Team and Research Based Learning Methods Applied in Multidisciplinary Marine Engineering Education

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Team and Research Based Learning Methods Applied in Multidisciplinary Marine Engineering Education

Amir R. Nejad[1], Yuriko Aoyanagi[2], Michaela Ibrion[3]

[1]Marine Technology Department, Norwegian University of Science & Technology, NO-7491, Trondheim, Norway
[2]Office of Marine Development Capacity Building, The Nippon Foundation, 1-2-2 Akasaka, Minatoku, Tokyo,107-8404, Japan
[3]Mechanical and Industrial Engineering Department, Norwegian University of Science & Technology, NO-7491, Trondheim, Norway

E-mail: Amir.Nejad@ntnu.no

Abstract. This paper presents an integrated team-based, and research-based learning approach utilized in lecturing multidisciplinary marine engineering courses. The approach is exemplified during one month Ocean Engineering Summer School program at the Marine Technology Department, Norwegian University of Science and Technology, Trondheim, Norway, for a group of students from different universities across Japan. Students with engineering background, but not necessarily marine, joined to learn fundamentals of marine technology, including structure, hydrodynamic and dynamic response analysis presented through offshore structures, subsea equipment, pipelines, offshore wind energy, marine machinery and marine operations. The marine industry has moved toward digitalization and this aspect was an important part of the curriculum, both in terms of tools and methods lectured and employed for each discipline and industrial examples for instance simulation-based design and operation demonstration. An integrated team-based (TBL) and research-based (RBL) learning approach was employed. The outcomes and positive feedback from students and the Nippon Foundation Ocean Innovation Consortium demonstrated that RBL integrated with TBL shifts the students from being "audiences" in the classroom to "active participants". The program was enriched with a rich cultural program which was found very helpful in learning process by the students. Moreover, the industrial insights added value for implementing the TBL and RBL. The marine engineering development and needs to adopt engineering education for modern marine industry, call for innovative and adaptive educational methods and this article presents some of the innovative methods which can be employed.

1. Introduction

In last decades the marine industry has shifted from traditional ship building sector to a multidisciplinary industry covering energy production (offshore oil and gas, offshore wind, wave and tidal), food production (aquaculture), mining (deep sea mining) and transport in harsher environmental conditions, such as in Arctic and Antarctic regions. In some areas, for instance offshore wind, the industry development has been extremely fast introducing fascinating technologies like multi-mega watts floating offshore wind turbines in recent years. Floating wind turbines, digitalization, hybrid power propulsion, autonomous ships, deep sea mining and emission reduction are just few examples of recent research activities in today's marine engineering universities.

In some countries, the changes in the marine industry have been reflected in the marine engineering education, and the traditional naval architecture schools have been gradually modified. In Norway, for instance, the Institute of Marine Technology (IMT) at Norwegian University of Science and Technology, Trondheim, addresses numerous international challenges in transportation, energy, and food production [1]. The research and education at IMT include methods and techniques which facilitate the assessment, development, and sustainable operation of Norway's biggest export industries – oil and gas extraction at sea, ship technology with corresponding equipment industry, fisheries technology and aquaculture technology – as well as newer developments including offshore renewable energy (wind, wave, and current), coastal infrastructure such as floating bridges, and marine robotics for mapping and monitoring the ocean environment, including polar regions [1]. The IMT is currently developing further to establish the "Ocean Space Center" within next few years [2].

The fast and diverse growth in different multidisciplinary marine engineering calls for new or modified education practices. Rugarcia et al. [3] has listed "multidisciplinary" as one of the futures of 21st century which may pose challenges to the engineers. A well established engineering education program is expected to address knowledge, skills and attitudes within the program [4]. Among the skills needed for 21st century engineers "developing problem-solving skills", "teamwork skills" and "self-assessment skills" are highlighted by Woods et al. [5]. Another important aspect of engineering in this century is the digitalized arena and information technology. The Boeing Company highlights the characteristics of an engineer including [4]:

- Knowledge of fundamental engineering science (math, physics, information tech);
- Knowledge of design and manufacturing;
- multidisciplinary;
- communication skills;
- ethical matters;
- team works.

