

Evaluation of The KINECT-Based Auscultation Practice System — Turning simulated patients into real patients —

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Abstract - Our group developed a system for practicing breath sounds auscultation using KINECT. This system solves several problems associated with past simulation education models. The system is inexpensive, and simply operated. We evaluated the process of learning breath sounds auscultation with a nurse and a nursing student. In this paper, we introduce practical exercises, using the KINECT system. We also report the student's evaluation of the system. We additionally completed an auscultation test using an existing breathing sound file and breathing sound data obtained using the KINECT system, and compared the results. We obtained responses from 78 students. All students replied that they were interested in the KINECT system, and 83.3% of students were able to distinguish an accessory murmur from normal breath sounds. In all, 97.4% of students reported feeling motivated to learn using the KINECT system. The result of the examination to identify a kind of the respiratory sound using the apparatus which we developed did not have a result and the change using existing sound data. The KINECT system was useful for learning breath sounds. Use of the system was interesting to the students because of the simulated patient interaction, similar to those encountered in "real life" clinical settings. Using the realistic KINETIC system, the nursing students were able to develop the skills necessary to distinguish breath sounds. Additionally, the system was motivating for nursing students.

Keywords-simulation; auscultation; nursing; physical assessment.

I. INTRODUCTION

We developed an auscultation practice system using KINECT to solve various problems related to simulation-based education [1] [2]. KINECT is a relatively inexpensive, easy-to-operate system that can produce respiratory sounds (e.g., wheezes) in synchronization with the respiration of a simulated patient.

In Japan, slowing birth rates and an aging population, as well as advanced medical treatments limit the scope and opportunities available for nursing students to practice nursing techniques within internship settings at hospitals; additionally, enhanced consciousness of medical care safety can limit opportunities to practice [3]. For example, most inpatients in Japan are elderly. Therefore, in clinical practice

it is difficult to be in charge of adolescents and children. In addition, nursing students cannot perform invasive procedures, such as blood sampling or intravenous IV injection.

Amid this climate, simulation-based nursing education is poised for wide dissemination, allowing students to repeatedly experience realistic practical settings without risking patients' safety. Simulations represent learner-oriented education, and the equipment has been introduced to our university [4].

There are three types of trainings conducted in simulation education, i.e., task training for acquiring techniques, algorithm training like learning Basic Life Support, and situation-based training in which various clinical situations are reproduced [5].

Education with a highly functional simulator capable of computerized control of vital signs, breath sounds, and heart sounds has been practiced in areas such as intensive care [5] and in operating rooms [6]. Simulation training is necessary for learning team-based cooperative skills involving nurses and physicians [7].

This highly functional simulator is unable to simulate conversation; however, it has a limited capacity to elicit simulated communication via an integrated microphone (operated remotely) in cases where conversation is warranted [8]. Communication is an important skill for nurses, and communicative competence is very important to patients' care [9]. Therefore, simulated patients designed to replicate patient-specific sentiments and personalities, not only in terms of clinical history and physical findings, are widely used for medical staff and allied health students [5] [9].

However, we cannot reproduce abnormal breath sounds because a simulated patient is a healthy person. In exercises for learning diseases such as pneumonia, a hybrid simulation is conducted where conversation is made with a simulated patient and respiratory sounds are auscultated by a simulator placed nearby, but this is also unnatural. These problems interfere with the natural flow of clinical settings.

Furthermore, high-performance simulators and existing auscultation training equipment are very expensive. At our university, more than 90 nursing students are registered in one class. The number of expensive simulators necessary to

provide training and practice opportunities to this many students is cost-prohibitive.

We therefore developed the auscultation practice system using KINECT to address these issues. In our system, a simulated patient play the role of a patient, instead of a humanoid, and stethoscope locations on the body are measured with KINECT. Movements of the upper body from breathing can also be detected by KINECT. Also, appropriate disease sounds including normal ones can be assigned at four points on the upper body. Practicing students hear such disease sounds, synchronized with the movement of breathing, through earphones when a stethoscope is placed on the assigned area [1] [2].

