto the ACGME competency framework suggests that telemedicine should be conceptualized not as a separate competency domain, but as a clinical context in which HCPs apply their established competencies. Consequently, telemedicine curricula should be integrated within existing competency-based frameworks, with telemedicine-related learning objectives operationalized through established ACGME competency domains such as *medical knowledge*, *professionalism*, *patient care, interpersonal and communication skills,* and *systems-based practice*.

As 3 of the 6 identified clusters address the implementation, technical infrastructure, and practical application of telemedicine, *systems-based practice* emerged as a particularly relevant competency domain. At the same time, these clusters also require substantial procedural skills related to the operation and troubleshooting of telemedical technologies. Telemedicine curricula should, therefore, place special emphasis on developing learners' understanding of how telemedicine reshapes care processes across the health care system while integrating the technical and clinical competencies necessary for effective use of telemedicine in routine health care delivery.

Focus on Technology

The previously mentioned evidence originates from the United States. As health care systems, medical education structures, and the implementation of telemedicine differ considerably between countries, we expected a partial overlap with the findings of this study. At the same time, this study extends previous work by placing greater emphasis on competencies related to technology for medical education in telemedicine. Two out of 6 (33.3%) clusters and 14 out of the 47 (29.7%) statements were related to knowledge or the practical use of technology. This is a striking difference from the results obtained by Hart et al [49], where technology is barely part of any of the proposed competencies. In this expert panel, "Practical use of the technology" was considered the most important area among the learning objectives, suggesting that the participating experts in this study may feel that hands-on experience and proficiency in using telemedical tools are crucial for effective practice. This result shows that modern technology-enabled health care demands different competencies and skills from HCPs than does the traditional delivery of care. Although these technical competencies were considered important, they represent only one component of the telemedicine curriculum and must be complemented by clinical, communicative, and organizational competencies.

Internal Validity

As an interesting methodological side note, the ratings of importance and implementation effort confirm the validity of the 6 thematic fields in a way that is completely independent of the sorting task. Although the results slightly failed to reach significance due to the small number of clusters, the ratings of importance and implementation effort at the cluster level replicated the correlation pattern from the statement ratings remarkably well. This is far from trivial, bearing in mind that the participants were asked to rate only the statements, not the clusters. At the time of their participation, the participants were unaware of the clusters generated by other participants and thus unable to anticipate the final results, which were defined only in a subsequent analysis of the sorting results from the entire participant group. The replication of the correlation pattern at the cluster level thus indicates consistency of importance/implementation-effort ratings within, and heterogeneity between, clusters—a clear indication that these really stand for distinguishable thematic fields.

Telemedical Implementation

The learning objectives summarized in the cluster "Telemedicine implementation," including items such as "to be able to plan how to integrate telemedicine into a normal working day," were considered the most difficult to integrate into a curriculum. This is consistent with recent research suggesting that there are still barriers to telemedicine implementation at the system level that must be reduced to improve the adoption of digital technologies in health care [12,26].

Legal Principles

Our analysis for the cluster "Legal principles" showed high heterogeneity (indicated by high BV values), suggesting that the items clustered together in this group were less homogeneous. Thus, for curriculum development, these findings probably argue against handling legal issues as a separate thematic field in a telemedicine curriculum, but instead suggest incorporating legal aspects as a cross-cutting theme across other fields. Moreover, regarding the transferability of the study results, we expect legal issues to be the only thematic field that may show noteworthy differences between countries, depending on local legislation, which also argues for connecting them to the specific learning content of other fields in a curriculum.

Defining a Curriculum

Education always involves a trade-off between the time and resources available to teachers/trainers and learners/trainees, and the scope of the learning objectives to be achieved. The results of this study strongly suggest that decision-makers can prioritize the most important learning objectives, since participants also rated them the easiest to implement. However, this finding alone does not indicate how such prioritization should be reflected in the actual design of a curriculum or how the learning objectives should be structured to build logically upon one another. Other aspects remain open research questions, such as the optimal length

of the curriculum and whether short, intensive courses or longer weekly courses are more effective in achieving good educational outcomes.