"The real engineer is seen as a leader of a team of resources: financial, personal, and material, at all levels of engineering activity" as cited by B. M. Gordon from Analogic Corporation [4].

The engineering education should reflect the current and future society needs. Cloud computing, Internet of Thing (IoT), big data, digitalization, digital twin, machine learning, and many others are examples of tools available to engineers. Some of these tools are not necessarily new in the industry, but with cheaper and faster computational capabilities, they have become more attractive nowadays.

Research-based learning (RBL) and team-based learning (TBL) are methods that can improve significantly the learning objectives and can be a part of educational solutions for the new multidisciplinary marine engineering. This article presents RBL and TBL methods employed in an extensive Ocean Engineering Summer School (OE Summer School) program at IMT in 2018 and 2019. In following sections, the case studies, the methods used during the summer school program, and the lessons from the OE Summer School are presented. The outcome highlights the great potential of these methods in advanced engineering education programs.

2. Case Study: Ocean Engineering Summer School

With significant growth anticipated in the global markets for offshore oil and gas development and renewable energy generation going forward, companies in Japan are accelerating their efforts to enter and expand their presence in these markets. Abundant natural resources such as methane hydrate and seabed minerals are present in Japan's oceans and hold promising opportunities for future. At the same time, there are serious concerns regarding a shortage of marine resource development engineers who need to have the practical skills and expertise to

drive this growth and to gain access to additional market share in the near future. In this regard, at the Grand Opening Ceremony for special events held with the occasion of the 20th "Marine Day" on 20 July 2015, the Prime Minister Shinzo Abe announced as an important goal to increase the number of the Japan's marine resource development engineers from 2,000 to 10,000 by 2030. The launch of the "Project to Cultivate Marine Pioneers of the Future" was announced and a consortium made by government, industry, and academia was instituted in order to cultivate marine-related human resources [6, 7]. The Marine/Ocean Day or Umi-no-Hi is a nationally recognized holiday in Japan since 1996, and it was established to show appreciation for seas and ocean and to honour their importance to prosperity of Japan as a maritime or ocean nation.

The need for a nationwide approach to the training of the marine resource development engineers was officially recognized. In this view, in 2016, with cooperation from the Japanese government, the Nippon Foundation Ocean Innovation Consortium was established as a platform to bring together the Japanese universities, public institutions, and companies which seek to enter or to increase their presence in the marine resource development market. The Nippon Foundation Ocean Innovation Consortium is working to understand the corporate needs related to training of the marine resource development engineers and match them with university education. Moreover, the Nippon Foundation Ocean Innovation Consortium is also building a training structure which will operate in Japan and overseas and has assistance from companies and public research institutions to implement training that would be difficult for individual universities or companies to carry out on their own [6].

On the 4th of October 2016, the Nippon Foundation Ocean Innovation Consortium officially started its activities providing various educational opportunities not only for engineering students, but also for young engineering professionals interested in the field. As of June 2019, the the Nippon Foundation Consortium has 13 company members, and 26 university members.

The Nippon Foundation Ocean Innovation Consortium offers various support programs, information, and resources that help engineering students and young engineering professionals to pursue these academic and vocational goals in the field of marine development. One of the most popular educational program of the Nippon Foundation Ocean Innovation Consortium is the "Ocean Engineering Summer School". This summer school first started in 2016 in partnership with the Robert Gordon University in Scotland. There, students were provided with the opportunity to learn about marine engineering, oil and gas and offshore renewable. The partners expanded in the next years to the Texas A&M University in USA, the Norwegian University of Science and Technology (NTNU) in Norway, and the Delft University of Technology/De Oude Bibliotheek Academy (DOB-Academy) in the Netherlands. Each summer school has a different focus reflecting the country's strength in offshore industry.