This paper describes our early experiences using the KINECT system. Additionally, we report student assessments of the system. In Section II, we describe related simulators and their problems. In Section III, the method employed in the study is explained. In Section IV, the results of student assessments of the system, are outlined. A brief discussion is offered in Section V. In Section VI, the method of simulation training using this system is described, conclusions and recommendations for future research are presented in Section VII.

II. RELATED WORK

In this section, we describe related simulators and their problems.

There are several varieties of equipment currently used for learning auscultation of respiratory sounds. Kyoto Science's breathing sound auscultation simulator "Lang" [10] is an upper body instrument (Fig. 1). Users can auscultate from the anterior chest and back. Heart sounds are also audible. Also, the pedestal illuminates in accordance with inspiration and expiration.

The Sakamoto model "Choushin kun" is a similar upper body simulator (Fig. 2) with seven built-in speakers [11]. For each speaker, breathing sounds can be selected and the volume adjusted. Like Kyoto Science's "Lang," heart sounds are also audible.

The person-like simulator used in this research was the ALS simulator, made by Laerdal Medical [12] (Fig. 3). Speakers are built into both sides of the chest. The thorax can be moved up and down by injection of air from the outside. Heart sounds are also audible. The ALS is a high-performance simulator capable of displaying values such as electrocardiogram and pulse oximetry on the monitor.

In the model released from Cardionics, a seal is placed on the chest of a simulated patient [13] (Fig. 4). When a stethoscope is placed on the seal, respiratory sounds can be heard.

Cardionics's simulator evolves into a suit with built-in seal. A simulated patient wears this suit and exercises [14] (Fig. 5).

However, existing simulators are extremely expensive, ranging from one million yen to several million yen. Also,

the cost is high because the seal is disposable. It is necessary to prepare a suit for each simulated patient, and extra expenses such as washing are required.

The system we developed is designed only with KINECT and PC controlling it. Therefore, simulated patients can sit on a chair and express abnormal respiratory sounds, just like real patients, by breathing normally. Moreover, the system is relatively inexpensive [1] [2] (Figs. 6 and 7).



Figure 1. Breathing sound auscultation simulator "Lang." Kyoto kagaku.



Figure 2. "Chosin Kun," Sakamoto Model Co., Ltd.,



Figure 3. ALS simulator, Laerdal Medical



Figure 6. The KINECT-Based Auscultation Practice System (Face-to-face arrangement)



Figure 4. Simscope-Wi-Fi-the-hybrid-simulator, Cardionics



Figure 7. The KINECT-Based Auscultation Practice System (Screen of control computer)



Figure 5. SimShirt System, Cardionics

III. METHOD

In this section, we discussed the auscultatory exercise practice method and research method.

A. Participants and data collection

The subjects were 91 first graders at the School of Nursing. The first training was held in July 2017. The students were previously instructed on respiratory anatomy and physiology; however, they had not yet practiced conducting physical assessments. The next training was held in December 2017 after they learned the physical assessment.

B. Practice method and evaluation

a) First training

We practiced distinguishing an accessory murmur from normal breath sounds using a system which we developed and a realistic, person-like simulator (Figs. 8 and 9).

The students broke up into groups of 15 to practice. At first, an upper-class student explained how to use the system and the person-like simulator, then explained the breath sounds auscultation method.

After practice, we questioned the students using a Likert-like scale. The questions included:

- Did you develop the ability to distinguish breath sounds?
- Were you interested in a system and person-like simulator?
- Did this exercise motivate you to learn nursing?

Each student had an additional free response option for recording his or her impressions.

b) The second training

The second training focused on distinguishing accessory murmurs using the new system and existing breathing sound data. After listening to the breath sounds, the nursing students labeled the type of breath sounds using clickers.



Figure 8. Practice with the newly-developed system



Figure 9. Practice using the person-like simulator

C. Statistical analysis

We compared the results following use of the person-like simulator with the subsequently-developed system using the Mann-Whitney U test. In the test to distinguish the type of breath sounds, we compared the first and second training results using the McManey test. Using the chi-square test, we compared the existing data with the test of the breathing sound of the newly-developed system. We used the SPSS Ver.22 statistical software program for all analyses. The level of significance was set at 5%.