Based on a modified Delphi process, the American Board of Telehealth identified 8 core competencies for telehealth education, which form the basis of its Core Concepts in Telehealth Certificate Program [65]. Direct comparison is challenging, as some competencies, such as demonstrating *on-screen professionalism*, a *professional appearance,* or an *understanding of the ethics of telemedicine in specific situations*, are relatively broad and open to interpretation. At the level of individual statements for learning objectives, however, clear parallels can be identified. For example, these competencies correspond to statements such as "creating the telemedical conversation environment," "[verbalizing]...how trust can be created...despite the physical distance," or "[mastering] behavioral rules in dealing with impaired people." At the same time, several competencies emphasized in this framework were less explicitly represented in the study results. Ethical challenges arising in specific telemedical situations, such as managing suicidal ideation or criminal behavior during remote consultations, were not identified by the expert panel in this study. Similarly, competencies related to triaging patients for the suitability of telemedicine while considering their current location of care were only partially reflected in the results. Given their importance for safe and effective telemedical practice, these aspects should nevertheless be considered for inclusion in future telemedicine curricula.

Taken together, the findings of this study indicate that curricula should place considerable emphasis on developing technical proficiency in the use of telemedicine technologies. However, when considered alongside existing frameworks and the other results of this study, technical proficiency should not be regarded as the final educational objective, but as a prerequisite for understanding how HCPs can implement, integrate, and effectively use telemedicine within their real-world medical practice. This corresponds closely to the competency domain of systems-based practice. As these processes are inherently shaped by regulatory requirements, legal principles should be addressed as a cross-cutting theme throughout all other domains of telemedicine curricula. Although not identified in the GCM process, established teaching domains, such as ethical challenges, should not be omitted.

Limitations

This study has several limitations. Notably, 16 out of 36 (44.4%) of the participants had 2 years or less experience with telemedicine and began using it during the COVID-19 pandemic. This may affect the results due to their relative inexperience. Most participants in this study were HCPs or developers actively involved in telemedicine, potentially influencing their emphasis on, and high importance ratings for, application-related aspects. This warrants further discussion, as the importance of practical application may not be obvious to others. Experts engaged in developing guidelines or defining the legal framework for telemedicine might rate legal issues as more important to avoid creating situations for practitioners that could lead to liability concerns.

Another potential limitation of this study is the substantial attrition observed across the different phases of the GCM process, which resulted in only a small number of participants contributing to the sorting and rating tasks. However, following the sorting step and multidimensional scaling, we obtained an SV of 0.242 with 10 sorters. Based on a simulation study, Sturrock and Rocha [66] proposed an SV of 0.39 as the upper limit for interpretability, with higher values indicating a probability greater than 1% of a random data configuration. In an analysis of 69 GCM studies, Rosas and Kane [52] found an average SV of 0.28, with an average of 24.62 sorters. Thus, the SV in our study is within the suggested limits of interpretability and is relatively low compared with other studies. Since a larger number of sorters usually results in lower SVs, our observed value indicates a high degree of agreement among the sorters and thus good interpretability. Such a high agreement among independent sorters with diverse backgrounds further suggests that the identified data structure did not arise by chance but reflects an existing pattern.

However, the small number of participants in the 2 rating dimensions is a limiting factor. The average SEM across all importance ratings was 0.23 on the 6-point Likert scale. A larger number of participants might have led to more homogeneous ratings. Moreover, the small sample size did not allow analyses in participant subgroups (eg, clinical practitioners and educationalists), which could have provided insights into specific preferences depending on the experts' background.

The authors deliberately formulated the initial focus prompt for the experts openly, making the learning objectives applicable to graduate and undergraduate education, as well as to continuing professional development and lifelong learning. However, the individual learning units should probably be tailored to different target groups.

Interestingly, newly emerging topics such as AI-integrated diagnostics and digital equity did not emerge as areas of emphasis among the participating experts. Only one statement was related to neural networks. This finding may, in part, be explained by the timing of the study. The brainstorming phase was conducted in November 2022, coinciding with the public launch of ChatGPT (OpenAI) and before the widespread adoption of generative AI technologies. As a result, the potential implications of AI for clinical practice and medical education may not yet have been fully appreciated by the participating experts. Future telemedicine competency frameworks may therefore need to incorporate AI-related competencies explicitly.

