The Co-Design of Simulation-Based Training for Collaboration between Healthcare Services

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Abstract. As part of developing simulation-based training for better collaboration between healthcare services, we developed instruments for measuring key teamwork constructs *role understanding* (*responsibility*), *trust*, *communication* and *collaboration* as experienced during simulation-based training in virtual reality. We co-designed these instruments together with healthcare workers and healthcare students in three workshops and a survey. We followed a method for generating unidimensional *Thurstone scales* with equal-appearing intervals. We then used the instruments in training sessions with healthcare students. We gathered feedback on the simulation and conducted initial analyses on the instrument data. Results are encouraging for the simulation design, but with clear points for improvement. The preliminary analyses from the instruments indicate that they seem to measure the intended constructs as perceived by the training audience. Correlational analyses indicate relationships between these constructs, particularly highlighting the challenge of balancing responsibility with trust and collaboration. Findings advocate the potential in our approach to mirror realistically, and improve, collaborative practices among healthcare professionals.

Keywords: Scenario Design · Measurement Instruments · Healthcare Collaboration · Virtual Reality · Simulation-Based Training · Survey

1 Motivation

National health reforms geared towards efficiency tend to attempt to increase patient throughput by offloading post treatment onto local health services, often without implementing measures for the transfer, reception and treatment at local institutions. Norway and its neighboring Nordic countries have been at the forefront globally in organizing healthcare for its citizens. Nevertheless, recent research has uncovered that personnel with municipal healthcare services might not have the required skills regarding emergencies and general observation abilities [1]. Furthermore, specialist staff at hospitals do not have sufficient knowledge
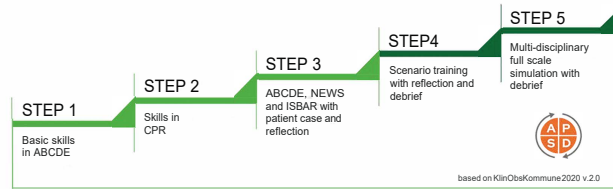
Fig. 1. Steps of the KlinObsKommune framework

about the skills of municipal healthcare personnel. Collaboration and communication issues due to different fields of expertise, work cultures, non-interoperable processes [2,3,4] and suboptimal, non-interoperable IT services [5,6,7] regularly lead to frustration for all involved. In the past years, studies focusing on capability improvement have greatly highlighted the urgent need for enhanced training in emergency response and observation skills among municipal healthcare personnel [8]. This is crucial as healthcare personnel face increasingly complex cases due to earlier hospital discharges, emphasizing the necessity for systematic professional development to ensure high-quality patient care.

Healthcare workers in several Norwegian municipalities have in the recent years initiated work to improve on this situation, and developed, among other things, the Clinical Observation in Municipalities Competence Model (KlinObsKommune) [9], which addresses the education of municipal and specialist healthcare personnel in a five-step model (Fig. 1). In Steps 1 and 2, personnel train their skills in systematic patient observation using the *Airway, Breathing, Circulation, Disability, Exposure* (ABCDE) approach [10] and cardiopulmonary resuscitation (CPR). In Step 3, the integration of ABCDE with the *National Early Warning Score* (NEWS) for further clinical observation and decision-making is trained, together with the communication format *Identify, Situation, Background, Assessment and Recommendation* (ISBAR) [11]. Step 4 concerns training the ensuing collaboration within the municipal healthcare system to handle clinical patient deterioration, and Step 5 concerns training the ensuing collaboration between municipal and specialist healthcare systems. Focusing on Steps 4 and 5 is crucial as they address the vital need for enhanced collaboration between municipal and specialist healthcare systems.

Reality does *not*, at present, comply with the KlinObsKommune model. It takes time for Steps 1–3 to be fully in place, and one has to train collaboration skills even when basic skills are lacking [12]. We are therefore developing simulation-based training for collaboration, with the backdrop that basic skills are not in place.

2   Simulation-Based Training

We are developing a series of vignettes for training collaboration between healthcare workers in and between healthcare units. A vignette is a small, reusable,

temporarily ordered set of events that are ideally self-contained so that they can be reused in multiple scenarios [13]. The idea is that the vignettes can be combined to form a larger parts of patient processing through and across multiple healthcare units and services; for example from the patient's home, via various municipal services to the hospital and back.

Here, we focus on a vignette that starts at the patient's home and which concerns the first stage of collaboration to determine how and where the patient should be treated next. Figure 2 shows the flow of the vignette under development, where a home care worker must detect clinical deterioration in a patient. The worker might not be proficient in ABCDE, NEWS or ISBAR, and in reality, this has led to unfortunate outcomes for patients, when home care workers spend valuable time consulting peers or their administrative nurse in charge (which may be unavailable) or, in a worst-case scenario, may simply leave the premises counting on the next shift to deal with the problem. This vignette was developed earlier in a workshop with health administrators and practitioners to match situations that a home care worker may encounter [14]. In the vignette, the worker should consult the next stage in patient management, which is the emergency room. If the worker cannot perform ABCDE, NEWS or ISBAR satisfactorily, the emergency room nurse is to recognize this and collaborate with the home care worker in performing these procedures over the telephone and to reach a safe decision for the patient, rather than asking the home care worker to call back after all the observations are conducted.

