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Text-Mining and Gamification for the Qualification of Service Technicians in the Maintenance Industry of Offshore Wind Energy ☆

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Abstract

The competition of maintenance services in the offshore wind industry is continually increasing. The quality of the services acts as the distinguishing feature in the industry. Furthermore, there are public standards, which lead to the permanent necessity to offer further education and training programs for employees. To meet the requirements for further training in the specific field of application within the offshore wind industry, a gamified e-learning application has been developed and is introduced in this paper. It consists of a complete solution, which contains the automated analysis of service protocols to identify qualification needs, the involvement of service technicians in the generation of learning materials, the preparation, transmission as well as the further development of those materials in accordance with the principles of e-learning. Finally, the solution contains a gamified mobile application for qualification, which is designed to meet the individual learning needs of the service technicians. This concept paper follows a problem-centred approach. Based on the current state of technology and research, the problem and motivation are identified and the urgency is verified. Furthermore, a detailed specification of the solution and a first implementation approach is presented.

Keywords: Offshore Wind-energy, Maintenance, Qualification, Text mining, Gamification

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1. Introduction

Cost reduction in the area of qualification of service technicians in the offshore wind industry is a crucial competitive factor for service companies in the German market. At the same time, the quality of work of the service technicians is the main distinguishing feature. This paper proposes an approach, which addresses the dilemma of investing in higher quality further training as well as reduction of cost for qualification measurements.

The paper is organised as followed: Firstly, the current state of the offshore wind industry and the scope conditions for maintenance of offshore wind turbines (OWT) and requirements for qualification of service technicians are outlined. This is followed by the research approach described in section 2. The focus of this contribution is on the area of qualification for the maintenance work on OWT, on e-learning and gamification approaches in this context as well as on the analysis of large quantities of information via text mining methods on the basis of service protocols. Accordingly, the current state of research of the three areas is illustrated in section 3. In section 4 the description of this theoretical basis and the solution application are presented. The paper concludes with a summary and an outlook in section 5.

1.1 Research Background – Maintenance of Offshore Wind Turbines

With about 91 % of the globally installed ca. 9 GW offshore wind energy (OWE) capacities being located in European water and of that ca. 5 GW in the North Sea, the OWE in this region has gained increased relevance (Fried et al., 2015). The majority of those OWT is currently being planned or built. In order to remain competitive in the long term, it is necessary to guaranty a high level of availability and reliability of a vast number of turbines after they have been built to secure profits and minimize costs in the operational phase (García Márquez et al., 2012). To secure the availability of the OWT and by that to secure profit high quality maintenance is necessary. According to the DIN 31051, maintenance is defined as the combination of technical and administrative measures, this incorporates taking all measures to maintain and restore the nominal condition as well as to assess and evaluate the current condition. In the context of OWT the aim is therefore to minimize the error rate as well as to prevent long term consequences and damage of the OWT (Alsyouf 2011).

Performing maintenance activities on OWT is categorically different from those on onshore wind turbines. Indeed the maintenance process of OWT is substantially costlier in both effort and money. Furthermore, due to the great distance between the shore and the OWT it is not possible for the service technicians to commute between one place and another immediately (Burkhardt 2013). The transfer time to the OWT as well as the influence of the weather on the transfer and further factors have a direct influence on the ability to react to the maintenance activities. Down time, loss of speed and quality are the factors that have an impact on production time of the OWT beside the maintenance factors. In figure 1, this issue is depicted and it highlights the importance of maintenance for economic operation of the OWT.

1.2 Research Motivation – Need for Qualification in the Maintenance of Offshore Wind Turbines

Grantz et al. (2013) show that the amount of further training in the field of OWE in the north-west region of Germany continues to increase. Due to a quantitative coverage of the need for qualification, the quality of the qualification offers turns increasingly important. Here, not only the technical qualification but also increasingly the mediation of interdisciplinary competencies as well as managerial responsibility and security awareness are foregrounded (Grantz et al., 2013). The cost for high quality further training programs at certified institutions and further training facilities is significant for the maintenance branch. In the first four years of employment, more than eleven thousand Euro and at least 24 full working days were spent on training technicians and this does not include expenses of the trainers. Each year on average, the total amount spent on refresher trainings lies at above two thousand Euro and costs seven working days per person. Those significant costs for the qualification also face competition in the field of maintenance of OWE as well as the need for a high availability of OWT.

