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# Application of modern educational methods through implementation of the ambulance simulator at a clinic laboratory (NTNU Gjøvik)

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**Abstract**

This paper describes development of a novel ambulance simulator implemented at the Nursing department at NTNU Gjøvik and effects of its use for educational purposes. Cultural aspects of the simulator implementation are also discussed. The article covers peculiarities of the simulator development process and also description of relation of modern educational techniques (learning factories) to the application of similar novelties within the learning process. The construction, purpose and educational effects gained after implementation of simulator are described. The paper can serve as further research basis on topics of the simulators creation and modern educational techniques use.


*Keywords:* Ambulance simulator; Engineering; Nursing; Learning/Teaching Factories

## 1. Introduction

In the Northern countries of Europe there are few people per square kilometer and the distances between the hospitals are often large. Therefore, the ambulances should be well equipped, so that the initial treatment after an accident or illness could be done in the ambulance by nurses and doctors. Thus the ambulances are real work places for the medical staff meaning a tough area to work in and an environment that is constantly moving/shaking when the transportation to a hospital takes place. During the winters the roads are slippery, which increases the risk and inconvenience for the medical staff [1].

Such working conditions are impossible to be prepared for without any previous experience, while *"nursing education programs are faced with increased pressure to produce graduates who are capable of providing safe patient care"* [2].

However, this can be solved with help of simulation application. Simulation was applied for many years in the industry and since 1960s in medical education. It gives possibility to train the nursing staff efficiently without getting anyone hurt. In order to make the ambulance staff students ready for the difficulties of their future profession it was decided to take a real ambulance car out of use and place it on a hydraulic regulated table. Inside of the car nurses and doctors could work on patient replicas. This led to creation of the simulator that is successfully used for teaching students the working process inside the ambulance.

Before the start of the simulator development, project team has discussed what should be the final goal. According to users wishes, it should have become a simulation of 'real' situations in the ambulance with communication between ambulance workers and driver. The driver should be able to gain experience of driving the ambulance on different roads, while other medical workers learn how it is to be saving patients life in an unstable environment that is moving and shaking.

The following study describes methodology and development process of the ambulance simulator. It depicts cooperation of nurses and engineers during the simulator creation, as well as shows how implementation of study simulators influences the learning process and application of modern teaching techniques such as learning factories. The paper doesn't describe the ambulance development process and results of implementation in all details, however, it gives an insight of what was done, how it was done and which outcomes were received.

## 2. Development of the ambulance simulator

The two part of this section present theoretical concepts used during the process of product development in order to complete the project, while the third tells about the components, which the product consists of.

### *2.1. Product development theory*

When the new product development starts, the reason for that can be need of new knowledge creation and/or challenges [3] as shown in Figure 1.

At the same time, development of the new products can, as two extremes, be made according to dynamic theories [4] or classical theories – such as the stage-gate method [5]. In case of ambulance simulator, the product development was started because of the challenge and, in particular, need to increase the level of preparation of medical personnel for the ambulance services. The simulator was created following the dynamic product development procedure. Such *"models are designed to handle unstable conditions and increasingly complex developments"* [3].

In similar cases the change management concept is also often involved. *"Change management has been defined as 'the process of continually renewing an organization's (team's) direction, structure, and capabilities to serve the ever-changing needs of external and internal customers'"* [6,7]. In case of ambulance simulator, the needs were changing because of peculiarities of the development process, which will be described later in the paper, thus leading to changes in team's task.

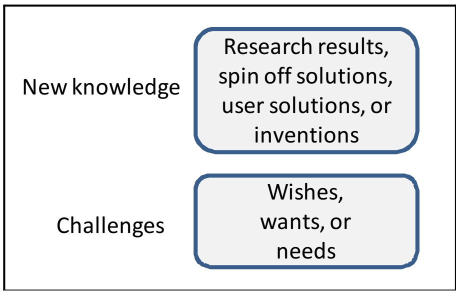


Fig. 1. Different starting conditions for new product development [4].

Among other methods participatory action research (PAR) was also used [8,9]. The main characteristics of PAR are: active participation of researchers and participants in order to create new knowledge, importance of self- and critical awareness, which leads to the change and building of alliances between the participants allowing taking active part in planning, implementation and dissemination of the research process [10].