The training sessions are based on deliberate practice principles [15] and integrate the PEARLS debriefing tool [16] to enhance learning [17]. The session consist of the following steps:

1. Introduction and learning objectives
2. Training in the vignette
3. PEARLS debrief with discussions on learning objectives and points of improvement
4. Retraining in the vignette
5. PEARLS debrief with discussions on learning objectives, changes from the first training session and points of improvement in real-life practice

The small circular (orange) symbols in Fig. 2 indicate points of observation during a play and prompts for ensuring the play is completed. For example, at the uppermost phone symbol, there is an observations point as to whether the home care worker makes a phone call, a prompt for making the call if it is evident that the home care worker is not intending to make the call, and a note that the failure to do so is to be discussed in the debrief. All of these activities are denoted *Game Master activities*, reflecting that plays are facilitated by a game master. However, some of theses activities may be covered automatically when computerized simulation systems are involved, and may also be registered by self-reflection in non-facilitated versions of the play; for example, when participants are given the opportunity to train at their own leisure for efficiency reasons.

There are a number of observation points in the diagram, but the current stage of the co-design effort focuses on those highlighted in frames: *role un-*
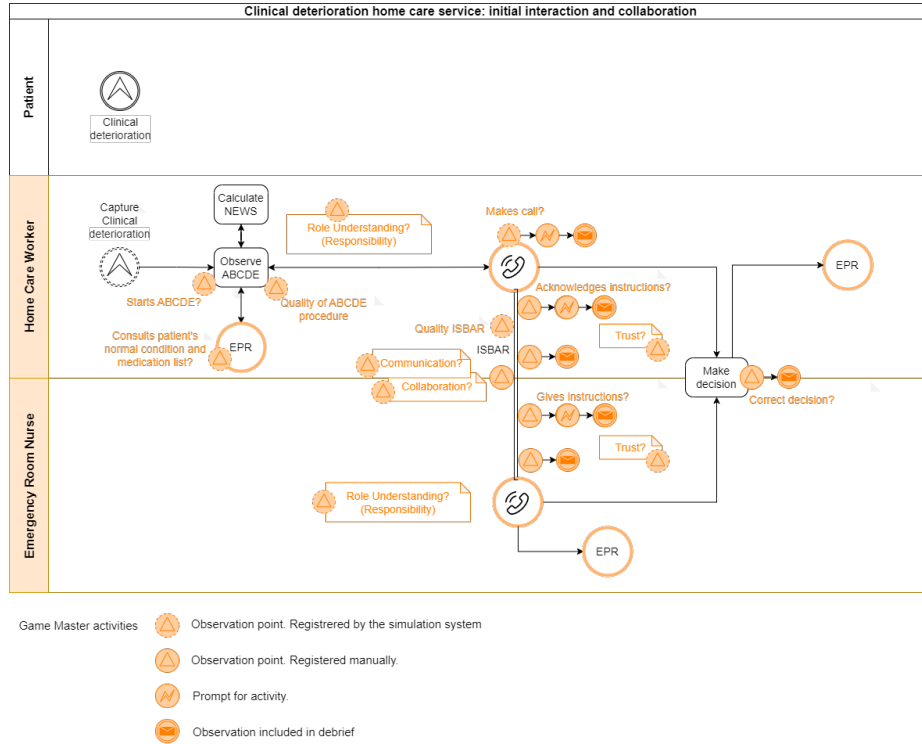
Fig. 2. Work flow in vignette for a clinical deterioration collaboration case

derstanding (*responsibility*), *trust*, *communication* and *collaboration*. These four concepts arose as central points for improvement in the above-mentioned workshop [14].

3   Training Objectives and Key Results

We formulate the training objectives and desired observable outcomes in terms of *Objectives and Key Results* (OKR) [18]. OKRs are used in a variety of ways; including at the organizational, team and individual levels. For the current study, the individual and team levels are appropriate. While we have decided to fix the objectives for the current vignette based on the workshop with healthcare administrators and practitioners [14], we wish to co-design the key results that operationalize the concepts together with the specific health care workers that constitute the vignette's main training audience. The reason for this is twofold: First, this adheres to design principles we state below for increasing the relevance of measurement instruments. Secondly, when searching extensively for suitable measurement instruments in the literature, we found measurement items that concern responsibility and trust as more persistent traits at the institutional and

personal levels, but nothing that pertains to these concepts in *a given situation.* For communication and collaboration, there are bodies of work on how to analyze discourse [19,20] and interaction [21,22,23], but these rely on content and thematic analyses of transcripts of verbal interaction, whereas we are interested in measuring communication and communication as experienced in the situation. In the OKRs below for the vignette in Figure 2, some suggestions for key results are given, but these are to be determined in the co-design workshops.

Home Care Worker (Individual):
Objectives:
- To increase my role understanding, in terms of my responsibility and my importance in this situation
- To increase my trust in the person with whom I am collaborating

Key Results:
- I take better responsibility for making sure to understand the patient's clinical status with the means at my disposal
- ...

Emergency Room Nurse (Individual):
Objectives:
- To increase my role understanding, in terms of my responsibility and my importance in this situation
- To increase my trust in the person with whom I am collaborating

Key Results:
- I take better responsibility for making sure to get the necessary information about the patient's clinical status from the caller.
- I try harder to instill trust in my collaboration with the home care worker
- ...

