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SIMULATION BASED LECTURES FOR STUDENTS IN LOGISTICS

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Abstract: Automation and digitalization in logistic processes nowadays increase the complexity of logistic systems (supply networks, terminals and warehouses) and leads to highly linked systems. Their dimensioning as well as start-up and optimization of operational processes require technical assistance today.
Simulation is used for understanding the behaviour of the seaport terminal and analysing the interaction of the complex processes at the terminal. This paper will show an investigation of the usage of specific port terminal simulator in the education of logisticians at university. It will show the effects of using simulation within the lessons in respect to the understanding of port operation and port simulation.

Keywords: simulation, port operations, container terminal, learning, logistics.

1. INTRODUCTION

In today's society, major companies within the maritime industry pose different requirements to graduates and applicants such as to learn, model and solve problems. Ananiadou and Claro [2009] in their "21st Century Skills and Competences for New Millennium Learners in OECD Countries" has proposed a new three-dimensional framework for 21st century skills and competencies, where one of the dimensions is information. Information dimension requires new skills for accessing, evaluating, and organising information in digital environments. There is also a need of being able to model and transform it to create new knowledge or to use it as a source for new ideas. It results in information as an input and information as an output. Information and communication technology (ICT) literacy skills are essential to navigate and analyse the overabundance of data available today [Irvin 2007].

Simulation is the ability to construct and interpret dynamic models of real-world processes [Jenkins et al. 2009]. There are two important regards of simulation for learning. Initially, students see simulation and modelling more compelling than other more traditional ways of sharing knowledge. As a result, they spend more time engaging with them and thus make more discoveries. These simulations expose users to powerful new ways of seeing the world and encourage them to engage in the process of modelling, which is central to the way modern science operates. Students who use simulation in their learning process have more flexibility to form customizing models and manipulating data to exploring questions that have captured their curiosity [Jenkins et al. 2009].

Simulation studies are usually used to develop approaches for improving the performance of dynamic and complex systems like intermodal terminal ports. Simulation helps imitate the port operations and provide predictions of outcomes and performances. Different scenarios can also be tested in a simulation model and the results can be studied and analysed [Kotachi, Rabadi and Obeid 2013].

Facilitation of the learning process involves understanding who the students are [McGlynn 2005]. The Millennials are the generation born in or after 1982 [McGlynn 2005; Howe and Strauss 2009; Bottomley and Burgess 2018] and is the subject of this research. They represent 93% of the Bachelor program students in Shipping and Logistics at the University of South-Eastern Norway in 2016 (from the first to the third year students). Thus, the objective of this research is to investigate if ordinary classroom education together with extensive use of simulation software increase the understanding of container port operation and optimization within higher education at university level in Norway [Berg 2017].

2. LITERATURE REVIEW ON LEARNING THEORIES

People agree that learning is important, but they hold different views on the causes, processes, and consequences of learning [Schunk 2012]. There is no one definition of learning that is accepted by theorists, researchers, and practitioners and varies widely across disciplines [Shuell 1986; Barron et al. 2015]. Although people disagree about the exact nature of learning, a general definition of learning, that captures the criteria most educational professionals consider central to learning, is:

'Learning is an enduring change in behaviour, or in the capacity to behave in a given fashion, which results from practice or other forms of experience' [Schunk 2012].

In addition, Schunk [2012] defines three criteria of learning: (1) learning involves change; (2) learning endures over time; (3) learning occurs through experience.

Theories attempt to explain various types of learning but they differ in their ability to do so [Bruner 1985]. Learning theories are the conceptual frameworks that describe how students acquire, process, and retain knowledge under the learning process [Simandan 2013]. Environmental, emotional and cognitive factors, as well as prior experience, play an important role in how understanding is formed or changed and knowledge and skills are retained [Crane 2016]. While trying to clarify the whole concept and process of learning, researchers have reached diverse theories. Learning theories are mostly connected to practice in the way that theory drives practice and some learning theories are close to practical teaching approaches while others are not [Pange et al. 2010]. The main learning theories prevailing educational environments are: (1) behaviourism; (2) cognitivism; (3) humanism, (4) social learning and (5) constructivism.

