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How Group Size and Composition Influences the Effectiveness of Collaborative Screen-Based Simulation Training: A Study of Dental and Nursing University Students Learning Radiographic Techniques

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Abstract

This study analyses how changes in the design of screen-based computer simulation training influence the collaborative training process. Specifically, this study examine how the size of a group and a group's composition influence the way these tools are used. One case study consisted of 18+18 dental students randomized into either collaborative 3D simulation training or conventional collaborative training. The students worked in groups of three. The other case consisted of 12 nursing students working in pairs (partners determined by the students) with a 3D simulator. The results showed that simulation training encouraged different types of dialogue compared to conventional training and that the communication patterns were enhanced in the nursing students´ dyadic simulation training. The concrete changes concerning group size and the composition of the group influenced the nursing students' engagement with the learning environment and consequently the communication patterns that emerged. These findings suggest that smaller groups will probably be more efficient than larger groups in a free collaboration setting that uses screen-based simulation training.

Keywords: Computer assisted simulation training, Simulations, Higher education, Communication;

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1. Introduction

In health care education, a great portion of the training is dedicated to learning skills necessary for developing professional expertise. Dental students, for example, need to learn how to deduce spatial relationships and understand radiographic images. These images produce a number of pictorial depth cues that human perception automatically analyses in order to make the viewer aware of 3D spatial relationships. However, as Liu and Chuang (2011) point out, human perception has limits: "…some natural phenomena that are not observable with the naked eye may require one to mentally visualize

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their dynamic mechanisms" (p. 435). Conventional radiographs are two-dimensional representations of three-dimensional objects where no information about depth relationships among objects is available. The pictorial depth cues in radiographs can be irrelevant or not present at all and spatial relations must be analysed to determine 3D information. Therefore, an important part of dental education includes training students to interpret 3D information in such images. As learning of radiographic principles requires practice and feedback, developing effective methods to train students in 3D interpretation is desirable. To train students in 3D interpretation, health educators have recently turned to computer-assisted simulation training (CAST). Since the 1960s, educators have been intrigued by the possibility of using computer simulations to support conventional teaching (Egbert, 1965; Gorman, Meier & Krummel, 2000; Lane, Slavin & Ziv, 2001). Issenberg, McGaghie, Petrusa, Gordon, and Scalese (2005) point out that simulation technology has a long educational history. Early on, educators and researchers highlighted how computers could simulate operations and functions that could be used in education (Egbert, 1965). Presently, health care educators have concluded that CAST works well for several reasons: CAST provides cost-effective (compared to clinical training) educational experiences and realistic training when actual patients are unavailable (Lane, Slavin, & Ziv, 2001; Scalese, Obeso, & Issenberg, 2008).

Because dental students traditionally have had difficulties interpreting radiographic images and have limited possibilities for clinical training, educators have turned to new technological developments in computer simulation that allow students to practice interpretation skills and receive timely feedback (Nilsson, 2007). CAST provides images of internal anatomical structures of patient models while simultaneously providing real-time rendered radiographs, a pedagogical set up that intends to improve a student's ability to interpret radiographs. In this empirical article, we report data from a research and development project – "Learning Radiology in Simulated Environments" – to study the effectiveness of collaborative learning when students use a screen-based Virtual Reality simulator. Research also suggests that the effectiveness of CAST may be enhanced by collaborative learning (Bolton, Saalman, Christie, Ingerman & Linder, 2008; Keser, Uzunboylo & Ozdamli, 2011; Mawdesley, Long, Al-Jibouriand, & Scott 2011; Rogers, 2011). Only a few studies have focused on the factors surrounding screen-based simulations in higher education with respect to the interaction and communication patterns exhibited by students during training. Liu, Andre and Greenbowe (2008) found that prior knowledge influenced learning interactions during chemistry simulation. They compared six first-year university students working in pairs: two low knowledgeable students, two high knowledgeable students, and one low and one high knowledgeable student. Only the low-high combination produced relevant interactions. Similarly, Hmelo-Silver (2003) illustrated that prior knowledge influences collaboration for students learning to design clinical trials by comparing two groups of four fourth year medical students grouped by levels of prior knowledge. The less knowledgeable groups had more concrete discussions and the more knowledgeable groups had more theoretical discussions and asked more questions. De Leng, Muijtjens and van der Vleuten (2009) concluded that the social context – i.e., individual vs. collaborative training – did not influence the degree of elaboration during diagnostic training. Their research compared 47 fourth-year medical students working either individually or in triads. Research has also investigated the query construction in relation to simulation training. Hmelo and Day (1999), focusing on 36 first-year medical students, showed that contextualized questions during simulation training can improve diagnostic skills, but this approach requires giving instructors sufficient training in applying the simulation and the intended pedagogy.

