Development and implementation of VR-simulated experiences to train communication skills

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A VR EXPERIENCE EXPOSING THE HIDDEN CURRICULUM OF THE OPERATING ROOM: A CASE STUDY

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ABSTRACT

Introduction

The rise of immersive technologies, particularly VR, has significantly impacted medical education. During the COVID-19 pandemic, medical students faced a dearth of exposure to the clinical environment, notably the operating room, which impeded their learning. Vital habits acquired through physical presence and implicit learning were notably lacking. This paper delineates the development of a dual VR experience, offering insights into the unspoken norms and hidden curriculum of the OR from a first-person perspective.

Methods

Our set-up included a development process, incorporating considerations of user experience, technical implementation, content creation, and validation. Content creation involved the collaborative delineation of how medical students navigate their initiation into the OR, engaging stakeholders through storyboards and scripts.

Results

The script and storyboard were initially conceptualized by the principal researcher following an in-depth study of landmark articles on the hidden curriculum and field observations. Validation was performed through group discussions with an expert panel comprising medical students, OR assistants, surgeons, anaesthesiologists, and educators.

Conclusions and practice implications

The findings and insights presented herein contribute to the growing knowledge domain of educational VR development. They underscore the feasibility and potential of harnessing immersive technologies to cultivate engaging and impactful virtual experiences.

INTRODUCTION

Clinical skills learning during the preclinical years serves the purpose of equipping medical students with essential clinical competencies (1). These include skills in clinical examination, mastering basic medical procedures, refining history-taking techniques, and enhancing clinical communication abilities. By integrating CSL into the early stages of medical education, students have the opportunity to familiarize themselves with crucial aspects of patient care before entering the clinical setting.

However, alongside formal instruction, there is often an overlooked yet influential aspect of medical education known as the hidden curriculum (2). First developed by Hafferty in 1994, the hidden curriculum encompasses the influences within the organizational and cultural fabric of medical institutions that shape students' learning experiences (2). While formal education focuses on explicit learning objectives, the hidden curriculum imparts implicit messages through everyday practices, norms, and interactions within the medical community. These implicit learning patterns underscore the importance of ample opportunities for experience in clinical settings. Where the hidden curriculum encompasses a wide range of implicit lessons and values, the *etiquette* of a work environment refers to the expected behaviors and norms within a particular workspace.

Increasing levels of burnout among medical students have raised concerns, emphasizing the need for educators to grasp contemporary junior doctor perspectives during their transition from school banks to the work floor (3). Managing challenges and transitions stimulates learning, but understanding these perspectives is crucial for preparing and supporting medical graduates.

Unfortunately, logistical challenges compounded by a high number of medical students seeking clerkships in popular specialisms such as surgery and anesthesiology may lead to waiting lists for placements in the OR, further hindering medical students' access to essential hands-on experiences.

The COVID-19 pandemic worsened existing challenges. For logistical and hygienic reasons, medical students are often prohibited from participating in hospital rotations and operating room (OR) experiences, leading to the cancellation of clerkships and hands-on clinical training opportunities (4). This disruption highlighted the importance of innovative approaches to clinical skills acquisition.

Medical education has increasingly embraced experiential learning as a means of enhancing clinical skill acquisition. Immersive technologies, particularly virtual reality (VR), have gained prominence in this regard (5-9). VR aligns with Constructivist Theory, positing that learners actively construct knowledge by building upon existing mental frameworks (10,

11). In immersive VR environments, students engage in hands-on exploration, facilitating deeper understanding and meaning-making from their experience. Moreover, VR-based immersive learning offers unique advantages by leveraging various sensory modalities to enhance engagement and *embodiment*. Through the phenomenon of embodiment, VR users can visually substitute their real bodies with life-sized virtual representations, experiencing scenarios from a first-person perspective. This concept, known as the *Proteus effect*, enables users to momentarily inhabit virtual personas, fostering a heightened sense of presence and emotional immersion (12). The integration of multisensory and motor systems during VR experiences further enhances cognitive processing, leading to realistic emotional and neurocognitive responses (13, 14). For instance, individuals who embody avatars with physically attractive features tend to engage in more confident and assertive behavior within the virtual space, mirroring the perceived traits of their avatars (15). This explains how a VR-embodied experience may be more influential than simply watching a video.