Behaviourists view generally the learner as passive who only responds to environmental stimuli. The basic stimulus-response relationship drives to an observable change in behaviour [Ormrod 1999]. In behaviour analysis, learning is the acquisition of a new behaviour through conditioning and social learning. There are three types of conditioning and learning:

- classical conditioning, where the behaviour becomes a reflex response to an antecedent stimulus [Myers 2004];
- operant conditioning, where antecedent stimuli results from the consequences that follow the behaviour through a reward (reinforcement) or a punishment [Myers 2004];
- social learning theory, where an observation of behaviour is followed by modelling.

Cognitive theories were developed in Germany in the early 1900s by Wolfgang Kohler [Soltis 2004]. Cognitive psychologists argue that learning cannot be described in terms of a change in behaviour. These theorists make a distinction between learning and memory, and learning is viewed as the acquisition of new information. Nowadays, researchers are focusing on topics like cognitive load and information processing theory.

Huitt [2009] shows to Rogers and Freiberg [1994] that refer to that humanism considers learning as an independent action related to the values an individual develops through the lifespan.

Social learning theory has a focus on the learning that occurs within a social context. Social learning considers that people learn from each other, including concepts as observational learning, modelling and imitation [Ormrod 1999].

Constructivism, founded by Jean Piaget, considers learning as an active process where the knowledge is "constructed" by the leaner [Pange 2000; Pange et al. 2010]. This forms the foundation for discovery learning – a highly self-directed and constructivistic form of learning [De Jong and Van Joolingen 1998].

Even though behaviourism, cognitivism, constructivism, humanism and social learning theories are the main learning theories, new approaches arise on how people learn [Pange et al. 2010]. New Technologies are dominating the learning era and their role in formal and informal learning stress new dimensions on pedagogical, theoretical and practical grounds [Pange et al. 2010].

The advancement of technologies have revealed other learning theories, which are either new, a combination or an outcome of the well-known learning theories. Technology in educational settings provides situational and visual cues allowing students to reflect, be involved, interact, communicate, produce and learn. Haugland [2000] supports the implementation of technology in classrooms in order to accomplish learning objectives that provide opportunities for experimentation, investigation and discovery either individually or in groups. Therefore, simulation methodology has been recommended and chosen to assist teaching course port operations.

3. SIMULATION IN PORT OPERATION

Terminal operations in container ports are becoming increasingly complex because of the high demands of shipping lines caused by the increases in vessel dimensions and container volume. As the result of a cascade effect, this is not limited to the largest ports. Future logisticians must be prepared to avoid bottlenecks during peak conditions in addition to improving the terminal layout and purchasing additional equipment, while innovative technologies may provide solutions, including automation and sophisticated control systems.

Simulation is assumed to be the best tool used for a “real world” system. For analysis of complex systems, simulation is often used prior to the operation of the real world system as a mediator for a dynamic situation [Yun and Choi 1999]. Advances in simulation technology have enabled an interesting amount of training and instruction to be conducted on training simulators instead of on real systems. However, experiences with the procurement and use of training simulators has not always been as successful, often owing to a lack of knowledge of didactics and of training programme development, and also to inadequate simulator specifications [Farmer 1999].

Pioneer studies in computer simulation of port operations were Steer and Page [1961] when they simulated operations of an iron ore unloading port. Nowadays, there are over 50 simulation tools and languages to perform port simulation [Dragovic, Tzannatos and Park 2017]. One example is the software package “CHESSCON”, developed by the Institute of Shipping Economics and Logistics, Bremerhaven, Germany. The software is modularized and the different modules are used for specific processes as calculating terminals capacity (Capacity), dimensioning of terminals (Simulation), visualization of the current yard utilization (Yard View), start-up and strategy optimization (Virtual Terminal) and the optimization of the day-to-day operation (Shift Preview).

The overall terminal simulation (CHESSCON Simulation) is used by terminal planners, terminal operators and universities and training institutes worldwide. The simulation of the port operation system used supports the user to investigate planning alternatives or elaborated designs of container terminals. The design comprises the layout and the deployment of equipment (Fig. 1). The interdependence of these two factors is a focal point of the model, i.e. it investigates which areas are available and which equipment types and operation system should be deployed best.