Due to the large number of OWTs which are required to be serviced and maintained, there is an urgent need for skilled workers as well in the next few years. Moreover, the quality of their qualification will play a

major role in the operation of the turbines. The personnel have to be versatile for offshore servicing.

In this regard, they have to be educated in their technical field of work and prepared for specific offshore challenges due to the diversity of activities depending on different types of turbines, substations, converter platforms, residential platforms and underwater cables.

2. Electric Submersible Pump(ESP)

The methodological approach of this paper is based on the Design Science Research Methodology. Peffers et al. (2007) defined the process for conducting Design Science Research into four possible starting points for research. These are known as the problem-centred approach, the objective-centred solution, the draft- and development-centred approach as well as the initialisation by contracting authority or context. Based on the practical question, for this paper, the problem-centred approach is selected. Particularly, the iterative process is divided into six steps in the process.

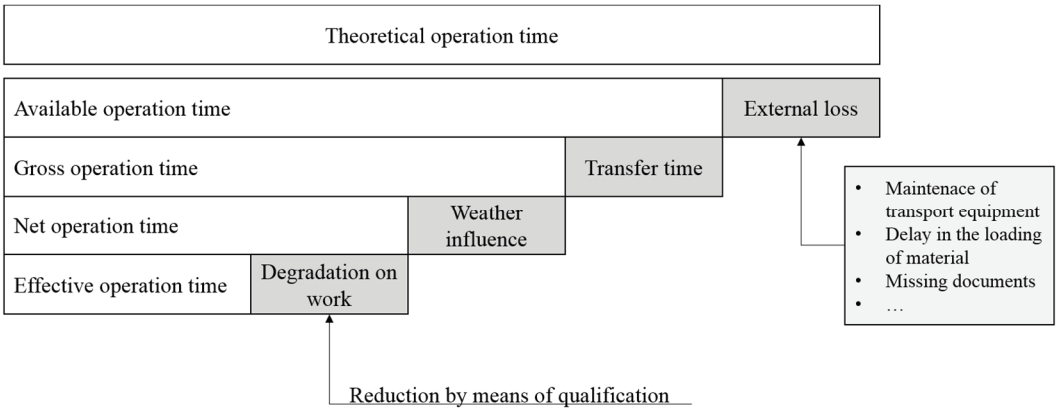

Figure 1: Theoretical operation time and influence on effective operation time

The first three of those steps are followed in this research paper. The first step is called „Identify Problem & Motivation“. It is the starting point for the problem-centred approach and contains the definition of the specific problems and the demonstration of the existing relevance. A deduction for the second step, “Design & Development” is made based on the identified problem. This step describes the added value through the solution. Subsequently, the third step of the process, “Design and Development”, includes the conception and implementation. Here, the transition from the object to the design and development is based on the theoretical background. In the scope of this paper, only preliminary conceptual considerations are taking into consideration. The remaining steps, “Demon-stration”, “Evaluation” and “Communication about the research findings” are not going to be considered during this concept paper (Peffers et al., 2007).

3. State of Praxis and Research

The areas of qualifications for the OWE, e-learning and gamification as well as the text-mining method provide the basis for the concept of this paper, which is introduced in the following and will result in a gamified qualification application for the OWE. Hence, the state of praxis and research is comprised of these three areas.

3.1 Qualifications for Service Technicians in the Offshore Wind Industry

The standards for qualifications of service technicians in the offshore wind industry are diverse and extensive. Table 1 demonstrates the required qualifications and certificates for service technicians at the Deutsche Windtechnik Offshore und Consulting GmbH (DWTOC), which they need in order to be fully deployable to all wind parks the DWTOC has maintenance orders in.

Note that the required qualifications depend on the orders maintenance activities of the relevant wind farm operator; there are service technicians who are working in wind parks with maintenance orders that require less certificates.