Both (Team):
Objectives:
- To improve communication per telephone
- To improve collaboration per telephone

Key Results:
- We are better at constructive communication toward deciding the next step for taking care of the patient
- We are better at having a shared constructive development toward uncovering the patient's clinical status
- ...

An objective and its key results speak in terms of changes on underlying constructs; here, *role understanding*, *trust*, *collaboration* and *communication*. A construct consists of a concept together with measurable indicators. This constitutes a reflective measurement model, in which the indicators operationalize the concept [24].

4   The Virtual Reality Application

We opted to create a Virtual Reality (VR) training program for health personnel, allowing healthcare personnel to practice complex scenarios and communication strategies in a controlled environment. Its immersive nature allows for a realistic simulation of healthcare scenarios—enabling practitioners from various disciplines to engage in collaborative tasks in a controlled, risk-free environment. This hands-on approach has the possibility to facilitate a deeper understanding of each other's roles, challenges, and communication styles, which is critical in a multidisciplinary healthcare setting.

The vignette is the first of several that will be developed for collaboration training and implemented in a VR development platform (Unity) for simulation-based training. Apart from the immersive aspects, VR has been chosen for simulating various clinical deteriorations in patients and for enabling distributed training at locations where human markers (enacting ill patients) or physical simulation dolls may not be available.

After registering their name and joining a group (for pairwise training), participants will find themselves in the lobby for the introduction and debrief (Fig. 3). Upon entry, they will see avatars of the other participants in the simulation, read the training objectives, choose their role (home care worker or emergency room nurse), and commence training. can talk to each other in the lobby.

Once the training starts, participants are either a home care worker in a patient's home (Fig. 4) or a nurse taking calls for the municipality's emergency room (Fig. 5). In the patient's home, there is a screen showing basic patient information, the patient's habitual state and page for registering patient mea-
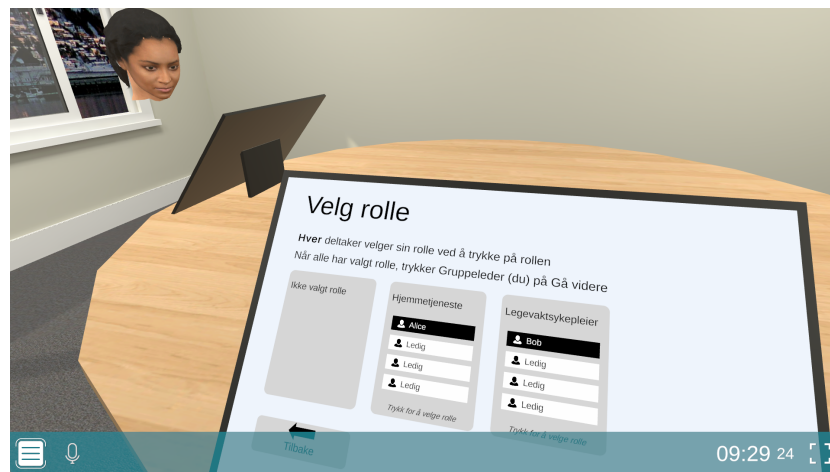

Fig. 3. In the lobby, prior to training, participants choose roles and initiate training. The lobby is also where the debrief takes place.
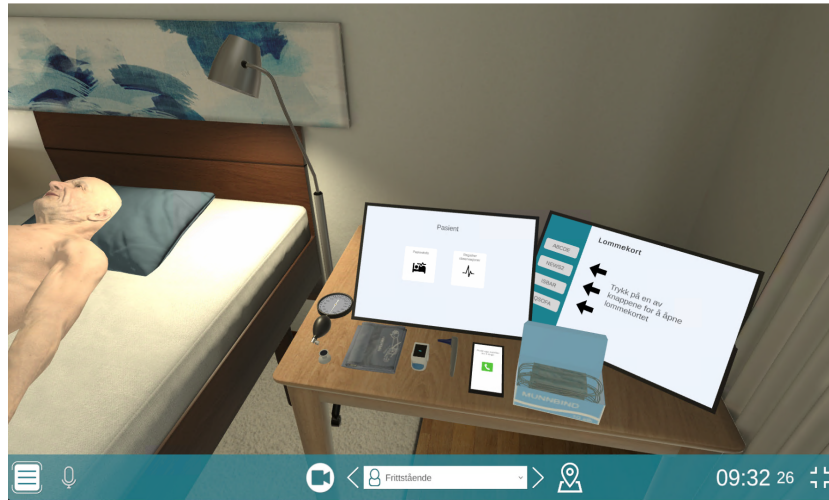
Fig. 4. In the patient home, the home care worker can use tools to check on the status of the patient and call the emergency room to discuss the next steps. Communication with the emergency room should be done using ABCDE and ISBAR.