The Ocean Engineering (OE) Summer School at NTNU started from 2017, but the case studies for the present article are the 2018 and 2019 OE Summer Schools. Figures 1 and 2 presents the students in 2018 and 2019.

The OE Summer Schools in 2018 and 2019 consisted of 10 students/each which were selected by the The Nippon Foundation Ocean Innovation Consortium from 9 different universities across Japan. The students have basic engineering knowledge from various fields such as mechanical, naval architecture, petroleum, electrical, civil, ocean, and the majority are the 1st year master students. The focus of the school has been on offshore oil & gas and offshore wind, fixed and floating.

3. Methodology

3.1. Team-based learning (TBL)

Towards shifting from purely lecture based teaching methods to more active learning style, the Team-based learning (TBL) has proved to be a well structured method. The TBL has been successful in achieving deep learning among students and to enhance learning of students and

Figure 1. Graduation day, 2018 (Photo Y. Aoyanagi, Nippon).

Figure 2. Opening day, 2019 (Photo M. Ibrion).

their higher cognitive level of thinking [8]. Moreover, TBL promotes student engagement with content of course, enhances the ability of students to learn challenging concepts and matters as is an effective strategy for teaching problem-solving skills in engineering. In addition, TBL fosters also development of team building skills [9]. Furthermore, TBL inspires critical thinking skills, supports active learning, and energizes a classroom with dialogue and debate and requires development of interpersonal and communication skills [10]. Another advantage is that TBL is seen as"an especially powerful way of using small groups" as presented by Michaelsen et al. [11]. Essentially, the TBL includes three main phases [12]:

- Phase 1: Preparation:
  Including study at individual level
- Phase 2: Readiness assurance:
  Including individual Readiness Assurance Test (iRAT), team Readiness Assurance Test (tRAT), and instructor feedback
- Phase 3: Application:
  Demonstrating application of the course concepts

One important aspect of TBL is selection of the group, and experience shows that random forming of the group is not the best choice for TBL. For the OE Summer School, the groups were formed by the school leader which took in account aspects such as the students background and their earlier education. Other aspects, like gender balance, average age, and university balance were also considered in forming the groups.

The program of the OE Summer School was extensive with daily lectures, 6x45 minutes lectures for every day, from 9:15–12:00 and 13:15–16:00, with 15 minutes break in between and 1 hour lunch break. Each three lectures covered one single topic. In the first hour (45 min.) the fundamental concepts were lectured by the lecturer. The second hour was used to demonstrate the concepts with examples, and for the last hour, group discussions and group exercises were employed. The lecture plan is illustrated in Figure 3.

In the last day of each week, a week summary and iRAT and tRAT was conducted by the school leader. Multiple-choice questions were used in iRAT and then, each group discussed the answer in the group and presented to others. Figure 4 presents the weekly exercise plan.

In the 2nd hour of the weekly exercises, a mini lecture was given either by the teacher, teaching assistant or each group. At the end of each week, each group presented what they

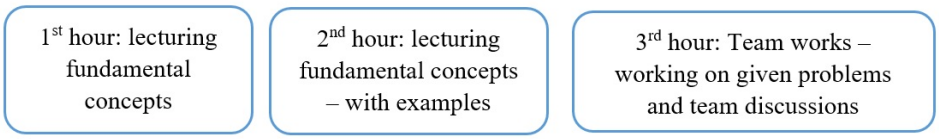

Figure 3. Lecturing plan employed in OE Summer School.

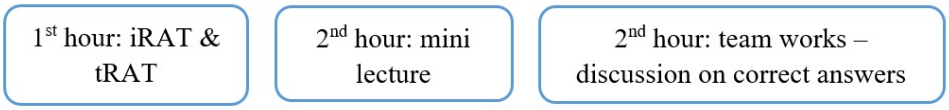

Figure 4. Weekly exercise plan employed in OE Summer School.

have learned over the week and a short exam was carried out. The final OE Summer School assessment was created based on the weekly exam results and the student performance in the final project presentation. Figure 5 shows the students during the weekly iRAT. The weekly tRAT and group presentation is presented in Figure 6.