In addition, the prompt was not restricted to a specific medical specialty. Precise competencies have been defined for individual medical specialties such as pediatrics [67] or patient populations such as older adults [68], but telemedicine is a cross-cutting technology and applies to many medical specialties. Different medical disciplines may have distinct

requirements for the use of telemedicine, and therefore, different training and education needs. This is also an open area of research. Finally, one must keep in mind that the identified learning objectives are still at a rather global level and are meaningful only in combination with the respective learning content, which must be defined separately. Thus, this study can guide our choice of important topics for a curriculum, but we must still fill them with content.

Future Outlook

Telemedicine solutions are becoming increasingly sophisticated and will probably integrate AI technologies in the future. A recent study shows that reliance on these technologies can lead to deskilling of medical staff, that is, impairment of clinical skills [69]. Providing research evidence for learning objectives is of crucial importance for developing standardized telemedicine curricula and evaluating their educational outcomes. The convergence between the study's findings and previously published competency frameworks, together with international initiatives promoting telemedicine education, suggests that a consensus is emerging regarding the fundamental components of telemedicine training. In this context, the results may inform the development and implementation of telemedicine curricula in Germany and contribute to ongoing efforts to advance competency-based telemedicine education. Furthermore, the substantial overlap between the study results and existing frameworks supports broader initiatives by organizations, such as the International Society for Telemedicine & eHealth, the American Telemedicine Association, and the American Board of Telehealth, to promote structured and standardized approaches to telemedicine education.

Conclusions

Using an online GCM approach within an interdisciplinary expert group, comprising medical practitioners, developers, and educationalists, resulted in the identification of 47 learning objectives for a telemedicine curriculum. These objectives were then grouped into 6 clusters. The importance and the implementation effort were evaluated both at the individual-statement and cluster levels. The expert panel identified a wide range of learning objectives. As the 3 clusters of statements considered most important were "Practical use of the technology," "Communication in telemedicine," and "Legal principles," telemedicine curricula should focus particularly on practical competencies and training, as well as on legal issues. Additionally, these learning objectives may be relatively easy to implement. Furthermore, the results underline the relevance of systems-based practice and the integration of telemedicine.

Generative AI Use

Generative AI tools such as ChatGPT (GPT-5; OpenAI) and DeepL Write (DeepL SE) were used for language editing.

Funding

TM, SV, and AF participated in this study as part of the AIDA project (Arbeitsentwicklung in der Altenpflege), which was funded by the European Regional Development Fund 2014-2020 of the European Union and by the state of North Rhine-Westphalia, Germany.

Data Availability

The translated version of all data generated or analyzed during this study is included in this published article and its supplementary information file. The original German data are available from the authors upon request.

Authors' Contributions

TM, LV, MK, AF, and SS conceptualized the study. AF and SS supervised the study. TM, LV, and MK collected and managed the data. TM, LV, MK, and SV interpreted the data. TM and LV drafted the manuscript. MK and SV critically edited the manuscript for important intellectual content. All authors reviewed and revised the manuscript. TM and LV are both first authors, and all other authors agreed to their first authorship.

Conflicts of Interest

AF worked part-time as chief medical officer for Docs in Clouds TeleCare GmbH (Germany), a company that distributes telemedical solutions, until March 2023. All other authors declare no conflicts of interest.

Multimedia Appendix 1

Translated results of the brainstorming session on the telemedicine curriculum.
[XLSX File (Microsoft Excel File), 39 KB-Multimedia Appendix 1]

References

1. Bhavnani SP. Digital health: opportunities and challenges to develop the next-generation technology-enabled models of cardiovascular care. Methodist Debakey Cardiovasc J. 2020;16(4):296-303. [doi: 10.14797/mdcj-16-4-296] [Medline: 33500758]
2. de Mooij M, Foss O, Brost B. Integrating the experience: principles for digital transformation across the patient journey. Digit Health. 2022;8:20552076221089100. [doi: 10.1177/20552076221089100] [Medline: 35392253]
3. Stoumpos AI, Kitsios F, Talias MA. Digital transformation in healthcare: technology acceptance and its applications. Int J Environ Res Public Health. Feb 15, 2023;20(4):3407. [doi: 10.3390/ijerph20043407] [Medline: 36834105]