surements. There are also tools for checking the patient's vital signs and a telephone for calling the emergency room. Further, there is a screen that provides the ISBAR, ABCDE and NEWS procedures. These screens emulate what home care workers usually have on their hand-held devices and on procedural quick
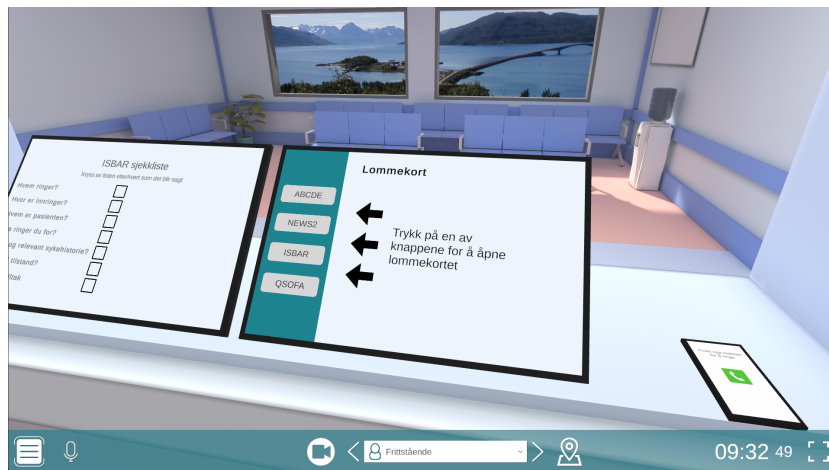

Fig. 5. In the emergency room, the emergency room nurse takes calls from the home care worker, communicates using ABCDE and ISBAR, and comes to a solution for the next step with the home care worker.

reference cards. The care worker is to examine the patient and determine what should be done next (possibly with the help of the emergency room nurse).

In the emergency room, the nurse has screens that provide checklists for ABCDE, ISBAR, and NEWS, as well as a medical index used in their daily work for triage and diagnosis. In addition, there is a telephone where the nurse can receive calls from the home care worker. At this point in the simulation, they can only discuss with each other after picking up the phone. Although it is possible in the scenario for the emergency room nurse to call the home care worker, the instructions are to wait for the call and insist on getting information via ISBAR and ABCDE, helping the home care worker to do so, if necessary.

5   Studies

For the co-design of the measurement instruments for the four constructs *role understanding* (*responsibility*), *trust*, *collaboration* and *communication*, we conducted three workshops with participants from four municipalities, where home care workers and emergency room nurses played the vignette to experience the situation in the vignette; whereupon they were interviewed on what actions (on the part of either role) they would say were characteristic of each of the four constructs. Several hundreds of statements were elicited in the three workshops. These statements were then used to form a survey in which respondents were to rate the degree to which each statement witnesses the relevant construct. The survey was distributed to healthcare workers, as well as to the training audience for the planned training session at the end. We then used the instrument in an actual training session in an educational setting at a high school that has a program for training health-care workers at the vocational level. Figure 6 summarizes these activities. We will describe each of them in the following sections.
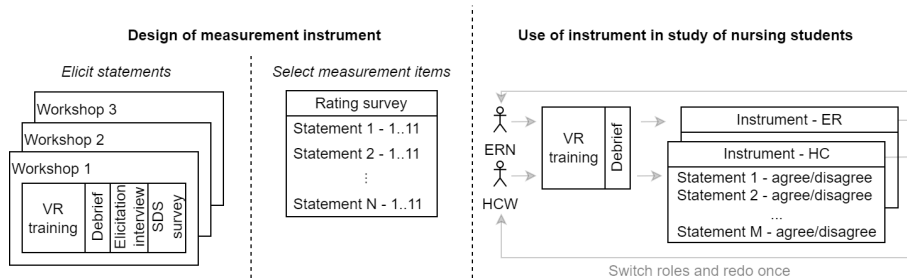

Fig. 6. Overview of the research process: Elicitation of statements (three workshops), selection of measurement items (survey), and the use of the instrument (workshop). Participating actors are emergency room nurses (ER) and home care workers (HC).

5.1   Design Approach for the Measurement Instruments

We declared the following design principles for the co-design of the measurement instruments for the four constructs:

Direct relevance: Those whose skills will be measured will be involved in designing the measurement items
Situational focus: The measurements concern the situation in the vignette
Structured elicitation: The measurement items are to be elicited in a structured manner

The co-design workshops described below observed these principles.

5.2   Co-Design Workshops

We conducted three co-design workshops on three separate days with home care workers and emergency room nurses in four municipalities in a region of Norway. Workshops 1 and 2 involved healthcare professionals from one municipality each, while Workshop 3 involved healthcare professionals from the two remaining municipalities. A total of nine pairs of home care workers and emergency room nurses participated in the workshops by playing the simulation pair by pair. In each play, the home care worker used a VR headset and two hand controllers to join the simulation, while the emergency room nurse and the game master joined the simulation on their respective PC desktop clients. The emergency room nurses also had pen and paper for taking notes.

Each play started with a brief introduction from the researchers as to the overall purpose of the workshop. Then the home care worker and the emergency room nurse went to separate rooms. The home care worker was led through basic training in the VR environment for gaining familiarity with the headset and controls and for handling the medical equipment for measuring blood pressure, O^2 saturation and temperature and for examining a virtual patient by sight and touch. The emergency room nurse was familiarized with the virtual emergency room environment and also entered the equipment training area via the desktop client to become familiar with how the virtual equipment functions for the home care worker.