In this article, we examine how students interact and communicate when using CAST. In a previous paper based on an observation analysis, we compared proficiency development and collaborative patterns for dental students working in triads learning radiology: one group used a simulator (SIM group), and another group used a MS PowerPoint-based exercise (CON group) (Söderström, Häll, Nilsson & Ahlqvist, 2012a) Compared to the SIM groups, the CON groups exhibited more inclusive peer discussions, more thorough interpretations of what is shown on screen, and more extensive application of subject-specific terminology. The SIM groups exhibited fewer discussions about how to interpret things on the screen and more discussions on performed actions, what should be done, and how to do it. The SIM groups were also more focused on how to manoeuver the simulator and applied a more context-dependent terminology. Their verbal communication was more fragmented with fewer references to prior contributions. The SIM groups, however, were more proficient at interpreting radiographs (ibid.). We also noticed that not all of the students in the SIM groups were equally involved in the collaborative work. These results motivated us, during the third year of the project, to conduct a new study on nursing students in which we adjusted structural aspects such as group composition procedures and group size to explore the influence on group collaboration and the communication patterns in this specific context. In this article, we analyse how these design changes in the group work influenced learners' engagement with the screen-based computer simulation training. Specifically, the study focuses on the communication patterns during the training and the students' perceptions on the group work. First, we describe the Learning radiology in simulated environments project. Second, we present the method in this study. This is followed by the results from the video observations and questionnaires. Based on this, we briefly discuss the consequences for design of collaborative learning with computer-assisted simulation training.

1.1. The Learning Radiology in Simulated Environments Project

The project "Learning Radiology in Simulated Environments" (LRiSE) used a task-specific 3D-simulator to train radiology interpretation, allowing for real-time radiographic examinations. The simulator was developed to help students learn the knowledge and skills necessary to interpret radiographic images where depth relations among objects and spatial relations must be deduced. The students needed to apply the principles of motion parallax and to locate object details in radiographic images. The project research design was built around a quasi-experimental core complemented with qualitative studies of the students' training process. In total, three studies that included dental and nursing students were carried out in the LRiSE project. Both the dental and the nursing studies were concerned with learning radiographic principles through simulation. The dental students worked with a radiology simulator for intra oral radiography and the nursing students worked with a simulator for radiographic examination of the cervical spine.

Year one of the project (study 1) was an observational study complemented with a questionnaire that compared dental students using simulation training (SIM-dental) and conventional training (CON-dental) to explore the training process and the learning outcomes. This study was followed-up during year two of the project (study 2) with in-depth interviews that asked questions about the dental students' experiences with their training. During year three (study 3), we adjusted structural aspects such as group composition procedures and group size from triad groups created randomly in study one to dyads created by students themselves. We conducted an observational study of nursing students complemented with interviews and a questionnaire with respect to the training process and interviews to catch their experiences with CAST (SIM-nursing).

1.2. The Simulator

The simulator is a standard PC equipped with simulation software. It has two monitors: one representing a three-dimensional anatomical model, X-ray tube, and film and one representing two-dimensional X-ray images (Figure 1). The control peripherals used for interaction include a standard keyboard and mouse as well as a special pen/mouse-like device. The simulator uses a Virtual Reality (VR) technique to allow the user to position models of the patient, x-ray machine, and the film in any desired position. X-ray images are then "exposed" and the simulator immediately presents geometrically correct radiographs rendered from the individual positions of the models (Nilsson, 2007). Exercises have been developed that replicate standard views and incorrect views.