4. Natakusumah K, Maulina E, Muftiadi A, Purnomo M. Digital transformation of health quality services in the healthcare industry during disruption and society 5.0 era. Front Public Health. 2022;10:971486. [doi: 10.3389/fpubh.2022.971486] [Medline: 35991021]
5. Global strategy on digital health 2020-2027. World Health Organization; 2025. URL: https://iris.who.int/server/api/core/bitstreams/a64d584f-015b-471f-9d86-9ea263cfb516/content [Accessed 2026-10-22]
6. WHO-ITU global standard for accessibility of telehealth services. World Health Organization and International Telecommunication Union; 2022. URL: https://iris.who.int/server/api/core/bitstreams/5c212450-b17a-4f2b-85c6-d7bd541bf279/content [Accessed 2026-10-22]
7. What is telehealth? Health Resources and Services Administration (HRSA). URL: https://www.hrsa.gov/telehealth/what-is-telehealth [Accessed 2026-10-22]
8. Consolidated telemedicine implementation guide. World Health Organization; 2022. URL: https://iris.who.int/server/api/core/bitstreams/d119a69e-e56d-4c78-a2b9-52572e14217c/content [Accessed 2026-10-22]
9. Neculau AE, LăcătușA, Mărginean M, Fărcășanu d. A guide to telemedicine in primary healthcare. UNICEF Romania/ Centre for Health Policy and Services Foundation; 2022. URL: https://www.unicef.org/romania/media/10891/file/A%20guide%20to%20telemedicine [Accessed 2026-10-22]
10. Mandal S, Wiesenfeld BM, Mann D, et al. Evidence for telemedicine's ongoing transformation of health care delivery since the onset of COVID-19: retrospective observational study. JMIR Form Res. Oct 14, 2022;6(10):e38661. [doi: 10.2196/38661] [Medline: 36103553]
11. The COVID-19 pandemic and the future of telemedicine. OECD Publishing; 2023. URL: https://www.oecd.org/content/dam/oecd/en/publications/reports/2023/01/the-covid-19-pandemic-and-the-future-of-telemedicine_1c878192/ac8b0a27-en.pdf [Accessed 2026-10-22]
12. Gullslett MK, Ronchi E, Lundberg L, et al. Telehealth development in the WHO European region: results from a quantitative survey and insights from Norway. Int J Med Inform. Nov 2024;191:105558. [doi: 10.1016/j.ijmedinf.2024.105558] [Medline: 39084085]
13. Transcription textuelle -"assises-telemedecine_chiffres_infographie_0.jpg". ameli.fr – L'Assurance Maladie [Article in French]. URL: https://www.ameli.fr/media/53979 [Accessed 2026-01-02]
14. French National Health Insurance Fund (Caisse nationale de l'Assurance Maladie), Directorate-General for Healthcare Provision (Direction générale de l'offre de soins, DGOS), Ministry of Labour, Health, Solidarity and Families (Ministère du Travail, de la Santé, des Solidarités et des Familles). Télémédecine: quelle juste place dans le système de santé et le parcours des patients, au bénéfice de la qualité et de l'accès aux soins? [Report in French]. Caisse nationale de l'Assurance Maladie (Assurance Maladie); Jun 27, 2025. URL: https://www.assurance-maladie.ameli.fr/sites/default/files/2025-06-27-cp-lancement-assises-telemedecine.pdf [Accessed 2026-01-02]
15. Mangiapane S, Kretschmann J, Czihal T, von Stillfried D. Veränderung der vertragsärztlichen Leistungsinanspruchnahme während der COVID-19-Krise – tabellarischer Trendreport bis zum Ende des Jahres 2021 [Report in German]. Zentralinstitut für die kassenärztliche Versorgung in Deutschland (Zi); 2022. URL: https://www.zi.de/fileadmin/Downloads/Service/Publikationen/Zi-TrendReport_2021-Q4_2022-06-10.pdf [Accessed 2026-01-01]
16. Mangiapane S, Kretschmann J, Czihal T, von Stillfried D. Zi-Trendreport zur vertragsärztlichen Versorgung: Bundesweiter tabellarischer Report vom 1. Quartal 2021 bis zum 4. Quartal 2024 [Report in German]. Zentralinstitut für die kassenärztliche Versorgung in Deutschland (Zi); 2025. URL: https://www.zi.de/fileadmin/Downloads/Service/Publikationen/Zi-TrendReport_2024-Q4.pdf [Accessed 2026-01-02]
17. Albrecht M, Bernhard J, Sander M, Otten M. PraxisBarometer Digitalisierung 2025: Befragung von Vertragsärztinnen/-ärzten und Vertragspsychotherapeutinnen/-psychotherapeuten im Auftrag der Kassenärztlichen Bundesvereinigung (KBV) [Report in German]. IGES Institut; 2025. URL: https://www.iges.com/sites/igesgruppe/iges/content/e2622/e2634/e5722/e16695/e16696/e16698/attr_objs16700/Praxisbarometer_Digitalisierung_2025_Kurzbericht_IGES_ger.pdf [Accessed 2026-01-02]
18. Albrecht M, Bernhard J, Sander M, Otten M. PraxisBarometer Digitalisierung 2025 [Report in German]. IGES Institut; 2025. URL: https://www.iges.com/sites/igesgroup/iges.de/myzms/content/e6/e1621/e10211/e82672/e98176/e98177/e98179/attr_objs98185/Folien_Pressegesprch_PraxisBarometer_20251015_ger.pdf [Accessed 2026-01-02]
19. Patient-facing telehealth: use is higher than pre-pandemic but with great variation across physician specialties. American Medical Association; 2024. URL: https://www.ama-assn.org/system/files/2024-prp-telehealth.pdf [Accessed 2026-01-02]
20. Cheng C, Humphreys H, Kane B. Transition to telehealth: engaging medical students in telemedicine healthcare delivery. Ir J Med Sci. Oct 2022;191(5):2405-2422. [doi: 10.1007/s11845-021-02720-1] [Medline: 34626350]
21. Camhi SS, Herweck A, Perone H. Telehealth training is essential to care for underserved populations: a medical student perspective. Med Sci Educ. Sep 2020;30(3):1287-1290. [doi: 10.1007/s40670-020-01008-w] [Medline: 32837786]