In order to make the product under development even better a user centered approach was also applied. It includes users influencing the development process and continuously testing the development outcome from the start of the development to the delivery of a new product [3]. Application of this approach has started with broad discussion of requirements to the simulator from side of medical team members.

Thus, design for usability should be applied from the beginning until the end of the development process. Therefore, of great importance for the product developers is to get to 'know the user' and the use of the product.

Before the start, it was planned to bring together nurses, doctors and engineers to set up project features and peculiarities for the ambulance simulator before the beginning of development process itself. This would lead to increase of quality and functionality of the final product, as setting up the project team consisting only of engineers could lead to missing of certain necessary for the learning process components or features. Adding nurses and doctors to the crew would significantly increase the practical component of simulator created, as they have more experience and understanding of skills required for successful work of the ambulance staff. In other words, such approach allowed having users of the ambulance simulator taking part in the product development, thus increasing its future application.

However, having in team people with significantly different backgrounds (medicine and engineering) led to combination of two communities of practice in one group. Communities of practice can be defined as *"groups of people who share a concern or a passion for something they do and learn how to do it better as they interact regularly"* [11]. Often these are groups of people with a same set of professional skills and interests that join in order to increase their knowledge or reach common goals. In [11] examples of activities typical for communities of practice is proposed: problem solving, requests for information, coordination and synergy, mapping knowledge and identifying gaps, etc. According to [12,13] communities of practice include three important dimensions: mutual engagement, a joint negotiated enterprise and a shared repertoire of negotiable resources accumulated over time. Mutual engagement means regular interaction for people that work together and thus have the same field of activities or for professionals that have similar education and meet each other in smaller or bigger groups to discuss/solve common challenges and problems. The joint enterprise, in its turn, refers to the process and *"is not just a stated shared goal, but a negotiated enterprise, involving the complex relationships of mutual accountability that become part of the practice of the community"* [12,13]. Shared repertoire is accumulated over time and usually results in specialized terminology and resources (knowledge, pictures, common gestures, etc.).

Combination of people from different communities of practice in one team led to additional challenges during the project run. Usually it can be complicated to cooperate in various engineering disciplines and/or projects, but here a much greater challenge occurred: nurses with care, as the main background, simply did not want to participate. An expressed reason for the unwillingness to participate was that the nurses did not see any role in a technology project. However, luckily the male head of the clinic laboratory and an emergency nurse, who had a significant motivation and technical insights from his experience in the area, expressed interest in the project and participated until the end. As a result, the project development team mainly consisted of engineers with only two people having the medical background, but having even the minor part of the crew with the necessary user experience was helpful.

The next subsection gives an overview of simulators use in the medical education.

### 2.2. Simulators use in the medical education

Even though there is a huge need of practical knowledge within medical field of education, such types of simulators are in a rather nascent stage [14]. According to [14] simulator can be defined as *"a physical object or representation of the full or part task to be replicated"*, while simulation is *"applications of simulators for education or training"*. Both of these terms fit perfectly to description of ambulance simulator developed and applied at NTNU in Gjøvik, as it is imitating a process of work of the ambulance crew both in the aspect of driving the car and saving the patient, also, it is used for nursing students training.

The history of simulators used for medical education starts in early 1960s with creation of mannequin for training in mouth to mouth ventilation by a Norwegian manufacturer of plastic toys – Asmund Laerdal [14]. Later in the mid-1960s at the University of Southern California an era of computer controlled simulators began with appearance of a mannequin that was simulating a whole patient. It was controlled by both hybrid digital and analogue computers. Unfortunately, the cost of such simulator construction was too expensive and there was only one of this type that was constructed.

In 1968 a full sized mannequin called "Harvey" able to imitate 27 cardiac conditions was created. This simulator went through huge amount of tests in educational efficacy. *"Pilot studies documenting Harvey's effectiveness in teaching bedside cardiological examination skills were first reported in 1980"* [14,15].

In 1988 in [16] a computer simulator possible to be used in order to teach students basic endoscopic retrograde cholangiopancreatography (ERCP) techniques was described. Later on, use of simulators started to become something more usual, however, still complicated to achieve because of difference in needs and possibilities in means of technology and cost. In 1988 and 1989 the first conferences for simulators developers were held. In the following years number of similar activities was growing, including organizations of symposiums, conferences and meetings.

Nowadays amount of simulators used for medical education is much bigger, however, still not as big as it should be. There are dozens of simulators used for training different aspects of medical personnel work, such as Human Patient, Bronchoscopy, Anesthesiology and many others [17].