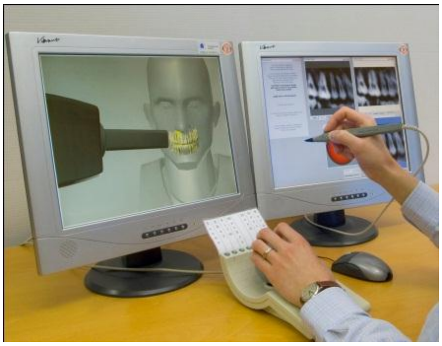

Figure 1. Illustration of a dental student training with the radiological VR simulator. During actual training, workgroups of three students collaborated to perform the tasks.

1.3. Simulation training

The students´ tasks were standardized and they followed a certain structure. In essence, students are presented with a task that requires interpretation of radiographic images and operation of the simulator (scene and objects). After the students positioned the simulation objects in what they deemed to be the correct way, they requested feedback from the simulator (by pressing a button labelled 'Next'). This feedback comes in the form of numerical information about the distance between their own model-position and a correct model-position. Based on this feedback, groups are given the opportunity to re-position the model before submitting their final solution. This final solution is evaluated by the simulator according to the distance between the actual position and a correct model-position. A correct/good enough solution renders a beep sound from the simulator along with the numerical and visual feedback. An insufficient solution renders only visual and numerical feedback. The student can also experiment with the two-dimensional X-ray image and view changes in real time. For further technical specifications and description of validity, see Nilsson (2007).

1.4. Conventional training

The image pair task that the CON-dental students worked with consisted of x-ray image pairs presented in MS PowerPoint. Each case consisted of two or three intra-oral radiographs that were presented on a monitor accompanied with questions concerning changes in projection and object depth. When they proceeded to the next slide, correct answers and commentaries were provided. The students discussed radiographic projection theory to develop understanding of and ability to apply the principles of motion parallax and to locate object details in the images. The computer used in the control group was a standard PC equipped with keyboard, mouse, and one monitor.

2. Methods

In this section, we describe the studies that focus on dental students who worked with a jaw/teeth simulator and with nursing students who worked with a cervical spine simulator (the observational data, communication patterns, have previously been published in "*Procedia - Social and Behavioral Sciences*", Söderström, Häll, Nilsson & Ahlqvist, 2012b). Both quantitative and qualitative methods were used to evaluate the screen-based computer-assisted simulator training for interpreting radiographic images. The data were collected before, during, and after training. To catch the students´ communication during simulator use, video recordings were used. However, a few things distinguish the nursing study from the dental study and what follows here is information regarding the methodology in the dental and the nursing study. First, we describe how the dental and nursing studies were designed. Then, we describe the video observations and questionnaires that were used in both studies.

2.1. The dental study

In the project, 36 students (20 women and 16 men attending the fourth semester of dentistry education in a course called Oral and Maxillofacial Radiology) voluntarily participated in a randomised experimental study. Students were placed into one of two groups. The simulation group (SIM) used a radiology 3D-simulator to perform four structured exercises to learn to interpret radiographs of the teeth. The conventionally trained group (CON) studied pairs of x-ray images shown in a MS PowerPoint presentation to learn to interpret radiographs of the teeth. The settings for the two groups were comparable in the sense that during the one-hour training sessions the SIM and CON groups worked collaboratively with their tasks while being supervised by a teacher who primarily acted as technical support. The setup can be described as free collaboration with the students deciding how to manage the learning. The study was approved by the local ethical vetting board.