For the free description responses, we organized the various responses around several response categories.

IV. RESULT

In this section, the effect of simulation training and the result of distinguishing breathing sounds were mentioned.

A. Participant and Questionnaire Responses

Response questionnaires were obtained from 84 (92.3%) students. Ultimately, 78 (85.7%) of those agreed to participate in the study.

All students expressed interest (“interested” – 74.4%; “moderately interested” – 25.6%) in the newly-developed system (Table 1). The mean \pm standard deviation was 3.74 ± 0.44 . Additionally, all students expressed interest (“interested” - 85.9%; “moderately interested” - 14.1%) in the person-like simulator (Table I). The mean \pm standard deviation was 3.86 ± 0.35 . There was no significant difference in the level of interest expressed, with regard to the developed system and the humanoid simulator.

When asked if the newly-developed system motivated the students to learn nursing, 71.8% responded “agree.” Additional responses included “moderately agree” (25.6%), “moderately disagree” (1.3%), and “disagree” (1.3%; Table II). The mean \pm standard deviation was 3.68 ± 0.57 . When asked if the person-like simulator motivated them to learn nursing, responses included “agree” (87.2%), “moderately agree” (11.5%), and “moderately disagree” (1.3%; Table II). The mean \pm standard deviation was 3.86 ± 0.39 .

TABLE I. STUDENT'S INTEREST IN THE DEVELOPED SYSTEM AND HUMANOID SIMULATORABLE (%)

Scale	Newly-developed system	Person-like simulator
Yes :4	74.4	85.9
3	25.6	14.1
2	0	0
No: 1	0	0

TABLE II. STUDENT MOTIVATION ATTRIBUTABLE THE NEWLY-DEVELOPED SYSTEM AND HUMANOID SIMULATOR (%)

Scale	Newly-developed system	Person-like simulator
Agree :4	71.8	87.2
3	25.6	11.5
2	1.3	1.3
Disagree :1	1.3	0

TABLE III. COMPARISON OF THE NEWLY-DEVELOPED SYSTEM AND THE PERSON-LIKE SIMULATOR

	Interest	Motivation	Distinction of the respiratory sound
Newly-developed system	3.74	3.68*	3.05
Person-like simulator	3.86	3.86*	2.95
p value	0.072	0.018	0.421

TABLE IV. DISTINGUISHING BETWEEN NORMAL BREATH SOUNDS AND ACCESSORY MURMURS

Scale	Newly-developed System	Person-like simulator
Distinguishable :4	23.1	19.2
3	60.3	60.3
2	15.4	16.7
Indistinguishable :1	1.3	3.8

With regard to the motivation to learn nursing, there was a significant difference between the newly-developed system and the person-like simulator (Table III).

In the exercise using the developed system, we asked if the students could distinguish between normal breath sounds and accessory murmurs. The students responded that the differences were "distinguishable" (23.1%), "moderately distinguishable" (60.3%), "moderately indistinguishable" (15.4%), and "indistinguishable" (1.3%; Table IV). The mean \pm standard deviation was 3.05 ± 0.66 .

In the exercise using the person-like simulator, we asked if they could distinguish between normal breath sounds and accessory murmurs. The students responded that the differences were "distinguishable" (19.2%), "moderately distinguishable" (60.3%), "moderately indistinguishable" (16.7%), and "indistinguishable" (3.8%; Table IV). The mean \pm standard deviation was 2.95 ± 0.72 . There was no significant difference in the reported ability to distinguish between respiratory sounds when comparing the newly-developed system and the person-like simulator.

TABLE V. FREE RESPONSE CATEGORIES

Category title	Newly-developed system	Person-like simulator
Communication	17	7
Learning abnormalities	17	8
Interested in equipment	9	2
Reproduction of the clinical site	14	11
Motivation to learn	15	39
Think as human	0	6
Total	72	73

B. Free response field

We compared the thematic categories extracted from the free response field for both the newly-developed system and the person-like simulator (Table V).