22. Waseh S, Dicker AP. Telemedicine training in undergraduate medical education: mixed-methods review. JMIR Med Educ. Apr 8, 2019;5(1):e12515. [doi: 10.2196/12515] [Medline: 30958269]
23. Meskó B. COVID-19's impact on digital health adoption: the growing gap between a technological and a cultural transformation. JMIR Hum Factors. Sep 19, 2022;9(3):e38926. [doi: 10.2196/38926] [Medline: 36121692]
24. Scott Kruse C, Karem P, Shifflett K, Vegi L, Ravi K, Brooks M. Evaluating barriers to adopting telemedicine worldwide: a systematic review. J Telemed Telecare. Jan 2018;24(1):4-12. [doi: 10.1177/1357633X16674087] [Medline: 29320966]
25. Kho J, Gillespie N, Martin-Khan M. A systematic scoping review of change management practices used for telemedicine service implementations. BMC Health Serv Res. Sep 1, 2020;20(1):815. [doi: 10.1186/s12913-020-05657-w] [Medline: 32873295]
26. Li X, Huang L, Zhang H, Liang Z. Enabling telemedicine from the system-level perspective: scoping review. J Med Internet Res. Mar 5, 2025;27:e65932. [doi: 10.2196/65932] [Medline: 40053725]
27. Greiwe J. Telemedicine lessons learned during the COVID-19 pandemic. Curr Allergy Asthma Rep. Jan 2022;22(1):1-5. [doi: 10.1007/s11882-022-01026-1] [Medline: 35061150]
28. Bajra R, Frazier W, Graves L, et al. Feasibility and acceptability of a US national telemedicine curriculum for medical students and residents: multi-institutional cross-sectional study. JMIR Med Educ. May 8, 2023;9:e43190. [doi: 10.2196/43190] [Medline: 37155241]
29. Jortberg BT, Beck Dallaghan GL, Schatte D, Christner J, Ryan MS. Expansion of telehealth curriculum: national survey of clinical education leaders. J Telemed Telecare. Jul 2022;28(6):464-468. [doi: 10.1177/1357633X211058330] [Medline: 34775863]
30. Hayden EM, Nash CJ, Farrell SE. Simulated video-based telehealth training for emergency physicians. Front Med (Lausanne). 2023;10:1223048. [doi: 10.3389/fmed.2023.1223048] [Medline: 37700768]
31. Wang SK, Goodrich RC, Strauss LD, Martindale JM. High-yield, case-based, interactive workshop on telehealth and teleneurology with pediatric resident physicians. MedEdPORTAL. 2023;19:11340. [doi: 10.15766/mep_2374-8265.11340] [Medline: 37638232]
32. Wilson LA, Harder B, Kelley C, Powell R, Foster M, Roberts E. Geriatric telehealth: a standardized patient case for medical students. MedEdPORTAL. 2023;19:11345. [doi: 10.15766/mep_2374-8265.11345] [Medline: 37706040]
33. Rueda AE, Monterrey AC, Wood M, Zuniga L, Rodriguez BDR. Resident education and virtual medicine: a faculty development session to enhance trainee skills in the realm of telemedicine. MedEdPORTAL. 2023;19:11302. [doi: 10.15766/mep_2374-8265.11302] [Medline: 36895763]
34. Mahabamunuge J, Farmer L, Pessolano J, Lakhi N. Implementation and assessment of a novel telehealth education curriculum for undergraduate medical students. J Adv Med Educ Prof. Jul 2021;9(3):127-135. [doi: 10.30476/jamp.2021.89447.1375] [Medline: 34277843]
35. Liew SC, Tan MP, Breen E, et al. Microlearning and online simulation-based virtual consultation training module for the undergraduate medical curriculum: a preliminary evaluation. BMC Med Educ. Oct 25, 2023;23(1):796. [doi: 10.1186/s12909-023-04777-1] [Medline: 37880711]
36. Behrends M, Paulmann V, Koop C, Foadi N, Mikuteit M, Steffens S. Interdisciplinary teaching of digital competencies for undergraduate medical students: experiences of a teaching project by medical informatics and medicine. In: Mantas J, Stoicu-Tivadar L, Chronaki C, et al, editors. Public Health and Informatics. IOS Press; 2021:891-895. [doi: 10.3233/SHTI210307]
37. Jin JW, Smith K, Helminiak A, John V, Wu HE. Current curricular trends after the COVID-19 pandemic: a national survey of psychiatry residency programs. Int J Psychiatry Med. Sep 2023;58(5):522-536. [doi: 10.1177/00912174231152575] [Medline: 36653916]
38. Severini R da S, Marcovici M, Farhat SCL, et al. How to incorporate telemedicine in medical residency: a Brazilian experience in pediatric emergency. Clinics (Sao Paulo). 2023;78:100162. [doi: 10.1016/j.clinsp.2022.100162] [Medline: 36805149]
39. Vogt L, Schmidt M, Follmann A, Lenes A, Klasen M, Sopka S. Telemedicine in medical education: an example of a digital preparatory course for the clinical traineeship: a pre-post comparison. GMS J Med Educ. 2022;39(4):Doc46. [doi: 10.3205/zma001567] [Medline: 36310883]
40. BÄK-Curriculum Telenotarzt/Telenotärztin [Report in German]. Bundesärztekammer; 2023. URL: https://www.akademie-wl.de/fileadmin/akademie-wl.de/Akademie/Dokumente/BAEK-Curriculum_Telenotarzt_Telenotaerztin_2023.pdf [Accessed 2026-10-22]
41. Musterfortbildungscurriculum für Medizinische Fachangestellte "Elektronische Praxiskommunikation und Telematik" [Report in German]. Bundesärztekammer; 2019. URL: https://www.bundesaerztekammer.de/fileadmin/user_upload/_old-files/downloads/pdf-Ordner/MFA/Curr_Telematik.pdf [Accessed 2026-10-22]