2.2. The nursing study

This study was more practice-oriented as the simulation training was integrated into the curriculum. The overall research aim was to support the 12 students' learning during a clinical training course. Nine women and three men participated. In addition to curriculum integration, a few things distinguish the nursing study from the dental study. To support collaboration, we allowed the students to choose their work partners (instead of randomization) during the training session, reduced group size from three to two, and removed the teacher supervision from the session. We also increased the duration of the simulation (from one hour to two hours) and allowed the students to decide how much of this time to use. The class (12 students) worked in groups of two with the spine-simulator tasks between one and two hours during the first week of the course. The students could work up to two hours with a radiology 3D-simulator to perform four structured exercises learning to interpret radiographs of the cervical spine. During the following eight weeks, the students did their nursing training practice at different hospitals and in the last week of the course there were different examinations. The students had the option to reserve the simulation for additional independent training throughout the eight weeks of clinical training. The setup can be described as free collaboration with the students deciding how to manage their own learning.

2.3. Video observations

Videos were used to capture and analyse the training sessions (cf. Hindmarsh, 2010; Rystedt & Lindwall, 2004). In the dental and nursing study, the video recordings captured the upper half of the students, but neither the computer screen nor the teacher was visible in the dental study. The analysis of the video recordings was performed in two phases. In phase one, three randomly chosen videotapes were analysed to uncover themes. The analysis focused on three aspects: What are the participants talking about? How are they talking about it? How do the students relate to each other and to the learning environment as a whole?

Phase one identified and generated categories or themes. The categories were inductively created based on student conversations and reasoning during the performance of the tasks. In relation to what the students talked about, the category *Interpretation* included suggestions on how visual information should be interpreted, the arguments supporting the interpretations, and implications of the interpretations. The category *Action proposals* included elaborated suggestions on what should be done and how it should be done, while *Action commenting* included less elaborated suggestions as well as comments on a specific student action. The category *Functionality/technology* includes talk about the applied technology. The category *Theory* included general expositions on scientific theories. The category *Social comments* included non-task related talk about social relations, jokes, and play. The category *Meta-reflections on learning* included reflections on the learning process or learning outcome more or less related to the exercise. The themes that emerged in relation to how the participants talked were *Continuity*, which refers to previous contributions and/or clearly extends them and appear to be longer threads of reasoning. The other main category, *Fragmentation*, indicated unspecified references to previous contributions and did not clearly extend them. In addition to these themes, some utterances were placed in the uncertain category. The analytical question about how they discussed the tasks generated two main categories: *Academic* and *Non-academic*. *Academic* included contributions where the students used subject-specific academic terms, and *Non-academic* contributions included talk that was context-dependent terms and utterances. Some of the contributions made by the students were categorized as uncertain.

Phase one ended when no more categories were found, i.e., when saturation had been reached. In phase two, all video data were split into one-minute time segments and coded with the themes generated in phase one. The time segments are our empirical unit of observation. This allowed us to conduct a structured analysis based on an understanding that was influenced by the current set of data. The coding and categorization was performed by one of the researchers. To measure coding stability (Krippendorf, 2004), one of the sessions was re-coded by the same researcher and compared with the original for each category. The agreement between original coding and re-coding was 97% for content, 92% for terminology, and 98% for pattern, verbal space, and verbal activity. The coding scheme developed in the dental study was re-applied without change to the nursing study.

2.4. Questionnaire

The questionnaire focused on the students´ experiences during the training session. Questions addressed the task, the participants' collaboration, and the working model in relation to communication and dialogue. In addition, the questionnaire addressed the students' ideas and experiences concerning their education and learning. Questionnaires were completed individually and collected directly after training. In total, 20 women and 16 men answered the questionnaire in the dental study and nine women and three men in the nursing study. Answers were given either by grading statements on a five-point scale or by choosing one "best fit" alternative and, in most cases, with the possibility of open-ended commenting.

2.5 Interviews

After the training was finished, we performed follow-up interviews: 18 (of 18) from the dental study (nine from the SIM group and nine from the CON) and 11 (of 12) students from the nursing study. The aim of the interviews was to better understand the experiences of participating in simulation training and to get a better understanding of students' perspectives on how they viewed and explained the training. The interviews were semi-structured with open-ended questions and inspired by previous analyses of the data from the project. The interview theme "respondent as a learner" contained questions about the participant's views on learning. The interview theme "training impact on learning" focused on what they were thinking about during the training and how they explained the way the training session influenced their thinking. The theme "the respondent as a group member" dealt with their participation in relation to their peers' and the teacher's role, concentrating on how it affected their meaning making and the reflections they made. The theme that focused on the tasks was directed towards their views on the relevance of the tasks. The theme that dealt with simulator and image pair material specifically addressed feedback issues. Finally, the theme about realism and functionality was asked at the end of the interviews.