【Can learn communication】 included the following items: "I can learn how to respond to patients" ; "I can learn while taking communication with before and after auscultation" ; "I knew how to talk to patients" ; and "I was able to learn how to attend to breath sounds and conversation."

There were 17 students who responded that "I can learn communication" using the newly-developed system. There were 7 students who expressed the same believe for the person-like simulator.

【Ability to learn abnormal breath sounds】 included the following items: "Learn the difference between murmur and normal breath sounds" ; "Can learn care for abnormality." There were 17 students who responded that "I can learn abnormal breath sounds" using the newly-developed system and 8 students with the same response to the person-like simulator.

【Reproduction of the clinical situation】 includes the following items. "I can learn skills that resemble practical nursing"; "I can learn how to avoid causing the patient discomfort" and; "The respiratory sounds I heard were realistic." Fourteen students felt the newly-developed system accurately reproduced.

There were 14 students who responded that the newly-developed system accurately reproduced clinical situations and 11 students who had the same impression of the person-like simulator.

【Motivation to learn】 included the following items. "I learned about advanced nursing care"; "I want to learn more about nursing"; "I felt motivated"; and "I am interested in nursing."

Fifteen students felt that the newly-developed system motivated them to learn. There were 39 students who responded that the person-like simulator motivated them to learn.

Free responses for the person-like simulator included, "I was able to practice thinking as an actual human" In addition, "There is a need to think humanoid simulator as human"; "There are similarities between people, but they cannot actually speak, there is no real person's weight."

Improvements on the developed system were proposed by six students. Critiques included: "The five ranges varied depending on the posture of the patient"; "It was difficult to react"; "The breath sounds were more realistic if you hear them through a stethoscope"; "The sound felt small"; "The sound was difficult to hear "; and "I thought that it would sound smooth if breath sensing improved. "

C. Determining the type of respiratory sound

Nursing students received an examination using existing data and the newly-developed system to examine their abilities to identify respiratory sound types. Following the first and second trainings, we compared the existing breath sound data with that obtained using the newly-developed system.

In testing the existing sound files, the students were able to accurately distinguish among the various kinds of respiratory sounds. Fourth breathing sounds (normal breath sounds, wheezes, coarse crackles, rhonchi) were the most frequent answers in the second test (Table VI).

In testing the newly-developed system, the students were able to accurately distinguish among the various breath sounds, with the exception of wheezes. Following the second training, the ability to distinguish between coarse crackles and normal respiratory sounds had improved.

However, the ability to distinguish between fine crackles and rhonchi was somewhat diminished following the second training (Table VII).

Following the first training, the number of correct answers for coarse crackles and normal respiratory sounds was significantly better when existing breath sound files were used. Using the newly-developed system, wheezes and rhonchi had significantly more correct answers (Table VIII).

Following the second training, correct responses to three kinds of respiratory sounds improved significantly more with use of the existing breath sound files, compared to the newly-developed system (Table IX).

TABLE VI. CROSSTABULATION OF THE NUMBER OF TESTS AND THE NUMBER OF CORRECT ANSWERS (EXISTING SOUND FILES)

Coarse crackles		After second training		p	
After initial training	FALSE	TRUE			
FALSE	3	24	<.001	**	
TRUE	2	61			

Fine crackles		After second training		p	
After initial training	FALSE	TRUE			
FALSE	4	3	<.001	**	
TRUE	27	56			

Wheezes		After second training		p	
After initial training	FALSE	TRUE			
FALSE	4	75	<.001	**	
TRUE	0	11			

Rhonchi		After second training		p	
After initial training	FALSE	TRUE			
FALSE	1	12	0.003	**	
TRUE	1	76			

Normal respiratory sounds		After second training		p	
After initial training	FALSE	TRUE			
FALSE	3	35	<.001	**	
TRUE	2	50			