The following subsection describes the ambulance simulator construction.

### 2.3. The ambulance simulator construction

After creation of working team, the final aim of the project was set up, as mentioned in the introduction section. The goal was defined as development of a simulator for training in 'real' situations happening inside the ambulance car with communication between the medical staff and a driver. The ambulance simulator was supposed to contain of the ambulance car that is shaking due to imitation of driving, screen that would be showing the road in front of the car and, of course, the patient inside of the ambulance, which would need to be saved while driving the car.

As a result, the simulator was created consisting of construction, which includes a real ambulance from Gjøvik County Hospital, a hydraulic regulated system imitating the movement of the ambulance on different roads and all electronics necessary to show the 'road' on the wall in front of the windscreen. In the ambulance car a robot-patient with human features is also placed. All technical components added together are imitating an injury situation that is to be managed during the training.

Figures 2 and 3 show the ambulance on the shaking table and how it is equipped.


Fig. 2. The ambulance placed on the shaking table.

Fig. 3. The interior of the ambulance.

Figure 4, on the other hand, shows an example of the virtual road the driver had to maneuver the ambulance on.


Fig. 4. Example of a virtual road the ambulance driver had to drive on.

The project was completed as a part of NTNU Gjøvik strategy (Gjøvik University College previously), where both interdisciplinary work and welfare technologies are highlighted as key priorities. Therefore, the Dean of the Nursing

Department allocated money and time resources for employees to be motivated and actively take part in the development project.

During development process, some technical problems occurred causing the nurses to be skeptical towards it. First of all, the engineers working on development of the simulator's construction didn't know which car are they going to receive. This has increased the time of the project execution, since planning and work couldn't start because of this simple issue. Secondly, after discovery of which car would be received, it was possible only to get the measurements and sizes of it, but not the ambulance car itself. It was still used at the hospital and would be finally delivered for application in the simulator only after the end of all the preparation processes and development of hydraulic and electronic systems. Thirdly, the team wasn't receiving all the necessary equipment for the beginning of work on time and thus had to wait again. After the car was finally received, it was discovered that the 'driving bridge' constructed for the simulator was not strong enough to hold the car on the hydraulic system and had to be changed and replaced. There were also minor problems related to absence of people related to the project at their work places occurring. After finally putting together all the parts of the simulator, electronic system didn't function exactly as it was supposed to, creating need to make necessary changes and improvements. These are ones of the main reasons for use of dynamic project development as well as change management within the project. However, in the end, all the issues were successfully resolved and the interest to the ambulance simulator has risen significantly making skeptical opinions to disappear. Today the simulator is used for training of students that are going to work as ambulance staff in future.

## 3. Modern learning techniques

As it was mentioned before, the ambulance simulator is used in the training of physicians, emergency nurses and paramedics. After actual implementation of the simulator the learning techniques used started to change more towards practical orientation being adapted to the "learning by doing" concept. It is easy to observe that *"learning by doing develops deeper and more profound knowledge and greater commitment than learning by reading, listening, planning or thinking"* [18]. However, for some of the students and teachers use of modern technologies during the educational process was challenging even though it proved being more beneficial both for the knowledge level and educational degree. This is result of being used to the old system of education and educational techniques, which are mostly theoretically based.

Thus it is important to implement certain features of the learning/teaching process leading to slight adaptation of students and teaching staff to more practically orientated education.

This can be done through turning the ordinary classrooms into the learning/teaching factories. *"Learning Factories pursue an action-oriented approach with participants acquiring competencies through structured self-learning processes in a production-technological learning environment"* [19]. This means that students have opportunity to, firstly, become more independent while studying, thus developing the habit of creative thinking and, secondly, gaining practical skills that will be useful in their future profession. The developed ambulance simulator can be called an attempt of brining the real world into the classroom and making it a part of the real hospital to some extent (learning hospital/factory).

## 4. Reflections

Application of ambulance simulator has affected not only the learning process, but also brought interesting findings related to so-called cultural crash between nurses and engineer's cooperation during the product development. Unfortunately, communication conditions between representatives of different spheres didn't function as good as it was supposed to leading to problems and misunderstanding. Such situation was result of combination of two absolutely different communities of practice that were hardly speaking to each other because of lack of common mutual engagement, joint enterprise and a shared repertoire.