Figure 5. Students during the weekly iRAT (Photo A. Nejad, NTNU).

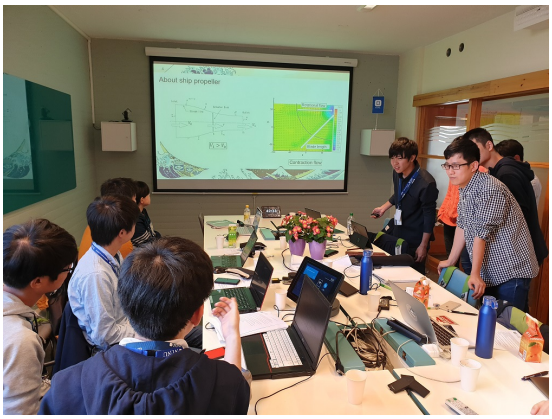

Figure 6. Group presentations during weekly tRAT (Photo A. Nejad, NTNU).

3.2. Research-based learning (RBL)

Different learning methods such as Problem-oriented and project-based learning (POPBL), [13] or discipline-based education [14] are offered for engineering education in the literature. However the Research-based learning (RBL) is relatively a new approach. Healey M. [15] distinguishes between the learning methods emphasizing on research content with those focusing on research process and problem. In his classification, the research can be included in the education through four different ways [15]: "Research-led" and "Research-oriented", where the research contents are used in the lectures, but students are not actively involved in the class, and "Research-tutored" and "Research-based", where the students are participants in the class trying to discuss, understand and find solutions for the research results demonstrated by the lecturer. In the other words, the RBL is more than using only the research results in the class,

but involving students to become problem solver and learn the fundamental of research in a systematic manner.

One practical and best way of implementing RBL is to use the results from the own research group in the lectures where the lecturer can share his/her own experience through the research process. For instance, the lectures on drivetrains in floating wind turbines given in the OE Summer School were built based on the research results from the lecturer's own research activities (i.e [16], [17] and [18]). Moreover, the OE summer school experience demonstrated that RBL integrated with TBL shifts the students from being "audiences" in the class to "active participants".

Physical and virtual labs were also employed as a part of RBL in the OE Summer School. "An important affordance of virtual laboratories is that reality can be adapted" [19]. Students visited the virtual marine operation lab at NTNU in Ålesund and exercised marine operation through virtual reality, see Figure 8. Lab activities can be less effective if are not supported with clear learning objectives [20]. Therefore, before any lab activity the related concepts and knowledge were instructed through lectures and exercises. In addition, as a part of RBL, students had an excursion on NTNU research vessel Gunnerus [21] where they learned about the subsea operation and use of remote operating vehicles (ROVs) and latest research activities in this area at NTNU. Figure 7 shows the students on board of the research vessel Gunnerus .

Figure 7. Students excursion with NTNU research vessel Gunnerus (Photo M. Ludvigsen, NTNU).

Figure 8. Student visit to NTNU Ålesund, the Marine Operations Simulation Center (Photo A. Nejad, NTNU).

4. Lessons from Ocean Engineering Summer School

4.1. Feedback & evaluations

After the OE Summer School at NTNU, the students were invited to provide their feedback through a digital survey. The survey was composed mainly by open-ended questions or questions which can be answered in depth, allow for original and unique responses, give opportunity to explain matters and situations, easily facilitate to see things through students' perspectives and bring forward their understandings, voices and experiences. The closed-ended questions which only can be answered by selection from multiple choice, through yes or no, or through a rating scale were not favoured for designing the survey. These kind of questions can offer direct, forthright, sharp answers and can be easily analyzed and offers quantitative data. However, the closed-ended questions provide very limited insights from participants, do not facilitate understanding of context and reasons and do not favour more learning about opinions, views

of participants and reasoning. The survey framework was particularly designed to capture intricacies of student experiences and to offer flexibility, space and opportunity for rich answers, opinions and feedback. Moreover, the survey took in account, important aspects with regards to culture of students. The Japanese culture is a high context culture and there is a close interrelation among culture and language. An awkward, an unreserved, very direct and sharp answer such yes or no, even in English language, is far from the Japanese subtle perspectives of culture with a multitudes of nuances and meanings [22].