The evaluation of the simulated container terminal is carried out with regard to economic and technical aspects. The output of the target variables, measured against each other and interpreted, are in particular the costs incurred and the handling volumes achieved.

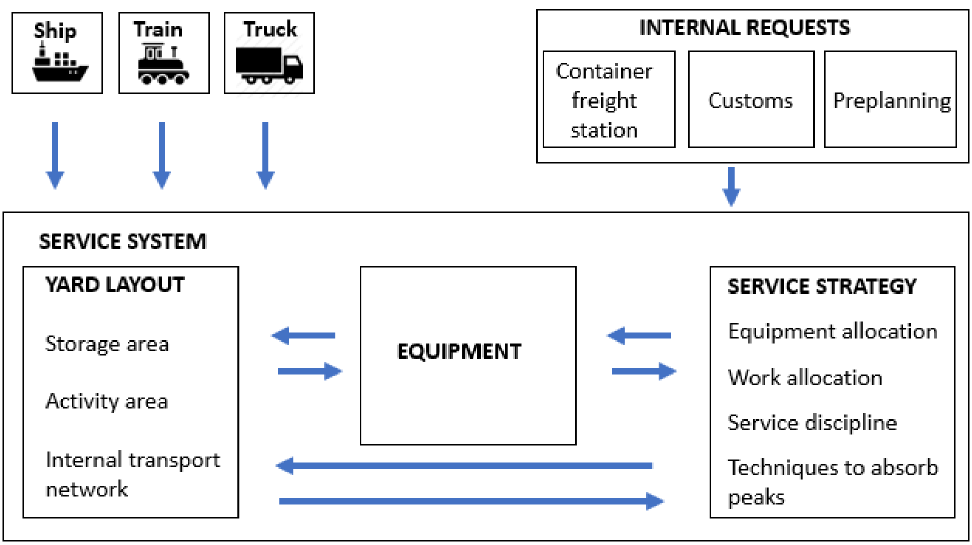


Fig. 1. Elements of a Container Terminal Service System

Source: [Ballis and Abacoumkin 1996].

This strategic level covers the planning of new terminals, the expansion of existing ones and changes in organisational structures. This tool does not track each single container but the behaviour of the whole system 'container terminal'.

With regard to simulation analysis of terminal's operations system a separate module is usually applied for drawing up appropriate simulation scenarios. Hartmann [2004] describes how to generate consistent data.

The simulation procedure shown in Fig. 2 provides the necessary flexibility for taking new concepts of the system interfaces waterside, gate and railway into consideration. After entering the information about the layout of the terminal – typically using a graphical editor –, the amount and technical data of the equipment needed and about the workload at the quayside, the gate and the rail facility the tool will generate job lists which have to be processed by the simulation. An animation is used to let the user understand, what happens within the "black-box simulation".

All steps of operation are recorded into a database to get information about waiting and idle times and the productivity achieved. With the results of the simulation the user can calculate the operation costs for each terminal operation system. In the end, a technical and economical evaluation of all analysed terminal systems will be executed.