Considering the challenges posed by traditional clinical training methods, VR represents a promising solution. Unlike conventional approaches, VR transcends spatial and temporal constraints, allowing medical students to access immersive learning experiences remotely. By simulating scenarios akin to those encountered in the OR, VR offers students invaluable exposure that is critical for their future medical careers.

This paper delineates the development of a dual VR experience, offering insights into the unspoken norms and hidden curriculum of the OR from a first-person perspective. It was part of a blended learning project in which an existing e-learning module was enhanced.

METHODS

This prospective exploratory study was carried out at the Leiden University Medical Center (LUMC, Leiden, the Netherlands), a large tertiary academic teaching hospital.

Informed consent was obtained prior to inclusion, participation was voluntary, and ethics and privacy rights were in alignment with the Declaration of Helsinki and GDPR guidelines, respectively. Data collection and development were conducted between July 2020 and February 2021. Participants received no financial compensation for participation.

Participants and procedures

Participants were asked to join in crafting the dual VR experiences after an initial email invitation describing the research project followed by an in-person meeting with eligible participants. Involvement included tasks such as crafting content, ensuring its accuracy, and filming and refining the VR experiences, as outlined in **Figure 1**. The participants

included a panel of medical students, OR assistants, surgeons, anesthesiologists, and educators.

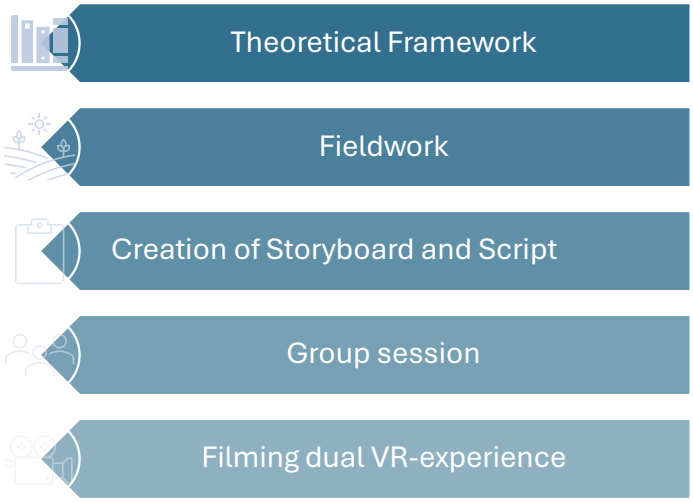

Figure 1. Structure of the study

Theoretic Framework and Content Creation

To construct the storyboard and script depicting the typical journey of a new medical student who starts working at the OR center, we began by establishing a theoretical framework grounded in seminal literature within the relevant field. Specifically, we drew upon landmark qualitative and quantitative studies depicting typical challenges of medical students debuting their careers in the OR, as well as articles on the hidden curriculum in this specific context (3, 16-19).

As Surmon et al. (2016) state, possible negative influences on the preparedness of medical students may involve a) uncertainty, b) disconnection, and c) feeling a part of the team (18). Uncertainty and insecurity of medical students in terms of what is expected of them occur frequently. In earlier studies, students cited the existence of unwritten rules or a hidden curriculum lacking familiarity with the clinical environment (20). Disconnection between the preclinical and clinical curricula contributes to challenges in the preparedness of medical students. As students often feel unsure of hierarchy and how professionals work together, these preoccupations may impede feelings as a part of the team. Throughout content creation, efforts were made to expose medical students to elements of the *etiquette* and hidden curriculum that potentially mitigate these negative influences.

As demonstrated by the work of Laraia et al. (2024), healthcare providers working in the operating room express concerns that students adopt a too passive role, lack situational awareness regarding when or when not to ask questions, and may lack understanding of sterility and the operating room workflow (19). A schematic overview of these themes as described by Laraia et al. (2024) from the OR can be found in **Figure 2** (19).