The interviews lasted for 30-60 minutes and were performed individually. All interviews were recorded on tape. In the dental study, video-recordings of the respondents' training session were played on a laptop computer to support recall because they were performed months later. In order to ensure that the students´ views of the training sessions were in focus, the students watched the video recordings and were urged to comment on the training sessions as they watched. A qualitative approach was adopted in the analysis focusing on inferring categories of responses, sometimes referred to as *meaning concentration* (Kvale & Brinkmann, 2009). We posed specific questions to each transcript, extracted the responses related to it, and inferred categories of ideas from these responses. Quotations of student responses have been translated from Swedish into English.

3. Results

3.1. The training process – communication patterns

As already mentioned, in a previous study we concluded that the verbal communication in the SIM-dental group, exhibited fewer discussions about how to interpret things on the screen and more discussions on performed actions, what should be done, and how to do it (Söderström et al., 2012a). The SIM groups were also more focused on how to manoeuver the simulator and applied a more context-dependent terminology. In the cervical spine simulation used by the SIM-nursing students, we also see that the content mainly consists of action proposals/comments (63%), and interpretation (20%) is in the background. This is a difference compared to the SIM-dental group, which had a larger proportion of the discussion addressing interpretation (38%) and to the CON-dental group where 92% of the verbal communication includes interpretation(figure 2).

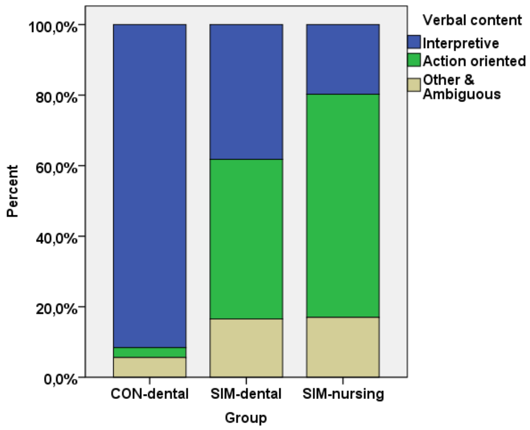

Figure 2. Comparison of training forms by distribution of verbal content over Interpretive, Action oriented and Other.

Talk in the SIM-nursing study is characterized as being mostly fragmented (81%), with 19% of the talk related to continuous reasoning drawing on each other's contributions. This percentage represents a major difference compared to the SIM-dental and CON-dental group, which both have a larger proportion of continuous reasoning comments (43% and 92%, respectively) (figure 3).

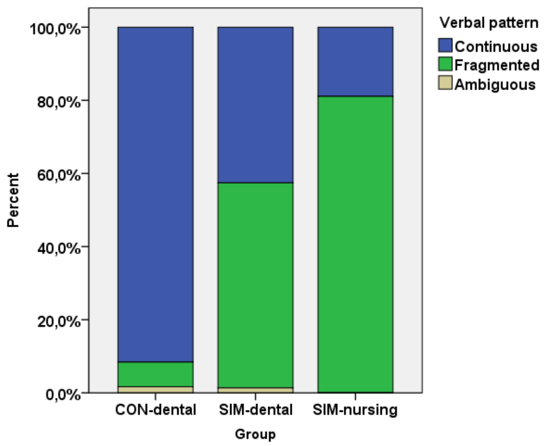

Figure 3. Comparison of training forms by distribution of Pattern over Continuous and Fragmented.

The terminology is foremost non-academic (subject non-specific) in the SIM-nursing group (75%), with a small proportion subject-specific terminology (25%). The SIM-dental group has 32% academic (subject-specific) terminology while the dialogue for the CON-dental students consists of 86% academic (subject-specific) terminology (figure 4).

