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Implementation of Advanced Collaborative Platform for Project Based Learning in Naval Architecture Studies

Abstract

In the education process it is of utmost importance to adequately prepare the student for the labor market in accordance with current achievements in the professional field. In doing so, the standard educational process is often not sufficiently aligned with the needs of the market, especially in terms of preparation for work in a collaborative project environment, which is expected in nowadays modern design company. Today, the industry uses advanced digital collaborative software solutions that integrate ideas, design, development and follow the product life cycle. Such software needs to be implemented in the contemporary education process. In this paper authors present the implementation of the 3DExperience Collaborative Platform in the education process of naval architecture, based on modeling of a sample ship in order to analyze its global strength. Students are being familiarized with team work, they are able to monitor their work and progress of their colleagues, influence on the execution of the tasks and adjust the course of the project, redistributing and reallocating the resources. All of this actions are comparatively realistic depiction of the real working environment. Finally, the application of VR technology for the visualization of the model of the ship is presented in order to better understand the project challenges, ship structure and control of the performed tasks. At the end of the paper, the authors give an overview of the achievements and also stress out guidelines for further application of the software in the education process. Next milestone in this ongoing process would be to produce a detailed model of the ship and its documentation and other production information.

Keywords: 3D Experience, collaborative software, project base education, virtual reality, ship design and construction

1. Introduction

The environment in which engineers operate in modern companies have changed. New sets of available tools, advance in technical and technological knowledge has shifted the focus of engineering tasks from producing the tools to resolve problem in the first place, to using the existing set of tools as well as to cooperate in multidisciplinary teams and even master the management skills. This triggered the need to reorganize and provide a new strategy based on problem-oriented and project based learning (PBL) as a possible answer to this change [1]. Some of the most developed Europe countries, like Denmark have already recognized the need for project based learning approach, incorporating it into curriculum and exercising the projects in various fields of higher education. The project based learning was recognized in fast growing countries that are affected with rapid advances of the industry. According to [2], [3] and [4], they are implementing the project based learning in various technical fields.

The one of the interdisciplinary, multicultural and constantly changing environment is shipbuilding industry, especially the design office, both in ship design and also in production design. Today, the industry uses advanced digital collaborative software solutions that integrate ideas, design, development and the product life cycle management (PLM). The need for fast design and rapid and accurate quality control of the product in early stages of production have triggered the implementation of such collaborative product life cycle management software not just in shipyards, but in design offices working for production. Such software platforms are also good for students to gain an insight of a real project mechanics. Furthermore, they are ideal within project based learning concepts, as they are encouraging and providing tools for students to browse the project and incorporate the information from different departments and fields into their design. In a way, they are forced to look at design process as multidisciplinary effort and they are taught that the successful design is a result of cooperation between different fields of engineering. Also, advances in technology and virtual reality (VR) is giving the engineers the ability to “walk” trough the ship structure before the plates and stiffeners are set in production, thus gaining the feeling for proportions and dimensions of the ship without having to step out of office. The authors find this feature especially helpful in educational process where the ability of a field practice is limited. Hence, authors implemented such approach and technology into regular class curriculum within naval architecture studies at Faculty of Engineering. For the purpose of project based learning concept and VR technology application into education process the particular 3D Experience collaborative software platform was chosen. The short insight of the student projects, within naval architecture studies, using such approach will be presented in following text. At the end authors give an opinion about the achievements and also stress out guidelines for further application of the software in the education process.