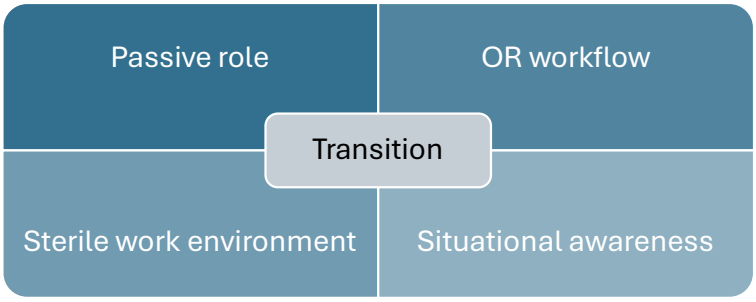

Figure 2. Schematic overview of thematic barriers impeding the transition to the clinical environment

Furthermore, the researcher (KH) engaged in fieldwork comprising informal discussions with healthcare providers, educators and medical students supplemented by observational data collection. This approach facilitated the development of an initial script outlining medical student journeys.

Two VR experiences were to be developed: one in which a colleague medical student fails to adhere to a rule or follow OR *etiquette*, and the other portraying a colleague medical student who respects the rules and *etiquette* of the OR. The specific communication styles, attitudes and professional conduct of the OR needed to be shown, exposing important elements of the hidden curriculum of the OR implicitly. The two VR experiences differed only slightly, requiring the learner to focus and decipher how these differences would impact a workday. We decided on the epistemological assumption to let the learner *feel* these differences, rather than explaining them, by adhering to constructivist theory (11).

Content validation

Group sessions are an adapted tool for validating storyboards and scripts (21). Group input, such as photographs, focused and selective observation notes, reflective notes and commentaries, was used to write and adapt the medical student journey, which was used for final validation until a consensus was reached; that is, until the final script was obtained, all group members provided consent (22).

The specific learning objectives were verified once more by the educators during a final session.

Filming and editing

Requesting that healthcare providers portray their own roles offers several benefits, including cost-effectiveness and easy identification with their professional responsibilities. We tasked the participants with embodying their respective professional roles; for instance, a surgeon would portray the role of a surgeon, a medical student was asked to play a medical student, and so forth. An anaesthetic nurse volunteered to play the patient, as she had already been a patient in our hospital before.

The shooting of the VR-experiences was done with a *GoPro®* camera. Editing and stitching were performed using *PTGUI®*, a panoramic image stitching software, as well as *Pano2VR®*, a virtual tour software that converts 360° into interactive experiences.

RESULTS

Participants and procedure

Seven healthcare professionals participated in the development of the VR-experiences. This included one OR- assistant, two surgeons, two anaesthetic nurses, and two anaesthesiologist. Two medical students participated, as did two educationalists and one VR cameraman/editor, as shown in Table 1. Participants were invited to participate during the development process of the VR experiences, including content creation, validation through a group session, and filming of the VR experiences.

Table 1. Demographics

Role	Number
Medical student	2
OR assistant	1
Anaesthesiologist	2
Surgeon	2
Anaesthetic nurse	2
Educationalist	2
VR cameraman and editor	1

Development of the VR-experiences

Data collection and development were conducted between July 2020 and February 2021. The final durations of the experiences were seven minutes and 32 seconds and seven minutes and 26 seconds, respectively. The narrative environment required consistency with reality, employing objects, characters, and actions to enhance the feeling of immersive *presence*.

A blueprint framework was written describing the purpose of the project, the current education, the learning objectives (cognitive, affective, psychometric), the priming of prior knowledge, and when the education was deemed to be successful, as shown in **Figure 3** and detailed in **Annex 1**.

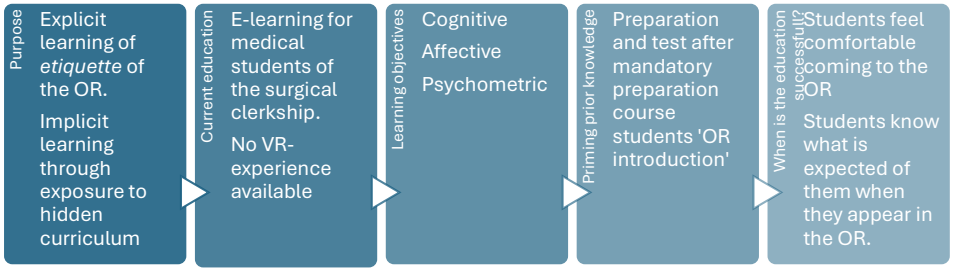

Figure 3. Blueprint of 1) purpose, 2) current education, 3) learning objectives, 3) priming before knowledge and 4) educational success

Script and Storyboard

The fieldwork and group sessions further specified the themes, as shown in **Figure 2**, into specific examples to be used for the storyboard, as described below.