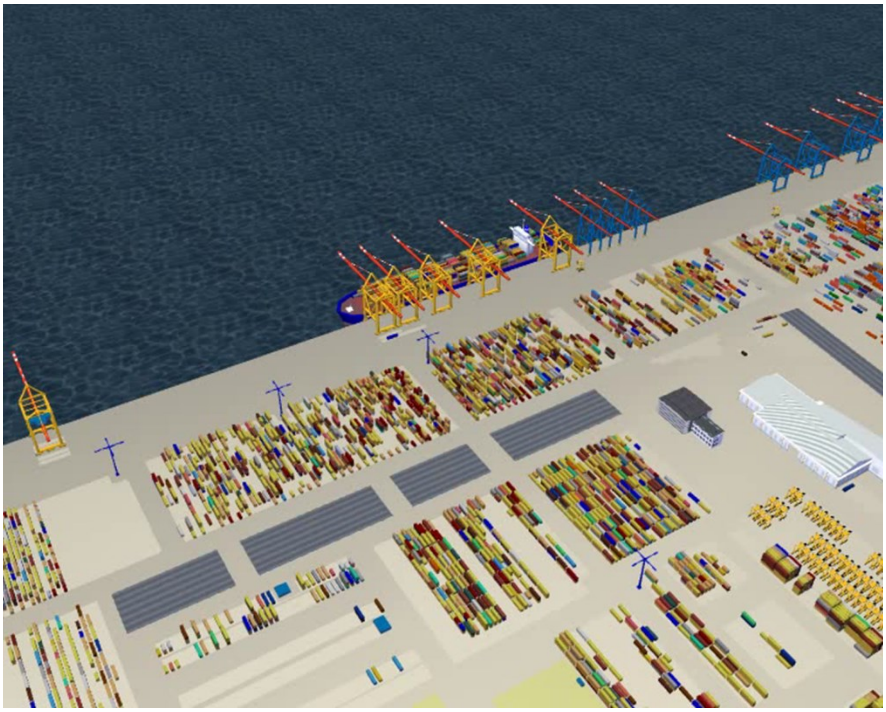


Fig. 2. 3D visualization of a terminal simulation

Source: [ISL Applications GmbH 2018].

In this way the whole terminal operation may be analysed and optimised. Different stacking equipment (e.g. straddle carriers, rail mounted gantry cranes (RMG) combined with automated guided vehicles (AGV) or shuttle carriers, rubber tired gantry cranes combined with chassis or AGV) may be compared by key performance indicators (KPI) or costs per move.

The layout may be optimised regarding the size (length, width and height) of the stacking blocks, the traffic control (one way tracks, priority handling).

Furthermore the strategies (pooling transport equipment, twin or tandem lift operation, block allocation) may be analysed and optimised with tools of this level of detail.

4. METHOD

The course Port Operations and Logistics (7.5 ETCS) was lectured at the 3rd year in Bachelor program Shipping and Logistics at the University of South-Eastern Norway. Port Operations and Logistics is a course with a focus of physical operations within a port goods terminal, ship to shore operations, internal port operations, and choice of transport modes with respect to hinterland transportation, identification of costs of port operation, pricing of port operations and the KPIs.

The main topics of the course are:

- terminal/port knowledge: geography, total port area, apron, dedicated areas for various operations, stacking patterns, gates, equipment, cranes, etc.;
- capacity calculation and evaluation;
- problem solving/-optimising of port problem areas with the use of various simulation software for port operations, and foreland and hinterland activities;
- port costs;
- port pricing;
- key performance indicators.

The learning objectives in the field of knowledge are mainly port operations with focus on container terminals, port costs, port pricing, key performance indicators and modelling port operations using simulation software and document flow related to export and import of cargo. Upon completion of this course, the students are to acquire following skills:

- to understand, determine and calculate charges/rates (taxes, duties, fees, and dues, etc.) that apply during port operations;
- to plan and optimize port operations;
- to identify environmental threats and challenges, plan and calculate countermeasures to satisfy requirements in accordance with regulations and society;
- to determine transport modes with respect to hinterland infrastructure and accessibility based on destination;
- to describe which implications choice of transport mode cause for the ports;
- to be able to plan and execute port operations aiming at optimization with respect to time, price, area, equipment, environment and simulate and explain these processes.

After accomplishing the course, the general competence obtained should make the students able to obtain deep insight in the various port operations, from the moment a container enters, until it is transhipped. Additionally, they should demonstrate understanding and establish key performance indicators from the point of view of both Port administration, Port terminal operator, and Ship-/liner operator.

This course is tutored as a combination of:

- traditional lecturing (combination of oral presentations, usage of whiteboard,

PowerPoint-presentations and/or overhead presentations);
- computer labs to learn how to utilize Chesscon software to model and simulate logistic areas related to procurement.

Sessions are structured with bidirectional communication and the student is invited to engage in discussions and experience/sharing during sessions.

The student was required to read relevant literature, participate in lectures and group work, and to deliver mandatory assignments. Mandatory computer laboratory exercises were carried out during the semester. The home examination was mandatory for all students. It consisted of a group assignment to be submitted as a PDF document in LMS Canvas whilst the final project was presented in a plenum class session.