Further specific refreshing trainings for wind energy service technicians and their duration are listed below:

- Switching capacity up to 36kV (1 day)

- Personal safety equipment for protection against falling (PSAgA) rescue training (1 day)
- Global Wind Organisation Working at Heights (1 day)
- Save from cramped spaces (1 day)
- Cable access technology Level 1, 2, 3 (1 day)
- Practical seminar of optical waveguide technology (2 day)
- Practical seminar: Principles of screwing technology (1 day)
- Control HACA fall arresters (wind turbines) (1 day)
- Control Mobile ladders and kicks (1 day)
- Planning, control, maintenance, repair of "fixed-point ladders" (2 day)
- Basic control technology PLC S7-300 (5 day)
- Basic control technology PLC S7 - 1200 (5 day)
- Basics of hydraulics (5 day)

Safety Certified Contractor (2 day)

Table 1: Required qualifications and certificates for service technicians at the DWTOC

Title	Required standard	Requirements or necessary qualifications / trainings
First aid course	According to German Social Accident Insurance (instruction 1, principle 304-001) or Standards of Training, Certification and Watchkeeping for Seafarers	First aid according to German insurance association or Global Wind Organization
First Aid Offshore	German insurance association training	First Aid Offshore according to German Social Accident Insurance
Sea Survival training	Global Wind Organisation, OPITO or The Netherlands Oil and Gas Exploration and Production Association	Global Wind Organisation training
Basic Fire Fighting training	According to German Social Accident Insurance (instruction 1, information 205-023), Global Wind Organization training, OPITO or The Netherlands Oil and Gas Exploration and Production Association	Global Wind Organization training
HUET (Helicopter Underwater Escape Training)	According to OPITO or The Netherlands Oil and Gas Exploration and Production Association	Only for helicopter transfer
Working at heights training	According to German Social Accident Insurance (instruction 1, principle 112-199) or Global Wind Organization	Every two years, Global Wind Organization training
Manual Handling	According to Global Wind Organization standard	Global Wind Organization training
Confined Space Training	German Social Accident Insurance (principle 117)	
Offshore Medical Fitness certificate according to national or associative law	German regulation for ordinance on occupational health care	According to Working Group of Scientific Medical Societies S1-guidline or certified according to UK Offshore Operators Association, The Netherlands Oil and Gas Exploration and Production Association or Norwegian Oil Industry Association
Persons trained in electrical engineering	Trained according to Association for Electrical, Electronic & Information Technologies (guideline 105)	

3.2 E-Learning and Gamification

The e-learning approach is a new way of teaching and learning and it only emerged in the last two decades (Schüpbach et al., 2003 & Hillen and Landis, 2014). Therefore, there is no standardised definition and its meaning is still diverse in the research. The term has its origin in business and is considered as a means to offer electronically supported further training (Schüpbach et al., 2003). Within this context, there are various didactically designed approaches, such as web-based training, blended learning courses or virtual seminars as well as mobile learning scenarios and micro learning scenarios, all of which can be combined and extended (Knoll and Meinhard 2016). In order for these e-learning approaches to be successful, they need to provide learning scenarios with defined learning goals as well as a thought through project plans. Hereby, the aims of qualification and further training have to be defined in accordance with the greater goals of the company. Similarly, a clear definition of the necessary strategies and resulting measurements has to be taken into account as a basis for any form of e-learning (Dittler, 2011). By designing e-learning content, the decision between a sequential structure via exposition and a logical structure via exploration must be taken (Schüpbach et al., 2003). Figure 3 displays these differences.

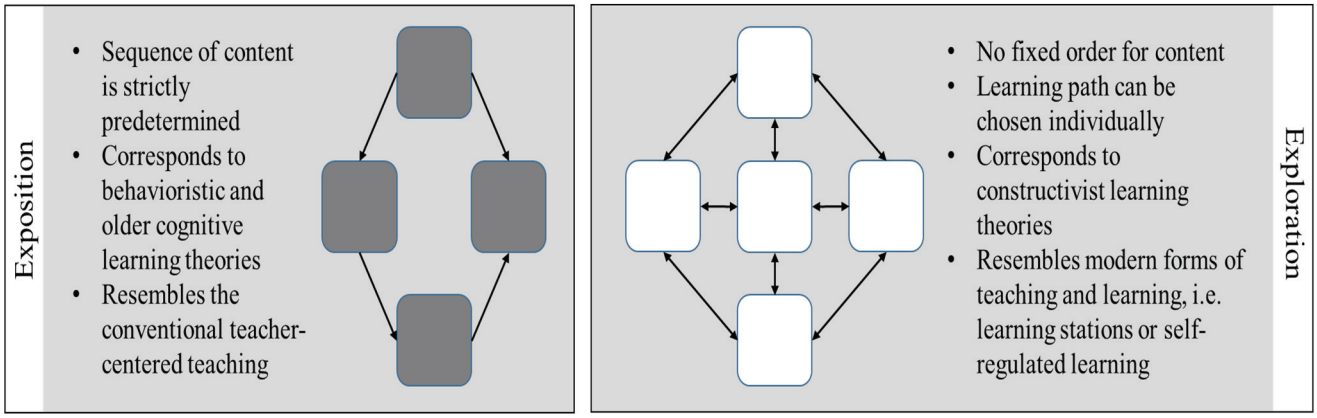

Figure 3: Preparation of learning contents of e-learning – Exposition vs. Exploration (Schüpbach et al. 2003)