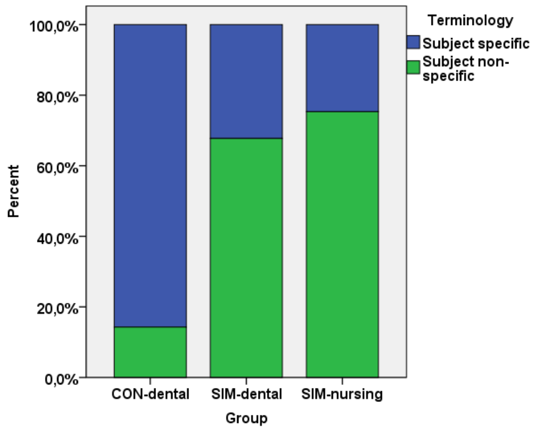

Figure 4. Comparison of training forms by distribution of terminology: Academic (subject-specific) and Non-academic (subject non-specific).

To sum up, the SIM-dental and SIM-nursing, compared to their conventionally trained groups, use more verbal communication in the form of action proposals/comments, and the communication is characterized by fragmented as well as a context-dependent communication. The CON-dental group's main verbal activity is interpretation, which is characterized by a continuous pattern as well as a more academic terminology. This communication pattern for the SIM training is more articulated and visible when students work in pairs as the nursing students did.

3.2. Conceptions of the collaborative training

The results from the observations of the group work indicate that our design choices influence peer interaction. The results from the questionnaire show that there were no major differences between the SIM-dental students and the SIM-nursing students concerning their experiences with computers, group work or higher education. However, a couple of conditions may be interesting to note. The nursing group had more female students (75%) compared to the dental students (56%). In addition, a greater proportion nursing students (25% compared to 6%) have experience of group work in front of computer. Perhaps the most important finding is that a greater proportion SIM-nursing students specified a stronger degree of relationship to their group members (67% versus 21%); that is, they are not just school friends but also tend to spend time together outside of school. The interviews also show that the nursing students emphasized that their opportunity to choose who to work with facilitated their collaboration and communication. In most cases, they chose someone they knew rather well.

We are buddies like that, joking and messing about. It is easier if you know each other when you sit like that. It's a little trickier if you sit with someone you do not know. Then there will be those tense moments with each other; you might be a little afraid of making a fool of yourself. But when you know each other so well as we do in our class, it's no problem. It was quite good to have someone to juggle with: Do you remember what it was you were doing? Well was it like that one? (SIM-nursing)

However, as one student noted the importance of choosing your own partner seems to be less if the class is small and everyone knows one another pretty well.

It might be good to choose someone you think is fun to work with so you are comfortable, equal. But my classmates, our class is so good that it would not make much difference. But if I had not known everyone, it would have been good [to have the choices]. (SIM-nursing)

Although there are differences in how the dental and nursing groups collaborate and communicate, a majority of the students stated in the questionnaire that the simulation training (SIM-dental/nursing) or the image pair training (CON-dental) positively influenced their learning, collaboration, and reflections. All students also believed that the exercise helped them learn what is important for their profession and that it contributed to fulfilling course objectives. In short, there are very few significant differences on how the dental and nursing students valued the training (Table 1).

Table 1 Students' conceptions of the simulation exercises and the conventional training CON-dental n=18 SIM-dental n=18, SIM-nursing n=12. (All numbers are percentages).

	Group	1)Strongly disagree	2	3	4	5)Completely agree	Mean value
Encouraged	CON -d	5.6	5.6	11.1	44.4	33.3	3.94
discussions in the	SIM -d	-	-	22.2	50.0	27.8	4.06
group	SIM-n				58.3	41.7	4.42
Encouraged	CON -d	-	-	16.7	61.1	22.2	4.06
cooperation and	SIM -d	-	5.6	16.7	33.3	44.4	4.17
dialogue	Nursing-d				58.3	41.7	4.42
Was a good ground for	CON -d	-	5.6	-	61.1	33.3	4.22
subject-specific	SIM -d	-	-	16.7	50.0	33.3	4.17
reflections	SIM-n			8,3	58.3	33.3	4.25
Contributed to	CON -d	-	-	27.8	27.8	44.4	4.17
learning more	SIM -d	-	11.1	22.2	33.3	33.3	3.89
	SIM-n			25.0	33.3	41.7	4.17
Contributed to	CON -d	5.6	16.7	22.2	22.2	33.3	3.61
understanding more	SIM -d	-	11.1	11.1	27.8	50.0	4.17
easily	SIM-n			8.3	41.7	50.0	4.42