Exploratory case study of the Bachelor students in Shipping and Logistics at the University of South-Eastern Norway (USN) was conducted in 2016. They had completed a 5-day training course in "Chesscon Simulation" simulation software (Chesscon).The training was given by professionals from ISL (owner of Chesscon) while experienced students assisted training. Data collection was performed through a survey. The survey was located on the internet and published through the Questback.com. All potential respondents received a personal mail inviting them to reply to the survey. Survey was only open to invited respondents and the survey was open for a limited time of 14 days. Later collected data was exported to Microsoft Excel 2016 where the analysis was performed.

Sample Size Calculation:

$$n = \frac{z^2 p(1-p)}{\alpha^2} \tag{1}$$

Finite Population Correction:

$$n_1 = \frac{n_0}{(1+n_0)/N} \tag{2}$$

To maximize the sample size to be efficient for all the Millennial students and their learning process, we have calculated the Sample Size (1) for a prevalence of 50%, and consider the precision as the level of 5%. The initial calculation for the sample size was 384.16 cases. After we applied the Finite Population Correction (2), the finite sample was 20 with response rate of 100%. The results in our survey therefore has a statistical confidence level of 95% and a margin of error on 5%.

5. RESULTS

Respondents represent an age distribution from 19 to 41 years old, where males represent 80% and females – 20%. They are grouped in three age groups of 19–22, 23–27 and 28 years old and elder (Fig. 3). Majority of students fall into category of age range between 23 and 27 years old.

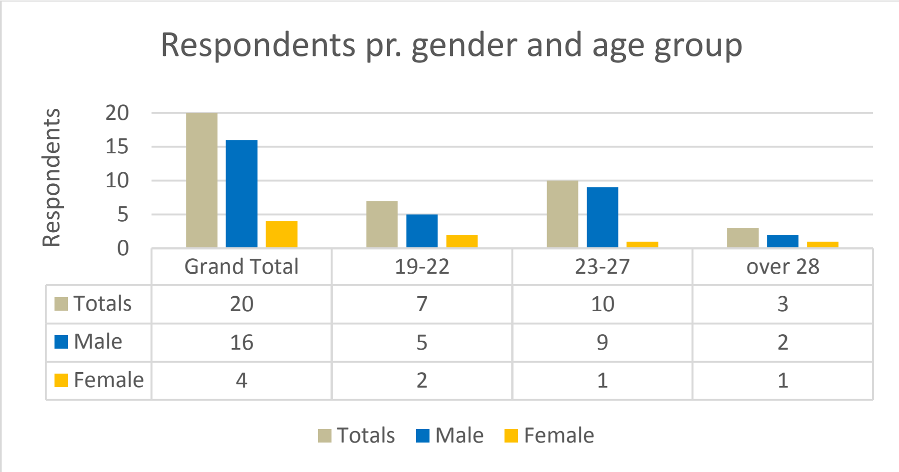


Fig. 3. Respondents grouped based on sex and age group

Source: own data.

5.1. Computer literacy

Computer literacy is a major factor, which might be hindering the learning of computer programs. In this study, Fig. 4. indicates that this is still the case at least if we study it based upon the average time the sexes have been working with computers, where our survey indicates on average nearly 9 years for boys and only 6 for girls.