The feedback with reference to the meanings and importance of the OE Summer School by the participant students can be summarized as very positive. Their perspectives of the OE Summer School are very rich, as the OE Summer School was perceived by students as "a change" within their both academical and cultural journeys, as "a good opportunity in my life", a "continuous invaluable experience", "great life experience", "Ocean and Photos", "a great time", "a part of my life", "Greatest time ever", and "This Summer School is the most valuable experience in my life". The importance of learning was brought up by students: "I learned many things during the summer school". It is well known that the Japanese are great and fast learners, and in a study by Ibrion and Paltrinieri [23], not only the importance of learning in Japan was identified, but also strategies of actions have been implemented systematically in Japan over the time. Moreover, the rhythm of learning was found to be higher in Japan than other countries in the world.

Their feedback about TBL approach is both positive , but also has rich nuances such as : "I think that team based study is rare in Japan, and it was so good for Summer School to experience it. Many thanks for providing us with such a great opportunity". Furthermore, a student described the OE Summer School and TBL as follows:"It was precious time filled with experience, encounter with people, getting knowledge, thinking deeply together".

According to the feedback received from the Nippon Foundation Ocean Innovation Consortium, it was observed that the overall interest level of the Japanese engineering students in the ocean engineering have increased steadily since the start of the OE Summer School program. Moreover, the students which participated to the program seem to have gained some of the important qualities/skills of a good engineer. For example, in addition to the technical and practical knowledge gained during the summer school, the students demonstrated better skills in teamwork, management, problem-solving, communication, better attention for detail, and better decision-making ability, compared with the time before their participation to the summer school. Moreover, the students have also become more responsible, practical and adaptable, and all of these make them attractive candidates for the Japanese marine industry.

4.2. Role of culture for engineering education and the cultural aspects of the OE Summer School in Norway

The importance of culture in engineering education can not be ignored in these decades. As an example, the Faculty of Engineering at McMaster University in Canada has already started an intense educational change under the "Pivot" program aiming five learning objectives: research, multidisciplinary, business, multicultural and social consciousness [24]. This program is expected to start from the fall of 2020 and is emphasizing that students shall obtain "understanding gained through experiences where serious consideration of cultural issues is mandatory to successfully implement engineering solutions". The impact of culture on engineering and engineering education was also emphasized by Carberry and Baker drawing attention to institutional culture, organizational culture, cultural beliefs, traditional educational environments among many other aspects. Improvements and even changes are required within longstanding traditions within engineering education in order to broaden the definition of what an engineer looks and does like. It is recommendable to enhance educational environments, particularly in engineering education, in order to engage students into deep thinking through active learning approaches [25].

The role of culture within the engineering education has also strongly highlighted within the program of the OE Summer School at the IMT, in Trondheim. In addition to the scientific program of the OE Summer School, a cultural program was held after the study hours, in order to ensure an harmonious balance between study and socio-cultural lives of the students, to assure a cheerful welcoming, and an early awareness about the impact of cultural parameters on studying and working life in Norway. Carberry and Baker [25] recommended also that engineering schools need to prepare engineers which need to think beyond the technology, to be aware about various cultural factors and to engaged into stronger bonds with society. Culture has very rich dimensions and can be articulated through legends, traditions, spiritual texts, poems, stories, folklore, inscriptions, rites and rituals, cultural heritage, museums, beliefs, but also through science and technology, geopolitics, legislation, policies, budget and planning, buildings, just to mention few cultural parameters. [26]. The students of the OE summer School were made aware about the rich cultural dimensions of the Norwegian culture and the harmonious balance which exist between normal working time, time-off and free time.