**= p < .01.

TABLE VII. CROSSTABULATION OF THE NUMBER OF TESTS AND THE NUMBER OF CORRECT ANSWERS (NEWLY-DEVELOPED SYSTEM)

Coarse crackles		After second training		p	
After initial training	FALSE	TRUE			
FALSE	7	33	<.001	**	
TRUE	1	49			

Fine crackles		After second training		p	
After initial training	FALSE	TRUE			
FALSE	9	4	<.001	**	
TRUE	44	18			

Wheezes After initial training	After second training		<i>p</i>
	FALSE	TRUE	
FALSE	0	0	.063
TRUE	5	85	

Rhonchi After initial training	After second training		<i>p</i>
	FALSE	TRUE	
FALSE	1	4	.012 *
TRUE	16	69	

Normal respiratory sounds After initial training	After second training		<i>p</i>
	FALSE	TRUE	
FALSE	12	13	.002 **
TRUE	1	6	

**= p < .01. *= p < .05

TABLE VIII. COMPARISON OF EXISTING BREATH SOUND FILE DATA AND THE NEWLY-DEVELOPED SYSTEM (FOLLOWING INITIAL TRAINING)

Coarse crackles The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	27	63	4.02 *
	(-6.5)	(6.5)	
Newly-developed system	40	50	
	(6.5)	(-6.5)	

Wheezes The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	79	11	140.79 **
	(39.5)	(-39.5)	
Newly-developed system	0	90	
	(-39.5)	(39.5)	

Normal The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	38	52	11.87 **
	(-11.5)	(11.5)	
Newly-developed system	61	29	
	(11.5)	(-11.5)	

Rhonchi The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	13	77	3.95 *
	(4.0)	(-4.0)	
Newly-developed system	5	85	
	(-4.0)	(4.0)	

Fine crackles The number of tests	The true-false test		χ^2
	FALSE	TRUE	
The existing data	7	83	3.15
	(-3.7)	(3.7)	
the development system	13	65	
	(3.7)	(-3.7)	

**= p < .01.

Adjusted standardized residuals appear in parentheses below group frequencies.

TABLE IX. COMPARISON OF EXISTING BREATH SOUND FILE DATA AND THE NEWLY-DEVELOPED SYSTEM (FOLLOWING THE SECOND TRAINING)

Coarse crackles The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	5	85	0.75
	(-1.5)	(1.5)	
Newly-developed system	8	82	
	(1.5)	(-1.5)	

Wheezes The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	4	86	0.12
	(-0.5)	(0.5)	
Newly-developed system	5	85	
	(0.5)	(-0.5)	

Normal The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	5	85	23.08 **
	(-8.3)	(8.3)	
Newly-developed system	13	19	
	(8.3)	(-8.3)	

Rhonchi The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	2	88	13.24 **
	(-7.5)	(7.5)	
Newly-developed system	17	73	
	(7.5)	(-7.5)	

Fine crackles The number of tests	The true-false test		χ^2
	FALSE	TRUE	
Existing breath sound files	31	59	25.61 **
	(-16.8)	(16.8)	
Newly-developed system	63	24	
	(16.8)	(-16.8)	

**= p < .01.

Adjusted standardized residuals appear in parentheses below group frequencies.

V. DISCUSSION

In our previous research, 50 clinical nurses felt that the newly-developed system was useful for learning to distinguish respiratory sounds [2].

In other words, this system is effective for 95.8% of nurses to learn by students, 87.8% is effective for nurses to learn. In this research, we compared the newly-developed system with a person-like simulator, which has been used conventionally.

Comparing the two systems, we found a significant difference in students' motivation to learn nursing. They appeared to be more motivating because the heart sounds and pulse were measurable, and the output of the electrocardiogram could be confirmed via monitor. Future development of the system should focus on enabling both respiratory and heart sounds. In addition, the result of the developed system is considered to be caused by students acting as simulated patients. The response of students and educators to high fidelity patient simulation has been extremely positive [15]. In the future, we plan to conduct training using simulated patients, rather than students.