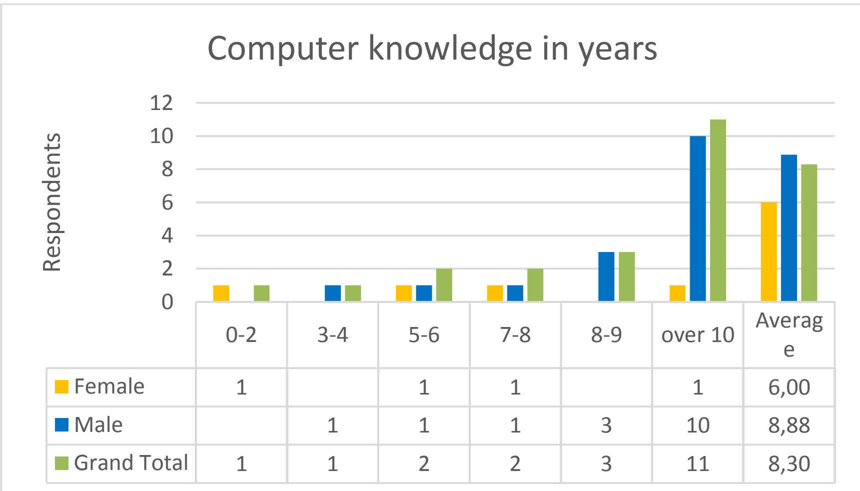


Fig. 4. Respondents grouped upon sex and years working with computers

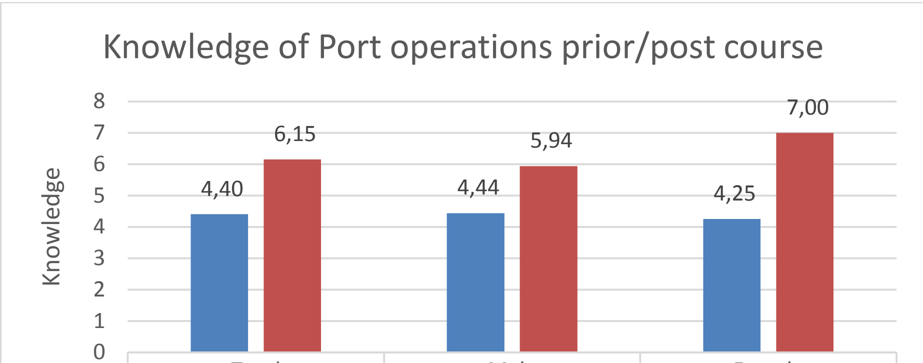
Source: own data.

5.2. Port simulation and learning goals

This study is based upon the statement that understanding of port simulation is based upon two major factors: *port operation knowledge* and *port strategy knowledge*. Our definition of port operation includes the following major processes:

- crane, transport and port equipment operation;
- administration and organisation of storage area in ports.

To be able to measure the effect simulation software might have on this factor the first question and the second latest question asked were a self-estimation. Students were to evaluate port operation and port strategy knowledge prior and post the CHESSCON simulation course on a scale from 1 (low familiarity) to 10 (high familiarity).



	Total	Male	Female
Prior	4,40	4,44	4,25
Post	6,15	5,94	7,00

Fig. 5. Port operations learning

Source: own data.

Fig. 5 shows a major improvement for both sexes, but the increase for the girls have been approx. 65% versus approx. 44% for the boys.

Port strategy knowledge is based upon the following major processes:

- economic understanding and knowledge on container-ports from a management perspective;
- what effect will a change in area for storage, new STS cranes etc. have for the capacity and the economic operation of the port;
- understanding of cost drivers within container ports and their competitive effect.

The survey followed the same principle as when port operation knowledge was measured.

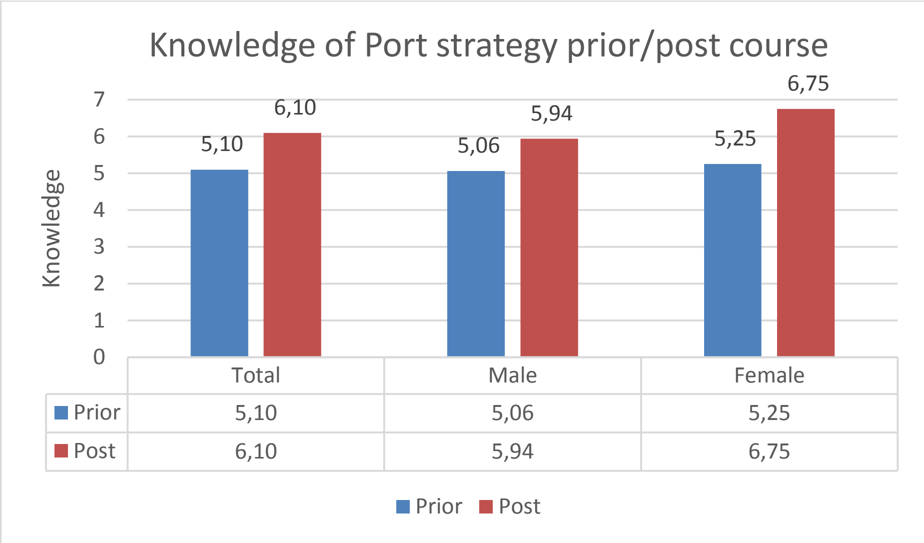


Fig. 6. Port strategy learning

Source: own data.