After this, both participants entered the lobby, chose names and the appropriate roles, and were presented with ethics and confidentiality information, as well as the learning objectives (Sect. 3). The simulation started with the health care worker entering the apartment of a patient and the emergency room nurse taken to the telephone dispatch at an emergency room. To help when there was ambiguity in the simulation and to maintain the flow in the simulation, one of the researchers facilitated the simulation as a game master [25]. The game master also gave voice to the patient to respond to home care workers who spoke with the patient. The simulation was then played through once with a PEARLS debrief facilitated by the game master. For these elicitation workshops, retraining was dropped. The game master then invited the participants back to reality and the VR equipment was parked.

We then commenced a structured method for developing unidimensional *Thurstone scales* with equal-appearing intervals [26] for each construct. Based on the experience they had just been through, we elicited potential measurement items by posing directed question for each of the basic constructs and asking participants what it is to act, in the particular situation of the vignette, according to a healthcare professional that does, and does not, exhibit role understanding (responsibility), trust, good communication and good collaboration. The elicitation session took the form of a structured interview on the questions in Fig. 7.

We found that is was better to ask these questions in an interview form, rather than as a survey, as this allowed us to focus the participants and to prompt the participants to consider additional conditions in the situation. For example, if an emergency room nurse would say "the home care worker would have vital readings ready before calling", we could ask, "what if the home care worker doesn't know how to take these readings?"

Providing an interview form was also beneficial for employing the Thurstones scaling method, allowing for a more dynamic interaction, and enabling us as re-

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1. In the situation you were in, what does a home care worker do who takes responsibility for the patient?
2. In the situation you were in, what does an emergency room nurse do who takes responsibility for the patient?
3. In the situation you were in, what does a home care worker do who does not take responsibility for the patient?
4. In the situation you were in, what does an emergency room nurse do who does not take responsibility for the patient?
5. In the situation you were in, what does a home care worker do who trusts the person they are talking to on the phone?
6. In the situation you were in, what does an emergency room nurse do who trusts the person they are talking to on the phone?
7. In the situation you were in, what does a home care worker do who does not trust the person they are speaking to on the phone?
8. In the situation you were in, what does an emergency room nurse do who does not trust the person they are speaking to on the phone?
9. In the situation you were in, what do a home care worker and an emergency room nurse do who communicate well over the phone?
10. In the situation you were in, what do a home care worker and an emergency room nurse do who communicate poorly over the phone?
11. In the situation you were in, what do a home care worker and an emergency room nurse do who collaborate well over the phone?
12. In the situation you were in, what do a home care worker and an emergency room nurse do who collaborate poorly over the phone?

Fig. 7. Questions used for eliciting statements on the four constructs

searchers to probe deeper into the initial responses to the questions, ensuring that statements generated for scaling could capture a more comprehensive range of perspectives and situations. Furthermore, this would enhance the scaling process by ensuring that the statements are grounded in real-world experiences, which can facilitate a more accurate analysis (in terms of medians and interquartile ranges; see below) of the responses from the participants.

5.3   The Simulation Design Scale

Although not the main purpose of the elicitation studies, we asked all the participants to answer the Simulation Design Scale (SDS) [27] to get feedback on the simulation design and implementation. As can be seen from the boxplots in Fig. 8, the median responses vary between agree (4) and strongly agree (5). It is worth noting that the statement that is perhaps the most important for the design of the simulation—D13: *The simulation allowed me the opportunity to prioritize nursing assessments and care*—had more variation in responses than most other statements. Still, the median response is 4 (agree).

In conjunction to administering the SDS, we also asked for concrete points for improvement. The most important points concerned confusion on the part of the home care worker when entering the patient's room, due to the open screens next to the patient. These screens display information and entry forms that the home
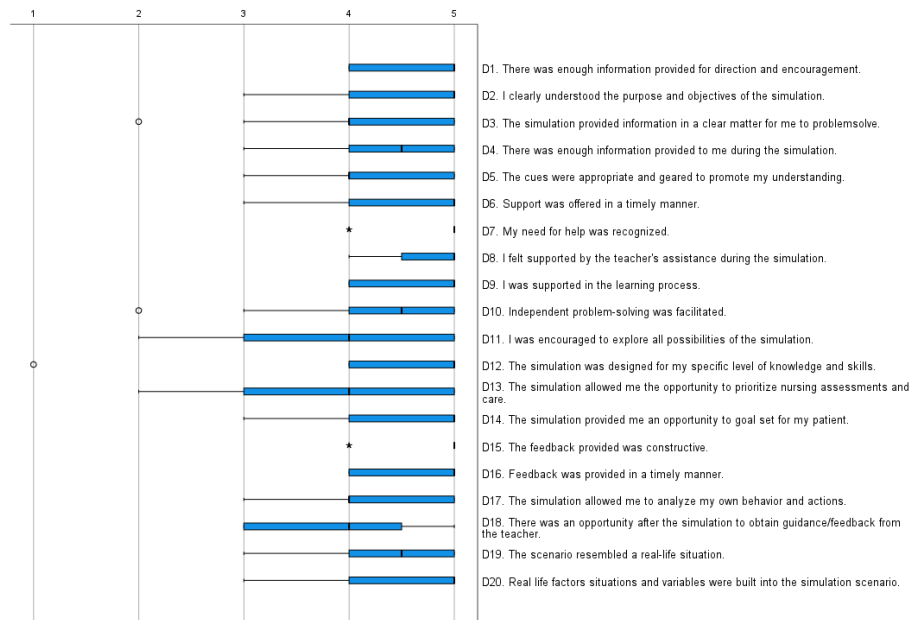

Fig. 8. Results from the SDS survey, with ratings from 1 (strongly disagree) to 5 (strongly agree). The statements D1–D20 and the rating scale can be found in [27].

care worker might access on their handheld device at need, but when presented upon entry, this presented too strong a cue to some participants, who focused their attention on these screens (perhaps thinking there were instructions on what to do in the simulation), rather than attending to the patient. This is part of a general issue of giving the ownership of when to use information, and also when to use medical equipment, to the player. A solution to this is to position all equipment, together with the handheld device, in an emergency rucksack (which they have in real life), which they have to open actively to get access to equipment, after which the handheld device has to be screen unlocked to access any desired information and entry forms.