2. 3D Experience platform in naval architecture

3DExperience platform (3DExp) is a collaboration based platform that works as an assembly of several products designed and incorporated in a package to suit the need of particular industry, organization etc. It is designed to enhance collaboration between the engineers, managers and workers and to deliver on time information to all parties involved in one project, thus enabling quick adoption of the changes in design and production processes, as well as being a good tracking tool for project management. The platform incorporates several products developed for different purposes. One of the most used product in design and development is CATIA, but also other products such as DELMIA, ENOVIA and SIMULIA have its purpose: consecutively in product development and life cycle management, and product simulation, each of them equipped with its special set of tools and capabilities. The aforementioned products are most common tools used in engineering and naval architecture, but there are other products that suit the need of civil engineering or even natural science like GEOVIA or BIOVIA. Due to the complexity, the platform as a product lifecycle management software inevitably had to be transformed from being on premises towards implementing the solution onto cloud. Although preferred as "on cloud", the software can also be set either on premises depending on the customer preferences (i.e. in naval shipyards where the integrity and privacy of data is a must). However, this is not influencing the functionality of the platform, nor it is limiting factor for the interdisciplinary collaboration between the parties involved in the project. On cloud technology is just offering customer to "pay as much as you need", offering the lease of software, platform services or infrastructure [5]. A good overview of up to date cloud based software besides 3DExp and cloud based engineering and manufacturing can be found in [6]. 3DExp platform can be customized to suit the need of particular industry through licensing packages which incorporate most of the tools of particular industry and educational institution. Each product contains the set of tools, called applications or APPs. APPs are the main tool for particular field of work. For naval architecture, besides the standard CATIA APPs like "Generative Shape Design" (GSD) and "Part Design" (PD), most used APPs are "Structural Functional Design" (SFD) and "Structural Detail Design" (SDD). The heavy industry manufacturing is also used for the technical and technological preparation of the model, as well as SIMULIA package. Combining the tools from these APPs the model of the ship can be created, tested and prepared for the manufacturing. For the purpose of the student projects the GSD and SFD APPs were used to model the ship geometry and structural elements, while SIMULIA package was used to prepare the finite element model and present the solution. However, the platform "out of the box" solution for shipbuilding comes with just a sample structural elements and complete working environment needed to be set and prepared. Therefore, some additional APPs like "Data Setup" and others were used to tailor fit the structural elements for the project. The preparation of environment was done and tested prior to the project start.

3. Case study within Naval Architecture study programmer

The following text will elaborate the use of 3DExp software in project based learning task, using the simulated model environment based on real shipyard project. The project was meant to simulate environment of one design office and its tasks in early stage of ship design process. The case described organized students around one common problem, forcing them to collaborate and use multiple resources in order to resolve the project task.

3.1. Structural analysis of the ship using the 3DExperience platform

The main objective of the project was to model the ship (chemical tanker) and to analyze its global strength using the finite element method. Students were provided with classification drawings of a ship that has been already designed and produced and also all documentation needed for resolving the task, such as scripts, books and modeling guidelines. Project was divided in three main stages, one being the introduction to the 3DExp platform and ships documentation, two being the modeling of the structure and three being the calculation and presentation of the results. In the first stage of the project the goal was to provide the students with enough information to start the modeling phase of the project. Coming from various levels of 3D modelling skills it was important to raise a skill level of a group on a global scale to satisfy the minimum knowledge in modelling. In the next stage a students were given a task to model a structure and simulate the real project environment where group of engineers is responsible for project execution. Each student took a part of a ship in order to divide the work and achieve task for the set milestone, thus participating in team activity with a common goal of finishing the model. After completing the modeling part, students were tasked to prepare the model for finite element analysis and to repair all irregularities on the mesh. In this stage, students had to make some decisions that can influence the final result and the end of the project (i.e. will they repair the model, or just the mesh itself). The last stage of the project was setting up the loads, restrains and material properties. As there were several load cases, each of the students received his own load case scenarios. At the end the results needed to be presented and discussed.

3.2. Project implementation

At the beginning each of the students received their own user name with assigned role of "author" which was grouped to the collaborative space *BGLab*, enabling the students to use the shipbuilding resources, but with restriction of changing them. Editing rights to particular project resources were only given to the teaching stuff, and each member of the student group had writing permission only on its own model. The most of the skeleton structure was prepared in advance in order to simulate the real project environment and to speed the process of modeling the ship. The project environment was set as close to the company project environments that can be. The group access rights were managed through the webtop application shown on figure 1.