In Norway, the summer days are very long and evenings turns very slowly into nights and just for few hours. The cultural activities were accommodated in the afternoons and over weekends, while evenings were used by students for self-study, exams and presentations preparedness, cooking, and other quotidian activities. On a normal basis, the cultural program started after 16.00, and duration was about two and half hours, over the week time. Over the weekends, particularly on Saturdays, the cultural program covered a full morning and afternoon.

The cultural program of the OE Summer School started with a brief incursion into the Norwegian language and culture and ended with celebration of the graduation day and ceremonial dinner. Over every week, the students got acquainted with the cultural fabric of the Trondheim city. The cultural program included, and was not limited to, visits of historical sites, for example, visit of the Nidaros cathedral or Nidarosdomen. Nidarosdomen is the world's northernmost medieval cathedral and the Norway's national sanctuary of the viking king, Saint Olav. It is a major historical pilgrim destination, not only for Norway, but also for other Scandinavian countries. The coronation and consecrations of kings of Norway took also place at the Nidaros cathedral. Visits to the local factories in Trondheim area were also included in the cultural program of students. First, it was a visit to the E.C. Dahls Brewery and its production line which was founded in 1856, by Erich Christian Dahl which was one of the first business people which paid sick pay to his employees and established the foundation E.C. Dahls Stiftelse for women giving birth in Trondheim. Another a visit was organized at the Nidar, the chocolate factory which in 2012 celebrated its 100 years jubilee, and its museum, Nidar Chocolate Museum. In addition of getting acquainted with the cultural fabric of Trondheim city, a cultural immersion into the regional history and traditions of Norway took place. Over one weekend, a visit by train was arranged to Røros which is one of the Norway's UNESCO heritage site. In Røros, the mining copper town, a Sami reindeer farm and the traditional Sami dwelling – gåetie – were visited. The Sami are the northernmost indigenous people of Europe, they live in four countries such as Norway, Sweden, Finland and Russia and they have a rich, beautiful and enduring culture. A trip was also arranged to Ålesund city where mountains and fjords meet the sea and the viewpoint of Aksla and Fjellstua were admired by students. Cultural trips were also arranged in Oslo and Bergen. In Oslo, the area of Aker Brygge was visited, particularly the Nobel Peace Center; in the past, contained the shipyards and engineering industry in Norway until 1982. In order to get a glimpse about the history of the maritime industry and rich culture of Norway, visits were arranged to various museum such as the Viking Museum, the Norwegian Maritime Museum, The Polar Ship Fram Museum, the Kon-Tiki Museum. In Bergen, the largest second city of Norway and a World Heritage City, the Bryggen which is an UNESCO heritage site was visited.

A fundamental part of the Norwegian culture is the outdoor life, as the nature and the

connection with nature are held in high respect in Norway. Being close to nature and spending time in nature is very important for the Norwegian people. Therefore, the cultural agenda of the OE Summer School included among others, a tour in the forest with blueberry picking trip, visit to lakes and dam and visit of a forest cabin. Moreover, over a weekend, a bus trip was arranged to the fjord of Geiranger which is an UNESCO cultural heritage. The fjords of Trondheim and Oslo were also admired in addition to Bergen which is known as the gateway to the fjords of Norway; Bergen is situated between the longest and deepest fjord in Norway, Sognefjord north of Bergen and Hardanger fjord in the south. All the students were very enthusiasts about the Norwegian nature: "The nature in Norway is very beautiful", "the nature of Norway is breathtaking", "What I like best about Norway is nature", "Landscape in Norway is very beautiful. I think this is thanks to the Norwegian people's attitude towards nature", "The Norway's nature! I was overwhelmed by a lot of magnificent scenery!", or "I felt the towns are well harmonized with nature in Norway". Moreover, the students highly admired the fjords and some of them even rated the visit to fjords as being the best cultural activity. The narratives of students are very illustrative about it: "I felt the grandeur of nature looking at the fjord", "I could touch the nature by hiking or visiting fjord. It was most valuable for me", "My best cultural activity was the visiting the fjord!", or "I love abundant nature like fjords". Sport and outdoor activities are an important part of culture in Norway. The Trondheim Marathon 2018 was an event which was enthusiastically attended by all students of OE Summer School.