42. Khullar D, Mullangi S, Yu J, et al. The state of telehealth education at U.S. medical schools. Healthc (Amst). Jun 2021;9(2):100522. [doi: 10.1016/j.hjdsi.2021.100522] [Medline: 33548854]
43. Yaghobian S, Ohannessian R, Iampetro T, et al. Knowledge, attitudes and practices of telemedicine education and training of French medical students and residents. J Telemed Telecare. May 2022;28(4):248-257. [doi: 10.1177/1357633X20926829] [Medline: 32517545]
44. Foadi N, Koop C, Behrends M. Medizinische Ausbildung: Welche digitalen Kompetenzen braucht der Arzt? [Article in German]. Dtsch Arztebl. Mar 20, 2020;117(12):A596-A600. URL: https://api.aerzteblatt.de/pdf/117/12/a596.pdf [Accessed 2026-10-22]
45. Aulenkamp J, Mikuteit M, Löffler T, Schmidt J. Overview of digital health teaching courses in medical education in Germany in 2020. GMS J Med Educ. 2021;38(4):Doc80. [doi: 10.3205/zma001476] [Medline: 34056069]
46. Neumann M, Fehring L, Kinscher K, et al. Perspective of German medical faculties on digitization in the healthcare sector and its influence on the curriculum. GMS J Med Educ. 2021;38(7):Doc124. [doi: 10.3205/zma001520] [Medline: 34957329]
47. Stovel RG, Gabarin N, Cavalcanti RB, Abrams H. Curricular needs for training telemedicine physicians: a scoping review. Med Teach. Nov 2020;42(11):1234-1242. [doi: 10.1080/0142159X.2020.1799959] [Medline: 32757675]
48. Budakoğlu İİ, Sayılır MÜ, Kıyak YS, Coşkun Ö, Kula S. Telemedicine curriculum in undergraduate medical education: a systematic search and review. Health Technol (Berl). 2021;11(4):773-781. [doi: 10.1007/s12553-021-00559-1] [Medline: 33996380]
49. Hart A, Romney D, Sarin R, et al. Developing telemedicine curriculum competencies for graduate medical education: outcomes of a modified Delphi process. Acad Med. Apr 1, 2022;97(4):577-585. [doi: 10.1097/ACM.0000000000004463] [Medline: 34670239]
50. Thomas PA, Kern DE, Hughes MT, Tackett SA, Chen BY. Curriculum Development for Medical Education: A Six-Step Approach. 4th ed. Johns Hopkins University Press; 2022. ISBN: 9781421444093
51. Jackson KM, Trochim WMK. Concept mapping as an alternative approach for the analysis of open-ended survey responses. Organ Res Methods. Oct 2002;5(4):307-336. [doi: 10.1177/109442802237114]
52. Rosas SR, Kane M. Quality and rigor of the concept mapping methodology: a pooled study analysis. Eval Program Plann. May 2012;35(2):236-245. [doi: 10.1016/j.evalprogplan.2011.10.003] [Medline: 22221889]
53. Kane M, Trochim WMK. Concept Mapping for Planning and Evaluation. Sage Publications; 2007. ISBN: 9781412940276
54. World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. JAMA. Nov 27, 2013;310(20):2191-2194. [doi: 10.1001/jama.2013.281053] [Medline: 24141714]
55. Begriffsabgrenzung Videosprechstunde, Telekonsultation und Telekonsil [Video in German]. Docs in Clouds Youtube page. May 4, 2020. URL: https://www.youtube.com/watch?v=iYE1wXAq9fw [Accessed 2026-10-22]
56. Ward JH. Hierarchical grouping to optimize an objective function. J Am Stat Assoc. Mar 1963;58(301):236-244. [doi: 10.1080/01621459.1963.10500845]
57. Afifi AA, Clark V. Computer-Aided Multivariate Analysis. 3rd ed. Chapman & Hall; 1999. ISBN: 9780412730603
58. Kruskal JB. Multidimensional scaling by optimizing goodness of fit to a nonmetric hypothesis. Psychometrika. Mar 1964;29(1):1-27. [doi: 10.1007/BF02289565]
59. ACGME common program requirements (residency). Accreditation Council for Graduate Medical Education (ACGME); 2025. URL: https://www.acgme.org/globalassets/pfassets/programrequirements/2025-reformatted-requirements/cprresidency_2025_reformatted.pdf [Accessed 2026-01-02]
60. Lauer AK, Lauer DA. The good doctor: more than medical knowledge & surgical skill. Ann Eye Sci. Jul 2017;2:36. [doi: 10.21037/aes.2017.05.04] [Medline: 30246173]
61. Telemedicine curriculum and training modules for family medicine. Society of Teachers of Family Medicine (STFM). URL: https://www.stfm.org/teachingresources/curriculum/telemedicine/telemedicinecurriculum/#:~:text=Use%20STFM%27s%20Telemedicine%20Curriculum%20to%20give%20your%20learners,five%20online%20training%20modules%20for%20residents%20and%20students [Accessed 2026-10-22]
62. Telehealth competencies across the learning continuum—version 2.0—quick reference summary. Association of American Medical Colleges (AAMC); 2026. URL: https://www.aamc.org/media/91111/download?attachment [Accessed 2026-01-02]
63. Chandra S, Weems K, Howley L. Telehealth competencies across the learning continuum: new and emerging areas in medicine series. Association of American Medical Colleges (AAMC); 2026. URL: https://www.aamc.org/about-us/medical-education/cbme/publication/telehealth-competencies-across-learning-continuum [Accessed 2026-10-22]