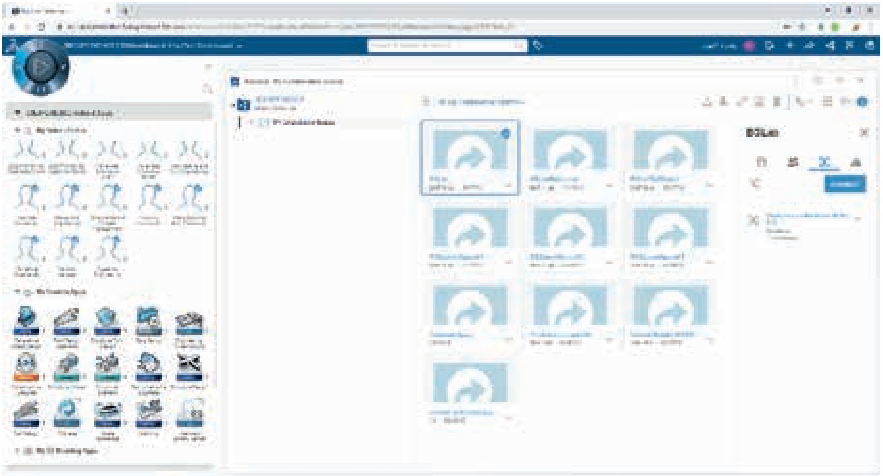

Figure 1: Webtop application for accessing the environment

The models were placed in a tree, organized to simulate one ship project. Each of the students had to model the part of the ship using mostly the SFD and GSD APPs. The working phase of the model is shown on Figure 2 and finished model is shown on figure 3.

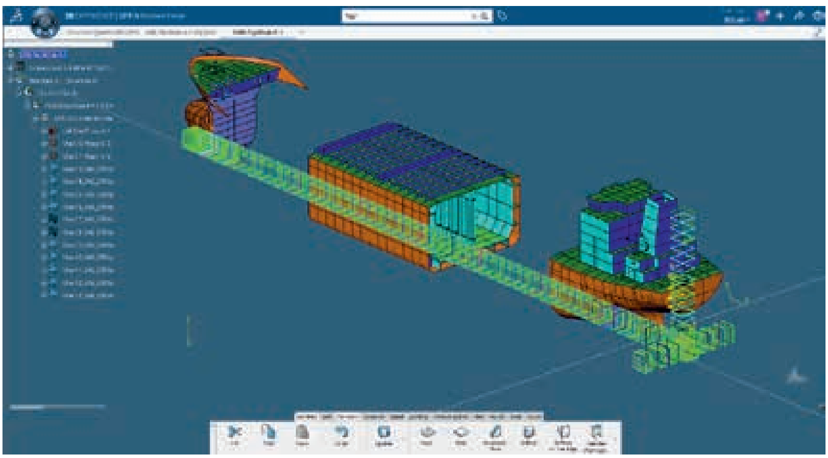

Figure 2: The working phase of ship model

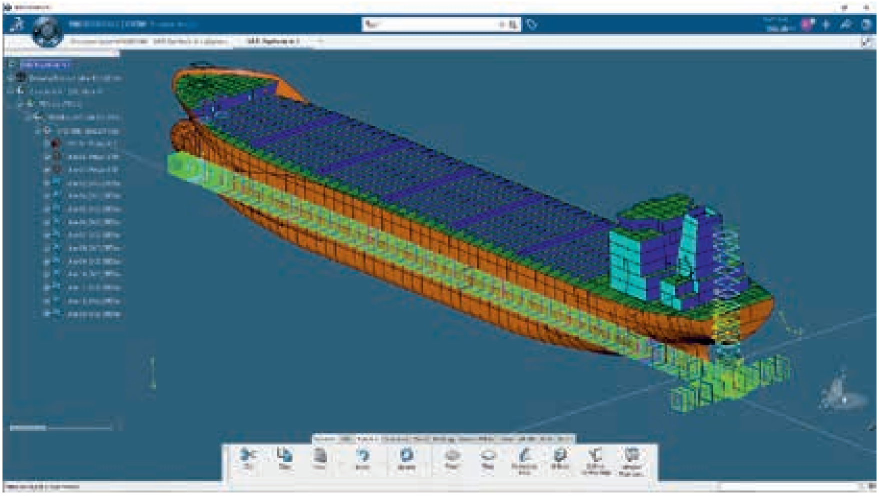

Figure 3: The structural model of the ship

After the SFD model a mesh needed to be applied on the geometry. Using the SIMULIA APPs for structural model and structural meshing the mesh was applied as well as boundary conditions and loads and the meshed ship was shown on figure 4.