Passive role

As students seem lost and do not seem to show any initiative, in the first experience, the medical student interpreted this passive role by not asking any questions, whereas in the second experience, the student actively asked the surgeon if and how he might participate during the procedure.

OR workflow

Students may enter or exit the OR at unfortunate moments, such as team briefing, debriefing or anaesthesia induction. In the first experience, the medical student enters during induction and is corrected by the anaesthesiologist afterwards. In the second video, the medical student awaits the end of induction before entering the OR.

Sterile work environment

Healthcare professionals express dissatisfaction with respect to sterility among medical students. In the first experience, the medical student enters during a prosthetic surgical procedure, a procedure where door movements need to be as limited as possible. He touched the sterile working space by accident. In the second video, the medical student asks for the right information and changes his schedule to be able to stay for another surgical nonprosthetic surgery. Additionally, in the second video, the medical student assures the correct distance from the sterile working space.

Situational awareness

Introducing themselves needs to be done at the right moment without interrupting healthcare providers. The same applies to asking questions, which healthcare providers encourage, provided that the clinical situation permits. In the first video, the medical student tries to introduce himself after entering the operating room, while the induction of anaesthesia has already started, interrupting this process. In the second video, the medical student enters the room, checks if the clinical situation is 'under control' before introducing himself, and asks how he might assist.

The storyboard provides an overview of the different scenes, as shown in **Figure 4**. The full script of the dual VR experiences is available in **Annex 2**.

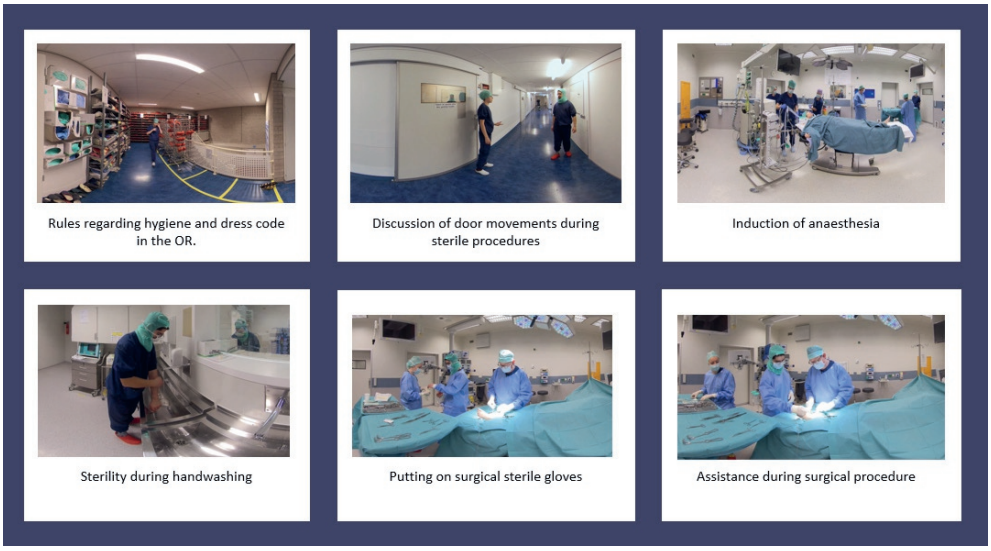

Figure 4. Storyboard of different scenes of the VR experiences

An overview of the main differences in interactions and shadow actions between the two experiences can also be found in Table 2. We crafted a script featuring 'shadow actions' that were observable when the learner shifted his or her gaze. Table 2 provides an overview of the key distinctions in setting, direct interactions, and shadow actions.