5.4   Selecting the Measurement Items

After the three elicitation workshops were completed (during Nov. 2023–Jan. 2024), the full set of 298 statements (sorted under their respective constructs) were presented in an online rating form distributed by email to home service workers and emergency room nurses in the four municipalities. The respondents were required to rate each statement according to how much the statement demonstrates the relevant construct (*role understanding* (*responsibility*), *trust*, *collaboration* and *communication*), on an 11-point scale from 1 (very little) to 11 (very much). To encourage responses, each complete response was awarded with a gift voucher of NOK 500. A total of 32 responses were recorded. We also distributed the rating form to the training audience for the planned training session at the vocational high school (gift voucher of NOK 300). Eight students responded, but two responses were invalid, leaving six responses for analysis.

Given the ratings for each statement, we computed the median and the interquartile range (IQR); i.e., the difference between the third and first quartile, selecting the statements with the smallest IQR; i.e., the smallest variance. There were sometimes ties, and some statements selected this way also happened to make less sense, so following [26], we used discretion in choosing statements when necessary. We also had to use statements with tied medians (e.g., 4.5) in place for integral medians (e.g., 5) in some cases.

For the planned training session at the vocational high school, we chose to use the ratings from the training audience for the training session, rather than the ratings from the professional health-care workers. We did this for two reasons. First, for pedagogical reasons, we wanted to show the students that they had themselves contributed to developing the instruments they would be subjected to (thereby also adhering strongly to the first design principle above). Secondly, the student's ratings were more evenly distributed across the 1–11 scale, making it much easier to use the method for developing the Thurstone instruments, than if we had use the ratings of the professionals who rated overwhelmingly at the extremities of the scale. Which rating is the "correct" one is open for discussion. It is possible to administer the instruments based on the professional health-care workers ratings when desired.

For this instance, the resulting instruments to be given to the home care workers are shown in Table 1 and in Table 2 for emergency room nurses. When ad-

Home Care Worker	Weight
Responibility	
I assessed the situation, even though I am a student or unskilled.	5
I did not get along with the person at the emergency clinic and said as little as possible.	4
I made good observations, watched how the patient was breathing and performed ABC, even though I might not have been able to measure.	7
I chose not to call anyone.	2
I had vital measurements ready when I called.	8
I called for expert help due to lack of skills.	9
I took measurements where it was relevant.	6
I renounced responsibility and walked away from the situation.	1
I went in to the patient, saw that the patient was sick, and said I would come back later.	3
I ensured good communication and interaction with the emergency room nurse.	10
Trust	
I felt safe.	9
I contradicted the emergency nurse when I disagreed.	5
I shared what I did not know.	7
I became unsure of my own assessments.	6
I did not call and left the patient in a potentially critical condition.	3
I gave poor information and cooperated poorly with the emergency room nurse.	3
I did not dare to consult with the emergency room nurse.	4
I informed about the patient's condition.	8
Communication	
We ensured that the other person understood what was said.	10
We had hectic and stressed communication.	8
We moved on to other questions before we had clarity on the first one.	5
We let external things influence, such as stress about moving on to other tasks.	4
We talked over each other's heads.	3
We used the same healthcare terms.	9
We spoke over each other.	2
We responded poorly to each other's questions.	1
We were on the same wavelength and immediately said so when we did not understand things.	7
Collaboration	
We had a good dialogue, step by step.	8
The emergency room nurse asked the home care worker: Can you ask the patient about ...	9
We did not come to measures that we considered implementing.	5
We did not follow up on the observations we had made, afterward.	4
We did not catch what the other person in the conversation said.	3
We were both calm, not stressed, talked a little back and forth, considered further observations.	7
We did not listen to each other, were not professional, and had no respect for each other.	2
The emergency room nurse listened to the home care worker and had faith in the measurements they took.	6

Table 1. The instruments given to home care workers for each of the four constructs: Statements and their weights (the medians from the ratings). Subjects are to indicate if they agree or disagree with each statement.