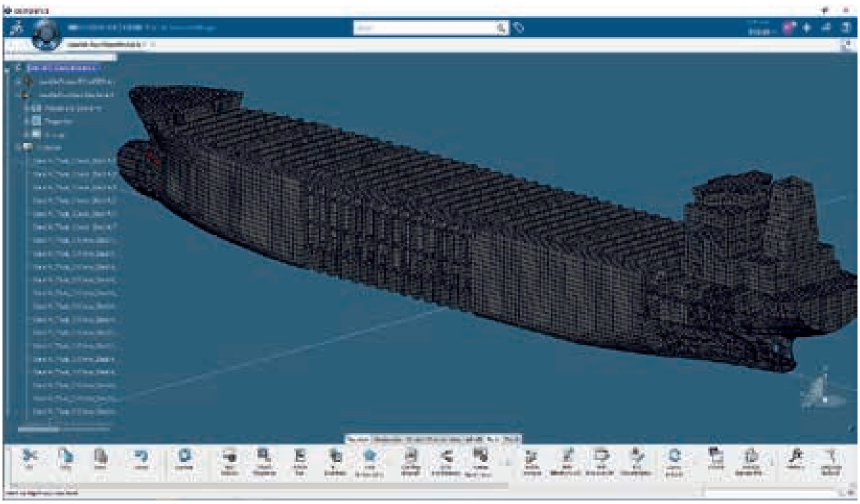

Figure 4: The mesh model of the ship

Finally, the results were extracted and shown on screen, see figure 5 where displacement of the cargo area was shown. Beside the displacement, Von Misses stress was extracted, as well as the forces in the supports.

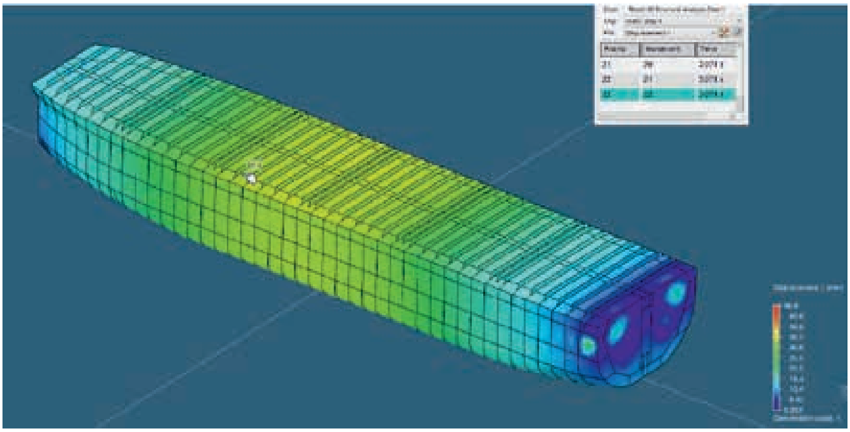

Figure 5: Cargo area displacement values

Similar to the cargo area model, which was used as a testing model, the results for a complete ship were extracted and presented in student's short Power point presentation following by the discussion on the results and project issues.

3.3. Discussion, observed benefits and future activities

Impact from the teaching staff was meant to be minimal, but at the beginning of the project steering was needed in the task assignment phase, in order to make an optimal division of the modeling tasks based on student skill level. After the initial phase, 20 students, have organized among themselves according to skills and preferences and in the second stage they took initiative to take a tasks which individually suit them best. A few students, skilled in modelling and with appropriate theoretical knowledge arose as a natural leaders of the groups and took upon themselves the solving of problems. The rest of the students were performing less demanding tasks, according to their skill and preferences. At the end, all of them presented the project from start to the end, with emphasis on their role in the project. All students but one completed the project successfully. Within class, the students were encouraged to use experience gained in college courses they attend with emphasis on courses dealing with ship structure, ship technology and structural calculations. Therefore, previously gained knowledge and learning continuity id very important in such learning approach and that could be an issue with some students. They exhibited a great degree of interconnection between the information received in the above mentioned courses, and showed the understanding of the problem and awareness of what the final result should look like. Therefore, previously gained knowledge and learning continuity is very important in such learning approach and that could be an issue with some students, which than should be specially addressed by such students and teaching staff. Also, using such project based learning concept in group work, students were starting to accommodate to a real world work environment within design offices or shipyards. Regarding teachers activities, it has been observed that teacher staff needs to be much more involved in such project based learning, and therefore such approach to learning is much more time consuming, which should be considered when planning activities.

Future activities will include using such approach in more naval architecture classes mainly regarding technology data and drawings, detail design modelling and drawings and manufacturing design and simulation. Also, in doing so, authors are already implementing VR technology for better understanding and learning various topics and problems within those classes. An example of VR technology application for education purposes is described in the next chapter.