Fig. 6 shows a large improvement for both sexes, but the increase for females have been approx. 24% versus approx. 17% for the males.

For each course at the University of South-Eastern Norway, there is a syllabus, which in detail describes the learning outcome for a selected course. In the survey, we asked all the respondents to reply to a simple yes/no questionnaire to confirm whether they had reached the specific learning goals for each subject. This questionnaire consists of two parts: one for port modelling and one for port optimizing/simulation.

Table 1. Port modelling learning outcomes

Goals building port model	Yes	No
Draw basic port outline	18	2
Draw basic port outline with background picture	15	5
Draw path for arriving vessel	12	8
Draw streets for transport	19	1
Draw stacking area	19	1
Draw gates for in/out transport by truck	17	3
Allocate container types to different stacking area	19	1
Add STC cranes to model	17	3
Achievement factor 1: 136/160= 85.0%	136	24

Source: own data.

Table 2. Port simulation learning outcomes

Goals optimizing port strategy model	Yes	No
Optimizing container handling	9	11
Explain & optimize container stacking area	13	7
Explain & allocate different terminal equipment	10	10
Achievement factor 2: 32/60 = 53.3%	32	28

Source: own data.

The results from Table 1 and 2 indicate that regarding port modelling 85% of the students have achieved the learning goals and 53.3% – for the port optimizing/simulation. An overall total achievement factor indicates that 76.3% of all learning goals have been obtained.

To ensure that the effect indicated with the use of simulation software we decided to compare the percentage of achievement of learning goals claimed by the respondent with the final grading on the course and the average grading on other logistic subjects within their Bachelor program.

Fig. 7 confirms that the results from percentage achievement learning goal is closely corresponding the average grade in this subject. The grades in this subject is also on average one grade higher than the other subjects in their Bachelor program.

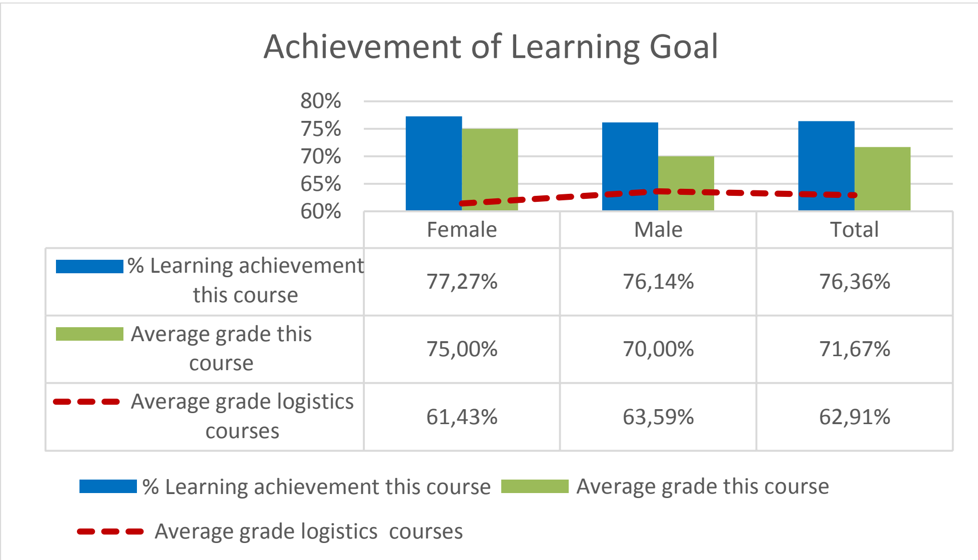


Fig. 7. Achievement of Learning Goal

Source: own data.

6. DISCUSSION

6.1. Skills

Baldwin and Ford [1988] call to the attention of future research the importance of training content emphasizing what the desired skills are to ensure skill acquisition. Today's labour market has to be supplied with the set of skills and competencies, which are suited to the knowledge management. This includes processes of information selection, acquisition, integration, analysis and sharing. Most of these competencies are either supported or enhanced by ICT. For university students, classes can be the only place where such competencies and skills can be acquired.