Which structure is most suited for the particular learning unit depends on the amount of prior knowledge the learners have. This has to be considered when developing the learning content in advance to defining the qualification and further training needs and before the analysis of the material logic can begin. The latter comprises the collection, structuring, weighting and reduction of the learning content (Schüpbach et al., 2003).

In recent years, e-learning was established in many companies as the preferred teaching and learning strategy. However, its success is mainly dependent on the acceptance and motivation of the learners. Gamification encourages these aspects and affects learning-related behaviors or attitudes, which either influence the learning directly or they strengthen the relationship of instructional design quality and outcomes (Landers, 2014). Thereby they make an e-learning scenario more attractive to its users. This in turn supports learning efficiency especially with regard to speed and longevity of the acquired knowledge (Pawelka et al., 2014). Gamification is defined as the use of game mechanics and game design elements in non-game contexts with the objective of improving motivation and engagement (Deterding et al., 2011). When using gamification in didactical contexts, two types have to be distinguished. The first type is structural gamification, which applies game elements to the way the content is transmitted. This might mean implementing rewarding elements such as points systems, levels, badges, achievements or a leader board, which are displayed after a given task is completed. The second type is content gamification, which means adjusting the taught content to make it more game-like. This could be achieved by developing a narrative or storyline, challenges and immediate feedback in order to demand more learner involvement as well as provide the learner with more control over his/her learning process (Kapp et al., 2014.