64. Telemedicine curriculum learning objectives mapped to AAMC telehealth competencies. Society of Teachers of Family Medicine (STFM); 2021. URL: https://www.stfm.org/media/3556/stfm-telemedicine-curriculum-learning-objectives.pdf [Accessed 2026-10-22]
65. Rhone K, Flanagan W. Evidence-based competencies to build a telehealth education program. American Telemedicine Association (ATA); 2021. URL: https://f.hubspotusercontent30.net/hubfs/5096139/ATA%20Partners/ATA%20ABT%20Webinar%20Top%208%20Competencies.pdf?utm_campaign=Member%20News&utm_medium=email&_hsmi=2&_hsenc=p2ANqtz-9i5MWHo4tIixiQufiTkMj535cTeQthghBe0_PVmeCQBWeSe9RxE9Lw8d3ChJo5KSz2Wsth7QUdx9COAvFcs5GkCwKqpeGclcEWTRMIm5I0_Y-rMD8&utm_content=2&utm_source=hs_email [Accessed 2026-10-31]
66. Sturrock K, Rocha J. A multidimensional scaling stress evaluation table. Field Methods. Feb 2000;12(1):49-60. [doi: 10.1177/1525822X0001200104]
67. Scott TE, Costich M, Fiorino EK, Paradise Black N. Using a modified Delphi methodology to identify essential telemedicine skills for pediatric residents. Acad Pediatr. Apr 2023;23(3):511-517. [doi: 10.1016/j.acap.2022.08.014] [Medline: 36084799]
68. Powers BB, Van Zuilen RM, Schwartz AW, et al. Competencies for video telemedicine with older adult patients. J Am Geriatr Soc. Apr 2023;71(4):1283-1290. [doi: 10.1111/jgs.18246] [Medline: 36951209]
69. Lam K. Endoscopist deskilling risk after exposure to artificial intelligence in colonoscopy. Lancet Gastroenterol Hepatol. Dec 2025;10(12):1060. [doi: 10.1016/S2468-1253(25)00290-0] [Medline: 41205614]