Ananiadou and Claro [2009] proposed typology of skills in question. Simulation classes with use of CHESSCON simulation software facilitate gaining skills and competencies from all the three following categories:

ICT functional skills, that include skills relevant to mastering the use of the CHESSCON application, by familiarizing with program interface, layout of the terminal, different stacking equipment, etc.

ICT skills for learning, which include skills that combine both functional skills with cognitive abilities or higher-order thinking skills for the use and management of CHESSCON. Logisticians learn to access, evaluate, and organise information in digital port environment and are able to model and transform it into new knowledge or to use it as a source for reasoning and decision-making.

21st century skills, which appose skills considered necessary in the knowledge society but where the use of ICT is not a necessary condition.

As a result, students with high ICT literacy will have a high probability to successfully solve real world problems based on their learned experience [Binkley et al. 2012].

6.2. Millennials

Differences in learning are based on age, learning styles, and students' nature. A current university student is between 19 and 41 and is a representative of a new generation of "Millennials". They have grown up playing video games, using PCs, having mobile phones and fast Internet. According to Statistics Norway approximately 1.6 million people in Norway fall in this category, where 48.6% are females and 51.4% are males [Statistics Norway 2018]. They are also the most diverse generation — up to 20% of them are minorities. Apparently, these students learn differently and interact differently than former students and than their older classmates. "Millennial" students believe that it is "cool" to be smart and are fascinated by new technologies [McGlynn 2005]. Moreover, research by Raines [2002] concludes that these students appreciate teamwork, use of technology, structure, and the experiential activities. Thus, use of simulation is *intuitive* to their desire to be involved with "real life" issues that matter to them, and proves that they are comfortable with and enjoy using technology. Study shows that this tool has shown *inclusiveness* in terms of gender, background and ICT skills. All the students has shown knowledge gain on average 28.5% in Port operation knowledge and 16.4% in Port strategy knowledge, while considerable age dispersion of age (11 years) and ICT knowledge of over 10 years.

6.3. Discovery Learning

One of the criteria for learning by Schunk [2012] is that learning occurs through experience. Through learning experiences, students and teachers share meaning in ways that allow them to arrive at mutual understanding of information [Morreale and Staley 2016]. This highlights how teachers and students co-create learning environments and with help of simulation software this learning environment and knowledge itself is dynamic.

Higher achievement of learning goals in the course of Port Operations and Logistics (7.5 ETCS) can be an indication of easiness of transference of the simulation method. Using the simulation software students are learning the skills rather than facts. Another significant advantage for simulation in education is its capacity to motivate students. It provides opportunity for the students to engage with learning environment rather than memorize facts and figures.

The reasons for a shortcoming of simulation as a part of curriculum is that it requires more time for users to explore and to test. This can be challenging when implementing this new learning tool in the traditional timeframe of the course.

6.4. Logisticians

Nowadays, competiveness and efficiency of port operations must be continuously improved to face worldwide competitors [Blondet et al. 2015]. Their processes and products must be continuously optimized with quality, cost and time objectives [Blondet et al. 2015].

Traditional classes fail to provide scenario-based dynamic learning for future logisticians. Drawing streets for transport, drawing stacking area, allocating container types to different stacking area, drawing basic port outline and adding STC cranes to the model, that got an 85% success rate among students, help students visualise and conceptualise port models as well as to test complex processes resulting in quality, cost and time estimates.

7. CONCLUSION

The use of simulation software has uncovered an improvement factor on the final grades of “Millennial” students in the course of Port Operations and Logistics (7,5 ECTS) as a third year course for Bachelor students. This is an indication that providing quality higher education for “Millennial” students require (a) cohesive simulation software that suits the purpose of higher education for logisticians, (b) adjusting instructional policies and course content to address millennial characteristics, (c) implementing new strategies and skills to be acquired (ICT, simulation skills), and (d) continuing to develop a research agenda that improves millennial students’ education experiences. As a result, the use of CHESSCON simulation is seen to be intuitive and inclusive tool for “Millennial” students that results in 8,76% higher average grade comparing to other courses in the program.

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