Table 2. Overview of the main differences in interactions and shadow actions

	First experience	Second experience
Interactions		
Entrance OR	Colleague medical student 1 forgot to take out earrings.	Respect of dress code of the OR.
Operation room	Colleague medical student 1 was refused access to an OR where prosthetic surgery was performed Colleague medical student 1 enters OR during anaesthesia induction	Colleague medical student 1verifies OR program beforehand Colleague medical student 1 checks entering the OR after anaesthesia induction
Transitional space OR	Colleague medical student 2 disrespects hand washing procedures	Colleague medical student 2 respects hand washing procedures
Shadow actions		
Entrance OR	Other healthcare professionals pass through the entrance of the OR	
Operation room	Anaesthesiologist and anaesthetic nurse intubate the patient, adapt monitoring and positioning of the patient OR nurse 1 starts prepping the patient. OR nurse 2 starts handing over sterile equipment as needed	

DISCUSSION AND CONCLUSION

Discussion

This manuscript describes the development of a dual VR experience for medical students in the OR. Through concrete Experiential Learning, medical students may *feel* what it is like to start working in the OR, preparing themselves for this important transition. As medical students commonly describe this transition as mentally, physically, and emotionally demanding, this dual VR experience may ease this transition, positively affecting their preparedness (16, 17).

We deliberately incorporated nuanced shifts in language and interactions, informed by conceptual frameworks and prior scientific investigations, as referenced in our manuscript. Moreover, the participation of healthcare providers, medical students, and educationalists further enhanced the internal validity of the experiences.

Explicit learning objectives of *etiquette* included respecting the dress code, presenting themselves appropriately upon entering the operating room, and being mindful of entrance and exit, as well as door movements, in relation to specific moments of anaesthesia and surgery. Additionally, respecting an appropriate distance from coworkers who are working in sterile conditions was emphasized. The implicit learning objectives of the hidden curriculum included the communication style of the OR and the professional conduct, roles and attitudes of different healthcare providers working in the OR.

The development of this dual VR experience was based on certain epistemological and methodological assumptions. For instance, we chose 360-degree videos with real humans instead of computer-generated images to make the video look as realistic as possible. However, this impeded interactions with the virtual environment. Learners have the ability to observe their surroundings; however, due to the recorded nature of their experiences, learners are not able to freely move around as they would in a virtual environment utilizing computer-generated 3D video imagery.

Additionally, one assumption underlying this project was that the dual VR experiences, created using 360-degree video, could effectively mimic real-life operating room experiences, which are known to ease the transition from academic learning to clinical practice (20). While 360-degree videos offer a high degree of realism by featuring real people and settings, this approach also introduces limitations. Unlike fully interactive VR environments, 360-degree video restricts the ability of learners to interact with the environment or make choices within the scenario. As a result, students may observe OR dynamics but cannot practice decision-making or physical interactions as they would in a fully immersive, interactive VR setting. This trade-off between realism and interactivity is an important consideration for future iterations of this training method.

Future directions

The results of this study have the potential to enhance ongoing research and healthcare education initiatives aiming to integrate experiential learning via VR.

Additional validation could involve assessing the first-hand experiences of medical students who engage in dual VR, along with evaluating the impact of integrating this dual VR experience into the introductory course of medical students' first surgical clerkships. Future studies should also examine the scalability of VR experiences across different medical fields and training levels.

After further validation, this education could be utilized for Bachelor's and Master's students in Clinical Technology, as well as integrated into the Bachelor of Medicine curriculum for students receiving education in the OR during their studies. Subsequently, it could be made accessible to all hospital employees who spend time in the OR as part of their job duties. Moreover, this education could be offered through the corporate training learning management system.

Conclusion

Utilizing immersive VR technology enables the creation of an interactive and captivating virtual environment, providing learners with the opportunity to engage with simulated realities. In this particular case study, medical students can immerse themselves on a typi-

cal day in the OR, where they encounter explicit etiquette and implicitly learn about the hidden curriculum of the OR.

The logistical and hygienic challenges that hinder the transition from school desks to the work floor may be overcome by the use of VR programs, such as the one described in this case study.

The development of this dual VR experience entails meticulous attention to content creation and validation. The findings and insights presented herein contribute to the growing knowledge domain of educational VR development. They underscore the feasibility and potential of harnessing immersive technologies to cultivate engaging and impactful virtual experiences

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Disclosure of Interests.

This research was subsidized by the Leiden Learning and Innovation Center. The authors have no further conflicts of interest to declare.

NOTES ON CONTRIBUTORS.

K. Hoek is a clinician specializing in education and communication within anesthesiology and intensive care and conducted this research. She was responsible for conceptualization, methodology, investigation, data curation, writing – original draft, writing – review & editing, visualization, and project administration.

M. van Velzen is an educationalist, clinical research coordinator, and assistant professor at the Department of Anaesthesiology of the Leiden University Medical Center. She contributed to validation, and supervision.