Abbreviations

ACGME: Accreditation Council for Graduate Medical Education
BV: bridging value
GCM: group concept mapping
HCP: health care professional
RWTH: Rheinisch-Westfälische Technische Hochschule
SV: stress value

Edited by Javad Sarvestan; peer-reviewed by Kabelo Leonard Mauco, Miguel Sousa, Teng Peng; submitted 19.Jan.2026; final revised version received 30.Sep.2026; accepted 06.Oct.2026; published 19.Nov.2026

Please cite as:
Martin T, Vogt L, Klasen M, Veldeman S, Follmann A, Sopka S
Learning Objectives for a Telemedicine Curriculum in Medical Education: Group Concept Mapping Study
JMIR Form Res 2026;10:e91748
URL: https://formative.jmir.org/2026/1/e91748
doi: 10.2196/91748

© Tobias Martin, Lina Vogt, Martin Klasen, Sarah Veldeman, Andreas Follmann, Sasa Sopka. Originally published in JMIR Formative Research (https://formative.jmir.org), 19.Nov.2026. This is an open-access article distributed under the terms of the Creative Commons Attribution License (https://creativecommons.org/licenses/by/4.0/), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work, first published in JMIR Formative Research, is properly cited. The complete bibliographic information, a link to the original publication on https://formative.jmir.org, as well as this copyright and license information must be included.