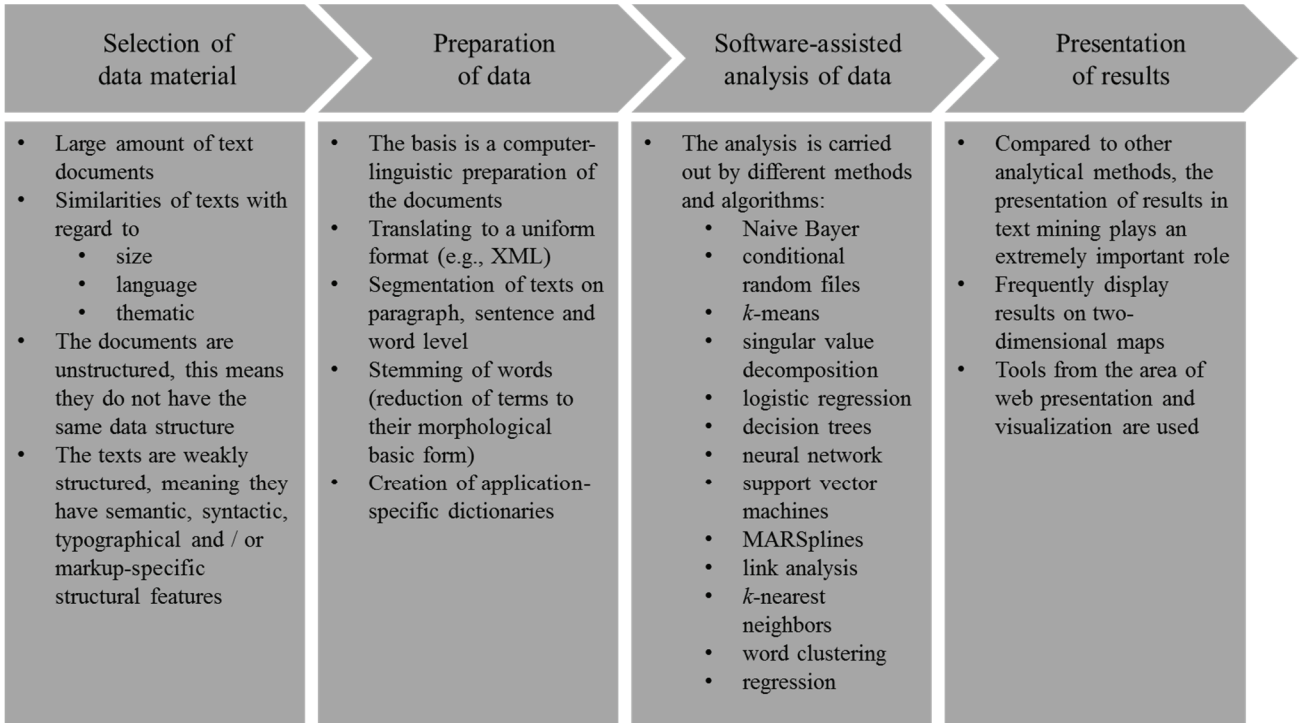

Figure 4: Text-Mining procedure (Miner et al., 2012; Feldman and Sanger, 2007; Weiss et al., 2005)

4. Conception

Based on the description of the theoretical and practical foundations, preliminary conception considerations for a gamified qualification application for service technicians in the OWE are presented. The starting point for any qualification effort is the identification of the subject matter. For the specific field of application in this paper, the knowledge about needs of the service technicians as well as a thorough documentation of the technical state of different types of OWTs, work protocols, maintenance checklists as well as experience reports of the technicians are being considered. To be able to use this documented knowledge and to automatically detect qualification needs from this text corpus, text-mining methods are applied. Here, not only the structure of different documents, but mainly the content poses challenges. The latter refers to a multitude of non-standardised abbreviations, which are used by the service technicians, as well as spelling mistakes. After identifying qualification requirements the phase of acquiring the qualification subject-matter is followed. The service technicians are being included in this process, since they hold extensive expert knowledge about the areas which need to be included in a qualification unit. This acquisition may be conducted using mobile devices, which the technicians are carrying for receiving instructions as well as for the documentation of their work. To enable a computerised processing later on, a defined workflow is provided for the acquisition. The focus of this developmental performance lies on the following steps, “processing” and “qualification“. The processing contains didactic as well as a data-focused processing of the content for the gamified qualification application. The didactic processing includes the relation of the practical knowledge, which is documented by the technicians, to the qualification demand and the consideration of different didactic approaches in order to remain learner-focused and accommodate for different preferences in learning.