There was also no significant difference between the newly-developed system and the person-like simulator for facilitating the ability to distinguish between normal respiratory sounds and accessory murmurs. An auscultatory learning equivalent to the person-like simulator is possible using the newly-developed system.

However, students made many mistakes when attempting to distinguish among detailed respiratory sounds. In the second auscultatory test of fine crackles, many students answered incorrectly, both when using existing sound data files and the newly-developed system. These mistakes appear to be attributable to hearing fine crackles only during inhalation and mistaking them as coarse crackles. We also did not observe improved accuracy at detecting rhonchi using the newly-developed system. The previous study suggested that highly contextualized learning environments may not be uniformly advantageous for instruction and may lead to ineffective learning by increasing extraneous cognitive loading in novice learners [16]. In addition, respiratory sounds were perceived as "difficult to hear." Other students reported, "We thought that it would sound smooth if breath sensing improved." We think that it is caused by the delay incurred when switching between inspiration and expiration. According to our study, the detection delay of respiration in KINECT v2 is 1.47-0.17 seconds for inspiration and 1.21-0.37 seconds for expiration [1] [2]. Under present circumstances, it is difficult to desire further detection capabilities. Therefore, respiratory sounds were not synchronized with breathing. After detecting the inspiration and reproducing the sound of inspiration, exhalation should be reproduced continuously.

Next, we discuss the issues clarified from student free comments.

"The five ranges varied depending on the posture of the patient" and "It was difficult to react."

Although the installation angle and the height of KINECT are constant, the position of the chair shifts when students

practice one after another. Measures that can mark the position of the simulated patient and the nurse's chair are needed.

"It sounds more realistic if you hear it through a stethoscope" and "The sound felt small";

This was likely caused by using a speaker connected by Bluetooth so that respiratory sounds could be heard by simulated patients and students other than those playing the role of nurse. The stethoscope auditory resolution can likely be improved by using a wireless earphone.

Also, the newly-developed system reproduces respiratory sounds synchronized with respiration of a simulated patient. Therefore, it would be unsuitable for use in scenarios such as cardiopulmonary resuscitation of patients with no response. However, the ability to communicate is an important ability for medical personnel such as nurses and doctors and requires entraining early on in clinical education.

From the free comments of this survey, it was revealed that the developed system is useful **【for learning abnormalities】** while taking **【communication】** that **【reproduction of a clinical situation】**.

For example, in a scenario where communication between medical personnel and patients is essential, we believe that the effectiveness of this system will be evident. Some examples may include:

- ◇ Physical assessment of patients with convalescent pneumonia
- ◇ Guidance for discharge from the hospital
- ◇ Cases requiring physical assessment and medication guidance for elderly patients
- ◇ A case of a febrile home care patient

VI. EXAMPLE OF A SIMULATION EXERCISE USING THE NEWLY-DEVELOPED SYSTEM

We introduced a simulation-based on a scenario of a patient with pneumonia before clinical practice.