4. Virtual reality for engineers and education

Virtual reality technologies for complete 3D visualization are rapidly evolving both for engineering needs and for the needs education Virtual reality technology as well as the required computing power become increasingly developed and affordable, and as such poses challenges for being effectively applied to different purposes. In this research the authors used such technology for ship structure modelling and education procedure improvement, using HTC Vive VR stereoscopic glasses [7]. The basic setup is shown on figure 6, it consist of VR HTC glasses, two controllers, two base stations which should be mounted in the corners of the room and additional gadgets required for connection to the computer. Such technology has the ability to track the head movement with the help of an adequate sensors and thus defines the direction in which the user is looking in the virtual space.

Figure 6: HTC Vive technology basic setup

Therefore, before described procedure of ship structure modelling workflow using 3D Experience software platform, is complemented by virtual reality technology for the complete 3D visualization and better structure understanding and overall design quality. Such an approach allows also a precise insight into complex structure and the equipment of the ship in the earlier and cheaper phase of the project, which contributes to minimization of potential errors and reworks in later much expensive phase of ship design process, figure 7.

Figure 7: Using VR Technology for ship structure analysis in 3D Experience

Furthermore, the value of the application of virtual reality in education has recently been much recognized, especially in combination with specialized engineering platforms such as 3D Experience [8]. One of the most significant advantages of VR is that it changes the role of the teacher, that is, puts the student in a role that is engaged and interactive with the problem being studied, for example, in understanding the structure of the ship as they can visualize and experience these elements in a virtual environment.

5. Conclusion

Classic educational approach proved to be outdated and not in line with a modern company environment. It certainly does not encourage collaborative work and team play. Authors emphasize that described project based learning approach, using contemporary collaborative software platform, improved the standard educational process in a way that he is now better aligned with the needs of the market, especially in terms of preparation for work in a collaborative project environment, which is expected in nowadays modern design company. Furthermore, tthrough the work with the students on ship design challenges, the authors have realized the need and benefits of early implementation of PLM support platforms and VR solutions into education process. To gain the best outputs from the students, the PLM concept as well as the design for production concept should be explained to students as early as possible but over the project based courses in group environment. Such approach, in author's observations, also greatly improved student's ability to better process and logically connect already gained knowledge in several other courses and more efficiently use it to solve the particular problem, which was constantly emphasized and encouraged by teaching staff during the duration of the project. Also, the students started to develop awareness for deadlines, lead time of the product and they sensed the responsibility for the project. Authors also want to emphasize that, from the teacher's point of view, PBL is certainly more demanding and it requires more involvement in the project supervision. The staff needs to be present and available to the students in order to steer the project in right direction as well as to provide guidelines and lead with the advice, thus preventing the project to stall and hinder.

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References

1. LEHMANN, M., CHRISTIANSEN, P., DU, X., THRANE, M.: *"Problem-oriented and project-based learning (POPBL) as an innovative learning strategy for sustainable development in engineering education"*, European Journal of Engineering Education, 33(3):283-295, 2008.
2. MACLEOD, M., VAN DER VEEN, J.T.: *"Scaffolding interdisciplinary project-based learning: a case study"*, European Journal of Engineering Education, 2019.
3. NGO, H.T., PHAN, M.H.: *"Design of an Open Platform for Multi-Disciplinary Approach in Project-Based Learning of an EPICS Class"*, Electronics, 8(2): Art. No. 200, 2019.
4. WANG, Y., YU, Y., WIEDMANN, H., XIE, N., JIANG, W., FENG, X.: *"Project based learning in mechatronics education in close collaboration with industrial: Methodologies, examples and experiences"*, Mechatronics, 22(6):862-869, 2012.
5. POPA, L., POPA, V.: *"Study on a collaborative platform for product development using cloud computing"*, Modtech International Conference – Modern Technologies in Industrial Engineering VI (MODTECH 2018), 400:Art. No.: 022048, 2018.
6. WU, D., TERPENNY, J., SCHAEFER, D.: *"Digital design and manufacturing on the cloud: A review of software and services"*, AI EDAM – Artificial Intelligence for Engineering Design Analysis and Manufacturing, 31(1):104-118, 2017.
7. https://www.vive.com/us/
8. https://academy.3ds.com/en/lab/immersive-vr-experience