Emergency Room Nurse	Weight
Responibility	
I asked questions, took control of the situation, and built trust.	7
I worked with the home care worker to understand the patient's condition and situation.	6
I did not take the caller seriously, trivialized, and did not understand the responsibility I had for the person calling.	6
I did not follow up and left the responsibility to the home care worker.	4
I did not provide advice or guidance on how to handle the situation further.	4
I listened to the home care worker.	9
I behaved condescendingly towards the home care worker.	3
I said the conditiion would probably pass.	2
I gave feedback/confirmed information that was given.	8
Trust	
I trusted observations given by the home care worker.	10
I felt embarrassed, appeared dismissive, and thought what the home care worker said was not serious.	6
I overrode the home care worker, underestimated the condition, and did not trust what was said.	5
I did not take the home care worker seriously, even though they know the patient better.	4
I came across as competent and conscious in the conversation.	8
I was not cooperative.	3
I took the home care worker seriously, even with their lack of competence.	7
I responded with little engagement.	2
Communication	
We ensured that the other person understood what was said.	10
We had hectic and stressed communication.	8
We moved on to other questions before we had clarity on the first one.	5
We let external things affect us, like stress about moving on to other tasks.	4
We talked over each other's heads.	3
We used the same healthcare terms.	9
We spoke over each other.	2
We were on the same wavelength and immediately said so when we did not understand things.	7
We responded poorly to each other's questions.	1
Collaboration	
We were both calm, not stressed, talked back and forth, considering further observations.	7
The emergency room nurse listened to the home care worker and had faith in the measurements they took.	6
We did not come up with measures that we considered implementing.	5
We did not follow up on the observations we had made, afterwards.	4
The emergency room nurse asked the home care worker: Can you ask the patient about ...	9
We did not catch what the other person in the conversation said.	3
We did not listen to each other, were not professional, and did not have respect for each other.	2
We had a good dialogue, step by step.	8

Table 2. The instruments given to emergency room nurses for each of the four constructs: Statements and their weight (the medians from the ratings). Subjects are to indicate if they agree or disagree with each statement.

ministered, subjects are to indicate if they agree or disagree with each statement. To get a subject's score on a construct, the weights of each agreed statement for the construct are summed and averaged over the total number of statements for that construct. These instruments form the key results for the objectives in Sect. 3.

5.5   Training Session

The training session followed the script in Sect. 2, where the instrument for each role was deployed immediately after each debrief. The retraining was done with switched roles. The students were not trained specifically for any of the two roles, but managed to enact their respective roles in the vignette satisfyingly.

The participants were twelve healthcare students at the vocational high-school level. Three pairs of students underwent training in parallel, and the students performed the PEARLS debrief unfacilitated. This was both deliberate, to examine the viability of unsupervised debriefs, and by necessity, since we did not have enough game masters for these parallel sessions.

After each debrief, the participants were welcomed back to the real world, and asked to complete the instrument for their role in the form of a survey where they would state if they agreed or disagreed to the statements in Tables 1 and 2. Each student played both roles in turn, and thus filled out both instruments.

5.6   Results from the Training Session

The data from the training session consists of the respondents' responses to the instruments for the four constructs (role understanding (responsibility), trust, communication and collaboration), as well timings in the simulation and the decisions for the patient made by the pairs. Table 3 shows participants by pairs and their scores across the four constructs, along with the pairs' decisions for

		Home care worker				Emergency room nurse				Decision for patient		
Pair	Round	R	T	Com	Col	R	T	Com	Col	Call EMS	Observe	Call doctor
A	1	3.8	3.6	3.2	4.3	3.3	3.1	3.9	3.3	x		
A	2	4.5	2.1	2.9	4.1	3.8	2.1	3.4	3.1	x		
B	1	3.3	4.0	2.9	3.8	4.0	3.1	2.9	3.8		x	
B	2	3.7	3.6	2.9	4.3	2.4	2.3	1.9	4.4		x	
C	1	4.5	1.6	4.6	2.3	3.3	3.1	2.4	3.8			x
C	2	3.7	3.6	4.2	3.3	3.3	3.9	5.0	3.8	x		
D	1	2.8	4.0	3.4	4.6	3.6	3.1	2.9	3.1		x	
D	2	4.5	2.1	2.9	2.6	3.6	3.1	3.3	3.8		x	
E	1	4.6	2.1	4.2	5.4	3.8	2.1	4.1	2.6			x
E	2	2.1	5.1	1.8	2.5	3.6	5.3	4.9	3.5		x	
F	1	4.5	3.0	2.3	3.8	3.3	3.1	3.6	3.8	x		
F	2	4.1	3.0	1.0	2.6	3.3	3.1	2.3	3.8	x		

Table 3. Participant scores per pair (A–F) across *responsibility* (R), *trust* (T), *communication* (Com) and *collaboration* (Col), and the pair's decision for the patient. EMS is short for emergency medical services (ambulance).

Group Statistics

	Decision	N	Mean	Std. Deviation	Std. Error Mean
Resposibility	Call EMS	10	3.3511	.72125	.22808
	Observe	10	3.7711	.46467	.14694
Trust	Call EMS	10	3.5765	1.05615	.33398
	Observe	10	3.0765	.58408	.18470
Communication	Call EMS	10	2.9779	.85970	.27186
	Observe	10	3.1882	1.12469	.35566
Collaboration	Call EMS	10	3.6260	.70956	.22438
	Observe	10	3.5635	.49347	.15605

Group Statistics

	Call EMS	N	Mean	Std. Deviation	Std. Error Mean
Resposibility	yes	10	3.7711	.46467	.14694
	no	14	3.5516	.74323	.19864
Trust	yes	10	3.0765	.58408	.18470
	no	14	3.1982	1.11726	.29860
Communication	yes	10	3.1882	1.12469	.35566
	no	14	3.2225	.93763	.25059
Collaboration	yes	10	3.5635	.49347	.15605
	no	14	3.5904	.89875	.24020