J. van der Hage is a professor of surgery, specializing in intracurricular education in surgery. He cosupervised the research and was responsible for validation, review & editing, and project administration.

E. Sarton is a Professor of Anaesthesiology specializing in education in medical training. She was responsible for supervision, and validation.

REFERENCES

1. Shuid AN, Yaman MN, Abd Kadir RA, Hussain RI, Othman SN, Nawi AM, et al. Effect of early clinical skills teaching on 3rd year medical students' learning: The student perspective. Journal of Taibah University Medical Sciences. 2015;10(1):26-32.
2. Hafferty FW, Franks R. The hidden curriculum, ethics teaching, and the structure of medical education. Acad Med. 1994;69(11):861-71.
3. Thun-Hohenstein L, Höbinger-Ablasser C, Geyerhofer S, Lampert K, Schreuer M, Fritz C. Burnout in medical students. Neuropsychiatr. 2021;35(1):17-27.
4. Jhajj S, Kaur P, Jhajj P, Ramadan A, Jain P, Upadhyay S, et al. Impact of Covid-19 on Medical Students around the Globe. J Community Hosp Intern Med Perspect. 2022;12(4):1-6.
5. Cannon-Bowers JA. Recent advances in scenario-based training for medical education. Curr Opin Anaesthesiol. 2008;21(6):784-9.
6. Gormley GJ, Murphy P. When I say … simulation. Medical Education.n/a(n/a).
7. Pottle J. Virtual reality and the transformation of medical education. Future Healthc J. 2019;6(3):181-5.
8. Le Duff M, Michinov E, Bracq MS, Mukae N, Eto M, Descamps J, et al. Virtual reality environments to train soft skills in medical and nursing education: a technical feasibility study between France and Japan. Int J Comput Assist Radiol Surg. 2023.
9. Bracq MS, Michinov E, Arnaldi B, Caillaud B, Gibaud B, Gouranton V, et al. Learning procedural skills with a virtual reality simulator: An acceptability study. Nurse Educ Today. 2019;79:153-60.
10. Whitman N. A review of constructivism: understanding and using a relatively new theory. Fam Med. 1993;25(8):517-21.
11. Anthony G. Active Learning in a Constructivist Framework. Educational Studies in Mathematics. 1996;31(4):349-69.
12. Bian Y, Zhou C, Tian Y, Wang P, Gao F, editors. The Proteus Effect: Influence of Avatar Appearance on Social Interaction in Virtual Environments. HCI; 2015.
13. Bem D. Self-perception theory. New York: Academic Press; 1972.
14. Navarro J, Peña J, Cebolla A, Baños R. Can Avatar Appearance Influence Physical Activity? User-Avatar Similarity and Proteus Effects on Cardiac Frequency and Step Counts. Health Commun. 2022;37(2):222-9.
15. Fox J, Bailenson J, Tricase L. The embodiment of sexualized virtual selves: The Proteus effect and experiences of self-objectification via avatars. Computers in Human Behavior. 2013;29:930–8.
16. Sturman N, Tan Z, Turner J. "A steep learning curve": junior doctor perspectives on the transition from medical student to the health-care workplace. BMC Med Educ. 2017;17(1):92.
17. Alexander C, Millar J, Szmidt N, Hanlon K, Cleland J. Can new doctors be prepared for practice? A review. Clin Teach. 2014;11(3):188-92.
18. Surmon L, Bialocerkowski A, Hu W. Perceptions of preparedness for the first medical clerkship: a systematic review and synthesis. BMC Medical Education. 2016;16(1):89.
19. Laraia KN, Frias G, Pilch A, Koury A, Pepe R, Volk L, et al. Analysis of Operating Room Personnel Perspectives to Enhance Medical Student Readiness for Surgery. Journal of Surgical Education. 2024;81(1):70-5.
20. Shacklady J, Holmes E, Mason G, Davies I, Dornan T. Maturity and medical students' ease of transition into the clinical environment. Medical Teacher. 2009;31(7):621-6.
21. Stewart D, Shamdasani P, Rook D. Focus Groups. Thousand Oaks, California2007. Available from: https://methods.sagepub.com/book/focus-groups.
22. Briggs R, Kolfschoten G, de Vreede G-J. Toward a Theoretical Model of Consensus Building2005. 12 p.