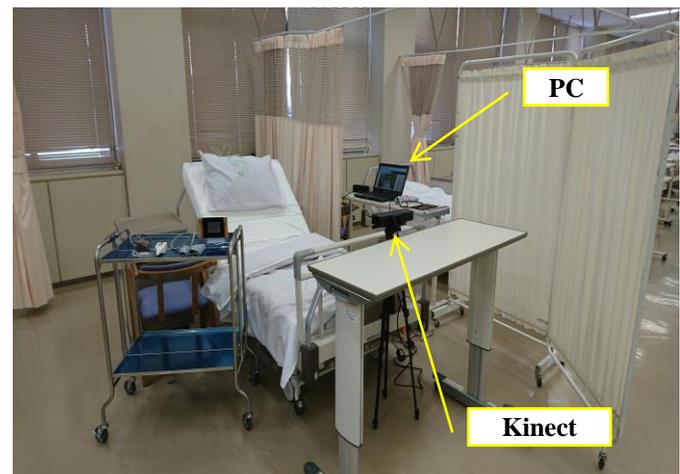


Figure 9. Simulation equipment arrangement of pneumonia patients



Figure 10. Simulation of respiratory sound auscultation

A KINECT was placed on the foot side of the bed with the head lifted (Fig. 9). This KINECT placement is in front of the patient, so the thorax can be sensed without distortion. Therefore, when the stethoscope contacts the thorax, it can detect respiratory sounds in the correct position. Also, since students approach from the side of the bed, they will not block the KINECT's detection field, which is a good arrangement. To assist students with concentrating on the simulation, a personal computer was placed behind the curtain. Nasal cannulas for oxygen therapy and devices for vital signs measurement were also available.

Patients with pneumonia generally receive oxygen therapy using a nasal cannula (Fig. 10). As advance preparation, the patient's breath sound sets featured accessory murmurs (coarse crackles or wheezes, rhonchi) in one or both lungs. This sound reproduces respiration that is affected by sputum over-production. The simulated patient wears typical clothing and sits on the bed.

The simulation training time was 10 minutes. First year nursing students entered the hospital room and greeted the patient. After that, they checked the nasal cannula, performed auscultation of respiratory sounds, and measured vital signs. The students asked the patient about signs and symptoms of dyspnea, the presence of sputum, and perceived pain. In addition, the students communicated with the patient to get a comprehensive sense of the patient's complaints. After the simulation, the students reviewed the session with the group members using the checklist. Debriefing time was carried out in 15 minutes using a 3-Phase Conversation Structures like the GAS method [17]. During debriefing, the students discussed what they were doing as nurses and how to improve, as a group. The simulation and debriefing were repeated three times. In these scenarios, the patient's respiratory state gradually worsened little by little. The patient also developed a medical device-related pressure ulcer behind the ear. Medical device-related pressure ulcers of the ear, results from contact with oxygen tubing, is included in the scenario for additional training [18].

TABLE X. CONTENTS OF SIMULATION TRAINING

Time allocation		Details of contents
15 minutes	Advance preparation	<ul style="list-style-type: none"> • Kinect, PC, nasal cannula, devices for vital sign measurement, extension cords, clothing of patient
10 minutes	Briefing	<ul style="list-style-type: none"> • Sharing study objectives • Guidance on using the equipment
10 minutes	Training 1	<ul style="list-style-type: none"> • The patient does not complain of breathing difficulties although some sputum is evident. • One student plays the role of a nurse. • The other students observe based on the checklist.
15 minutes	Debriefing 1	<ul style="list-style-type: none"> • Using GAS method
10 minutes	Training 2	<ul style="list-style-type: none"> • The patient has breathing difficulty because of cough and phlegm.
15 minutes	Debriefing 2	<ul style="list-style-type: none"> • Using GAS method
10 minutes	Training 3	<ul style="list-style-type: none"> • The patient has breathing difficulty because of cough and phlegm. • The patient develops a medical device-related pressure ulcer behind the ear.
15 minutes	Debriefing 3	<ul style="list-style-type: none"> • Using the GAS method
10 minutes	Self-evaluation Summary	

Nursing students were thereby trained to examine worsening respiratory conditions and determine necessary care.

VI. CONCLUSION

Our group developed a system for practicing breath sounds auscultation using KINECT. This system solves several problems associated with past simulation education models. The system is inexpensive, and simply operated. We evaluated the process of learning breath sounds auscultation with a nurse and a nursing student. In this paper, we introduced practical exercises, using the KINECT system. The newly-developed system was equally useful as a person-like simulator for assisting students with developing their ability to distinguish normal breathing sounds and accessory murmurs.

In addition, the system proved useful for learning anomalies while communicating in an environment that

accurately reproduced a clinical setting. Additionally, the system was motivating for nursing students.

Future efforts should address environmental settings, including the system, improving the stethoscope, and the timing of the respiratory sound reproduction in order to enhance training reproducibility within the simulated clinical setting.

ACKNOWLEDGMENT

This research was conducted using research expenses of Iwate Prefectural University (Iwate Monodzukuri · Software Integration Technology Center).

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