Fig. 9. Comparison of means between individuals for the decision to call the emergency response service (EMS) and the decision to continue observing (top); and for the decision to call the emergency response service (EMS) and all other decisions (bottom).

the patient. The patient in this case is suffering from sepsis and should receive attention without much delay, so the most appropriate response of those suggested is to call emergency medical services (EMS), while the least appropriate response would be to continue observing over time. To see if our data revealed any relationships between the decision and the four constructs, we compared the score means of each construct between those individuals who were involved in the decision to call for EMS and those who decided to continue observing; see Fig. 9 (uppermost table). There are only minor and statistically insignificant differences in score means on all four constructs. We also compared score means between the decision to call the emergency response service (EMS) and all other decisions; see Fig. 9 (lowermost table), also with small insignificant differences. Thus, there does not seem to be any relation between how the students in our sample experienced the four constructs and the quality of the decision.

Next, we checked to see if there were any relations between the four constructs. Figure 10 shows correlations between the four constructs for home care workers (uppermost table) and for emergency room nurses (lowermost table). For the home care worker players, there is a significant strong negative correlation ($r = -.925$, $p < .001$) between *responsibilty* and *trust*, that might suggest an inverse dynamic. Within the VR training context, as the perception of taking responsibility increases, the level of trust may decrease, which, ostensibly, could

Correlations Home Care Workers

		Resposibility	Trust	Communication
Trust	Pearson Correlation	-.925**		
	Sig. (2-tailed)	.000		
	N	12		
Communication	Pearson Correlation	.270	-.388	
	Sig. (2-tailed)	.395	.212	
	N	12	12	
Collaboration	Pearson Correlation	.084	.008	.306
	Sig. (2-tailed)	.794	.981	.333
	N	12	12	12

**. Correlation is significant at the 0.01 level (2-tailed).

Correlations Emergency Room Nurses

		Resposibility	Trust	Communication
Trust	Pearson Correlation	.101		
	Sig. (2-tailed)	.755		
	N	12		
Communication	Pearson Correlation	.378	.546	
	Sig. (2-tailed)	.226	.066	
	N	12	12	
Collaboration	Pearson Correlation	-.656*	.161	-.435
	Sig. (2-tailed)	.021	.618	.157
	N	12	12	12

*. Correlation is significant at the 0.05 level (2-tailed).

Fig. 10. Correlations for home care workers (top) and for emergency room nurses (bottom)

pose potential challenges for collaborative practice. This should be investigated further, and if robust, should be thoughtfully addressed in training vignettes.

For emergency room nurse players, there was a significant medium-to-strong negative correlation ($r = -.656$, $p = .021$) between *responsibility* and *collaboration*. Here, perhaps, emergency room worker players who take responsibility take charge of the situation and get into a mode of telling the home care worker what to do, rather than trying to figure out what to do together. Indeed, the vignette is designed for *in-situ* instruction of possibly unskilled home care workers by more experienced emergency room nurses, and the instructions to the emergency room nurse players are to help the caller to follow ABCDE and ISBAR.

6 Discussion

The study's findings indicate that there may be nuanced dynamics between *role understanding* (*responsibility*), *trust*, *communication*, and *collaboration* in the situation played out in the vignette.

Notably, the negative correlations between *responsibility* and both *trust* and *collaboration* may indicate a phenomenon of taking responsibility in the sense of taking over when trust is low, with low collaboration as a result. This degree

to which this is advantageous, is probably situation dependent. The possible dynamics in the challenges that highly responsible individuals may face in collaborative efforts would need further investigation.

7   Limitations

The most prominent threats to validity are the threats to construct and external validity. On the one hand, the entire study concerns the building of constructs in an empirical manner. On the other hand, the manner in which we did this has limitations. First, the number of responses was low, thereby limiting the validity of the instruments we developed. Further, we based the instrument on student input (although we did have input from healthcare professionals), which may not bring valid insights gained from experience into play. On the other hand, involving the training audience in developing the instrument would arguably increase its meaningfulness to the respondents, thereby heightening an aspect of construct validity. Our goal in these studies was to develop methodology, and we think that the methodology is sound, and that better validated instruments can be built using the same methodology with a larger set of respondents. Further, the question of validity also depends on whether the context is participatory for educational purpose or for professional training.

Using students for the training session poses a threat to external validity, in that the results from the training session may not transfer to other relevant settings; e.g., with professional healthcare workers. For example, the negative correlations observed in the data must be replicated in other training sessions if one wishes to use our reflections on the correlations in those settings, and there may then be other underlying causes for those observations than for ours. Also, the perceptions of the four constructs may be different between student and professionals, but this also depends on how general the constructs are across people, which is a construct validity question.

A further threat to validity is the possible selection bias introduced by rewarding responses with gift vouchers. However, we prioritized getting possibly biased responses over few, or no, responses. We are also uncertain as to what the bias would be in this case.

8   Conclusion

It is challenging to develop serious games with high relevance for professionals, and it is not straightforward to find and apply relevant validated instruments to measure the impact of simulation-based training on situational variables. In health care collaboration, difficulties with collaborations are often tacit and not expressed in ways that help on improving on the situation. We posit that using the design principles set forth and used in this article to develop the key results for vignettes formed around given objectives, will prove to be a favorable way to make simulation-based training more relevant.

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