Table 1 shows that all groups believed that the training encouraged cooperation and dialogue and that it facilitated subject-specific reflections. It also illustrates that students in the SIM groups were more convinced that the simulation task contributed to their understanding compared to the CON group. This difference is significant for SIM-nursing group compared to the CON-dental group ($t(28)=1.98$, $p<.028$). Although the SIM-nursing students were not strongly convinced that the discussion was at the centre of the group work (SIM-nursing 33%, SIM-dental 44% and CON-dental 61%), the table illustrates that they strongly agreed that the training encouraged discussions, cooperation, and dialogue**.**

Similar to what the students stated in the questionnaires, that all groups believed that their specific learning situation encouraged cooperation and dialogue, the interviews reveal that the students appreciated the group work and found it helpful for their discussions. Most students indicated that the support of peers is better and offers advantages compared to working individually. The students put forth that they appreciated the group work and relied on the group in the process to solve the tasks.

It worked great. We were trying to give and take. Discussed and like that. It is good to be two. You may see different things. It may be not that when you sit by yourself with the simulation. (SIM-nursing)

One must discuss. Some things I had not thought about; they thought about it. (SIM-dental)

It was fun and rewarding, absolutely. Sometimes, however, I needed more time for reflection. (CON-dental)

On the issue of team size, none of nursing students and dental groups had preferred working in larger groups. They highlight a number of explanations for this. It is about both collaboration and communication. A large group could mean too many opinions and suggestions, so inevitably someone in the group may get less time to participate actively in the group discussions and decisions. In addition, there are practical considerations. That is, with more than two people, it is more difficult to see the computer screen:

Very easy to discuss when you are two, then both have space. If it is more, it is always the risk of someone falling outside and does not get or dare talk or question. It is hard to fit more than two in front of the computer and less time to explore and discover. Two is appropriate (SIM-nursing).

Although the SIM and CON-dental groups did not clearly express that working in small groups (in pairs) would be better than working in groups of three, the interviewees perceived that everyone in the group was not equally involved in the training. Many responses indicated that some individuals in the group were not as active as other team members and that there was someone who dominated and steered most of the time.

Bruce and Emily decided most [issues]. (SIM-dental)

I was probably the most laid-back. Roger and Lisa were the most driven. (SIM-dental)

All participated, but not equally. (CON-dental)

This unequal involvement in the group collaborative work is also something that the SIM-dental students believed might have hindered learning. Moreover, In the SIM dental group, some students suggested that individual training would be preferable, which seems to be related to how they perceived the group work and their peers. The nursing students' interview responses show that they, like their view of the group members’ activity, perceived the distribution of control over the simulator as more equal as they took turns steering the simulation.

4. Discussion

This article investigates the participation and collaboration, the patterns of communication associated with different learning conditions – computer-assisted simulation and conventional training – when learning radiology. The results show that the simulation task guided the students learning and was entirely based on the simulator task. This result means that the learning took place in a well-developed contextual task in the form of simulation training (cf. Hmelo & Day, 1999). The findings indicate that the SIM-nursing students engaged with and experienced the training forms and the tasks in different ways as a result of the number of participants in the groups and the composition of the groups. Contrary to what de Leng, Muijtjens and van der Vleuten (2009) found, this study indicates that the social context affects verbal communication and how the students perceived the training. The study illustrates that the SIM training process is even more articulated in the SIM-nursing groups:

these students interpreted objects on the screen, commented on the actions at hand, and discussed what should be done and how it should be done. In addition, the SIM-nursing groups were more focused on manoeuvring the simulator, a situation that involved more context-dependent terminology with fewer references to prior contributions. The study shows that design changes, such as group composition, procedures, and group size, influence the training process.