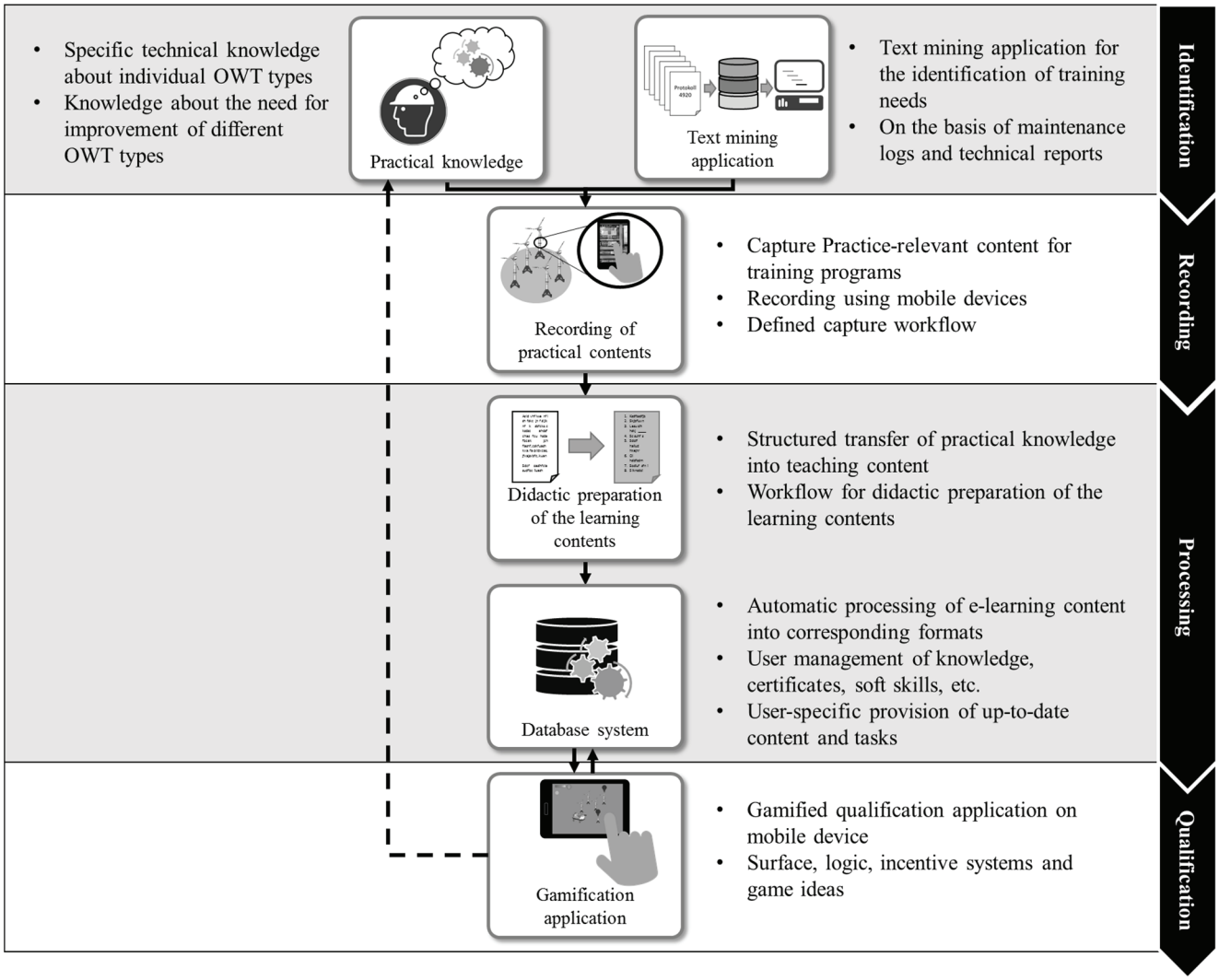

Figure 5: Process of gamified qualification application for service technicians of offshore wind industry

Similar to the acquisition of data, there is a defined workflow for the didactical preparation of it to ensure a goal-driven procedure. The following information-technological processing of the learning content in a database system and finally the deployment of the qualification application are conducted automatically. Furthermore, technician-specific facts, such as hard- and soft skills, acquired qualifications and certificates as well as their date of expiry are managed in the database system. These provide the basis for a user-specific provision of learning material in the gamified qualification application. The final step is the gamified qualification application. It is based on the game approach of strategic building. Through continuous progression in the individual game by solving tasks and in turn steadily receiving further qualifications the technician's motivation for receiving qualifications is supposed to increase as well as he/she improves his/her specialised knowledge at the same time. The user-specific results are stored in the database system in order to match the specific qualification to the technician. Figure 5 summarises the four mentioned phases and their contents.

Based on the didactic approaches shown in chapter III.II as well as on the different contents for qualification of service technicians there are three possible types of exercises. Tasks are dealt with (text or with images) based on multiple-choice questions in order to retrieve or establish recurring knowledge. These tasks may be adjusted in temporal intervals and applied to the knowledge and area of deployment of the technician. After successful completion of the tasks the technician receives items / resources (e.g. jaw spanners or first aid kits), which are necessary to proceed in the.

By collecting items and resources, the technician may upgrade existing OWTs in his/her gamified application or build new ones. At this point, the technician's motivation is increased by the game stimulus. Through upgrading or building new turbines, new tasks and learning content appears. Following a multiplayer-real-time-idea the technicians may discuss in forums or

participate in virtual development workshops, to find solutions for real problems. These may either be of a technical or an organizational nature. After successful completion of a task or solution to a problem, all technicians who participated in the forum or workshop receive a reward in the form of items or resources.

5. Conclusion

Within the scope of this contribution, a concept of a total system for qualification of OWE-technicians has been presented. The depiction of this approach is based on the theoretical and practical background, which incorporates the qualification standards of the branch, the maintenance of offshore wind turbines as well as gamified e-learning approaches and the text-mining method. The designed system includes the whole process from identification of qualification needs, the recording and preparation of the learning content as well as the provision in form of a qualification application.

Next steps will include further development of the project QUEST involving the analysis of existing qualification measures and needs, the gamified qualification approaches as well as existing text-mining methods. This will result in the conception and development of the subsystems "workflow gathering and transmitting of learner content", text-mining methods for qualification needs determination, "incentive system for qualification" and "gamified qualification application" as well as the evaluation and adaption of these subsystems.

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