Engineers and nurses were easy agreeing on user requirements and specifications of the product, while the specifications of design targets and details showed to be difficult to decide. When the engineers already developed certain part of the product, the nurses reacted negatively and were critical about the solutions causing re-engineering. Here the change management was used in order to try to optimize the development process.

However, such behavior resulted in development process being non-linear and consisting of several loops, thus increasing the cost of the overall product. The reasons for clashes appearing the most often were core values and difference of professional language. Both core values and professional language are part of the shared repertoire that wasn't shared at all.

### *4.1 Core Values*

It is hard to say that nurses and engineers have similar professions in any aspect; so, the difference in views on the most important values in professional sub culture was huge. Engineers were worried about *development and design of smart products that make life better and easier for older people, avoiding waste and efficient operation.*

At the same time, nurses were taking care of: *delivering care to the patient by the use of their skills in a good way and by having action competence.*

Both views are important, however, combining them within the product development process may lead to a costly and inefficient work.

### *4.2 Professional language*

However, core values are not the only reasons to cause misunderstanding. Often usual words are perceived as negative ones leading to unwilling to cooperate.

For an engineer such words as: production, customer, efficiency, robot, technology, lean, waste, resource scarcity and procedure are commonly accepted and easy to understand. At the same time, nurses often prefer quite different words as: supporting equipment for human care instead of robot technology, patient/user instead of customer and good working routine instead of lean/production.

In this case, it is possible to divide such key words into three groups: blockers, yellow words and green words.

Those words that are perceived as critical, in other word blockers, can destroy cooperation as they can be perceived as attacks on subculture/community of practice.

Yellow category word can also be perceived as negative association for some and lead to willing to stop the cooperation process, however, unlike blockers, they are not perceived as attack.

Green category words are those accepted in both camps and are not associated with negative. The next subsection will propose ways to solve the above mentioned problems and suggestions of further improvement of the simulator.

### *4.3. Solution of problems and suggestions of improvement*

In order to make teams combining different communities of practice more efficient it is possible to use the following advices:

- Increase quality of team management;
- Combine in team those people that have background from different communities of practice;
- For the long term projects hold trainings for participants with explanation of peculiarities of different fields;
- Use terms that are understandable for each community of practice involved.

These are only some of ways of avoiding the cultural clashes, however, their use should be enough to increase efficiency of the project run significantly. The first suggestion would lead to making the group of people feel more that they are working together and only good cooperation will lead to success. The second advice would make it harder to find the team members, however, their work would be more efficient from the very beginning, since they would use a shared repertoire. The third advice would help integration of people from one community of practice into another leading to increase of cooperation between them and the last point would be an attempt of avoiding the conflicts.

The ambulance described in this paper has been developed as a ready product, however, it still can be improved from the points of view of technological appliances used inside and the mannequin representing the patient.

It is possible to use a more sophisticated model of patient-robot, which would perform more types of injuries. If necessary, more roads choices can be also included into the simulator menu. In addition to this, it is necessary to follow the tendencies of the ambulance equipment to be sure that the car has everything necessary for the efficient and up to date training of nursing students. The next section provides a conclusion of the study.

## 5. Conclusion

The article covers the peculiarities of ambulance simulator development implemented at the Nursing department of NTNU Gjøvik. It provides description of the product development method, which was chosen to be participatory action research following the principles of dynamic product development and design for usability with engagement of specialists from both engineering and medical spheres (communities of practice). As the engineers and the nurses working together on the simulator development had different backgrounds and previously followed different trainings the development process turned out to be rather inefficient, because of combination of people from different communities of practice in one group.

Specifics of the project made it impossible to do it following the traffic light method, thus leading to use of dynamic development with non-linear processes and loops. Presentation of development of use of simulators for medical education is also provided.

Despite the cooperation and communication problem, an innovation from the public sector arouse based on a unique welfare technological product. The goal set up by the project team was reached brining the ambulance simulator for the training and licensing of ambulance staff. Now students received possibility to be trained both as ambulance drivers and as ambulance personnel, as it was requested.

Implementation of the ambulance simulator made application of “learning by doing” and learning factories techniques possible to be integrated into the classroom leading to increase of practical knowledge of the future ambulance staff. The paper can serve as further research basis on topics of the simulators development and modern educational techniques use. Suggestions of further simulator improvement are also provided.

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