Although the results from the questionnaires demonstrate that both the CON and SIM-dental/nursing groups thought that the exercises were valuable for their individual and collective reflections, there is some support from the questionnaires that more of the nursing students believed that the training was valuable. For example, the nursing students more strongly agree with the statement that the training encouraged them to discuss, cooperate, and engage in the communication**.** This difference may be explained by the fact that the dental groups consisted of three students and, as the interviews show, not all of them felt that they were included or engaged all the time in the problem-solving process. However, the interviews also suggest that an unequal group composition may be a barrier to learning since students may be able to take a passive role. Some of the differences between the SIM-nursing and SIM-dental group may be explained by the fact that the student population in the nursing class was relatively small (12 people), they chose their own partners, they worked in pairs, and they had a stronger personal relationship with other group members. The observations of the simulation training process and the interviews show that the co-regulation of the operations is more intense in the nursing study. The students in the nursing groups experienced their training to be more a result of high participation by both group members compared to the SIM and CON dental groups. The nursing groups worked together as a unit more often than worked alone. The SIM-nursing students expressed in the interviews that the work was more equal as everyone discussed and steered simulator roughly the same. This result is also reflected in the questionnaire: 75% of the SIM-nursing students believed that everyone in the group talked an equal amount of the time (see Häll & Söderström, 2012). The observations of the training process also showed that a greater portion of utterances was inclusive (i.e., exchange with the other participants) in the nursing groups (90%) as compared to SIM-dental students (65%) and the CON-dental students (65%) (ibid.).

The results from this study show further that the simulation groups, especially the SIM-nursing group, believed that the training contributed to their understanding. The findings are in this respect consistent with the literature suggesting that collaborative learning may enhance computer-assisted simulation training (e.g., Bolton et al., 2008; Rogers, 2011). Although no investigation of the learning outcomes of the nursing training was made, the results that the SIM training contributed to the students understanding (questionnaire data), support previous results from the project that concluded that screen-based simulation training increased the dental students' interpretative skills (Söderström et al., 2012a). In addition, a study of nursing students working in pairs with simulation or conventional training showed that the students that worked with simulation training significantly increased their post-test results (Ahlqvist et al., 2012).

5. Conclusions and Recommendations

We can conclude that the concrete changes in design concerning group size and composition of the group influenced how the nursing students engaged with and perceived the learning environment. and consequently what communication pattern emerged. A possible explanation for the differences between the SIM-nursing students and the SIM-dental students is that when there are only two students in the group, both students are active in the problem solving process and regulate each other simultaneously. All the nursing students were immersed by the simulation. When three people or more were in a group, some students were, as the interviews show, less active than others and there might be a greater need for contextualized interpretations (e.g., continuous pattern), which function as a point of reference for the group. It is possible that groups with more than two people need contextualized teacher question support during simulation training to help them in their problem solving process (cf. Hmelo & Day, 1999). A factor that also may have influenced the training process is that the nursing students have a stronger relationship to their group members and chose their work partners, two characteristics that might have further encouraged active peer-regulation and mutuality. However, it is likely that in small classes it is probably less important for students themselves to choose their own partners because they know one another better than students in large classes know one another.

In free collaboration settings for screen-based simulation training, like the one in this study, smaller groups will probably be more efficient than larger groups (cf. Trowbridge, 1987). However, in a teaching situation where computer simulation training is to be used, many factors influence the organization of learning and training. This study has only scratched the surface of simulation research in educational settings. We only studied changes in group size and composition of the group in relation to CAST. Future research should explore whether the dialogue patterns expressed by the SIM-nursing students are desirable in educational settings. From a wider perspective, there is a need for more rigorous research about CAST uses in different teaching situations in health care education as well as further investigation into whether and how CAST can be integrated into the curriculum to enhance teaching and learning to develop professional competence.

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