An important cultural experience in Norway for the students of the OE Summer School was the food and its rich cultural dimensions. The welcoming reception for students, the inaugural lunch, daily lunches, visits to Røros, Ålesund, Geiranger, Oslo, Bergen, tour in forest, tour of Trondheim, the graduation ceremony, and all other events included a wide range of the traditional Norwegian products, regional culinary specialties and local food of a high quality, made with fresh ingredients. The students enjoyed a beautiful combination of culture, activities and food. As an awareness point, food is just simply culture, food is even more than a spoken language itself, it serves as an important mediator among cultures, and even is impacting our values and way of thinking and nurture bridges among generations and different cultures [27]. The students of the OE Summer School displayed an amazing flexibility, willingness and curiosity in trying different types of food in Norway. Moreover, a high respect is ingrained in their attitudes towards food and food resources. According to Japanese culture, each meal is more than just food and eating and food plays an important cultural role. People through a meal can easily socialize, have a good time with friends, family and colleagues, build stronger cultural bonds, allow a better cooperation, working in team, sharing, building trust and respect towards resources and nature [28]. Food as a culture was very much perceived in this way by students, and one of the narrative very well captured this message: "I like nature, salmon, people, architecture, and everything in Norway", but "I like best the brown cheese and I strongly recommend to the next year Summer School students to try all types of brown cheese". Another narrative pointed out that "The delicious food like salmon and cheese" is what he/she liked best about Norway and the Norwegian culture. Other narratives hinted to other specialties such as "I like best reindeer meat and fish cakes".

Fish scored high among the favourite meals of the OE Summer School's students and their favourite was salmon, "What I like best about Norway is salmon", "Salmon is delicious" and "Best food is salmon". As an interesting note, Norway introduced the salmon sushi in Japan and this can be categorized among the best Norwegian inventions [29]. Fishing was very popular among students during the week, in the afternoons or during the week-end, or even during the trips in Norway. Some of students proved great fishing aptitudes in the coastline fishing and their catch of fish was a delicious meal cooked together and enjoyed by all students.

In order to give a hint about the importance of fish for both the Norwegian culture and the Japanese culture, the groups of students received the names from very popular type of fish in

Norway: torsk (cod), laks (salmon), makrell (mackerel) and sild (herring).

The cultural program of the OE Summer School was very welcomed by all students and was greatly perceived as having a positive impact on the learning process during the Summer School. The feedback of students emphasized that cultural program helped them to harmoniously balance the academic program: " Learning can be sometimes hard, but cultural activities made me relaxed", "Within the cultural activities, I could refresh my mind" , "I could refresh my mind after classes by visiting the forest or joining the marathon". Moreover, the cultural program was also linked to a cultural awareness about marine engineering study and cultural understanding. as presented by the students' feedback: "Now it is not so difficult to study many things through the Internet. I can lean almost everything...But culture things are different. Cultural understanding and experience are acquired only through the real experience. The cultural activities planned during the summer school gave me invaluable experiences". Another narrative highlighted that "The Summer School was a continuous invaluable experience. What I learned during the Summer School was not only marine engineering. I also learned culture in Norway, and how to communicate with people from different places and which have different backgrounds". The importance of creating bridges among cultures, among marine engineering and other disciplines/fields was further brought to attention by students' feedback.

4.3. Industrial insights

As a part of implementing the last phase of TBL which refers to demonstrate application of the course concepts, applications, companies visits, fabrication sites visits, and shipyards visits were included in the OE Summer School program. These visits were enriched by guest lectures offered by senior specialists, either prior or after the respective visit took place. Moreover, during the visits, in addition to site visit, and rich explanations on practical matters offered by specialists, presentations were given by the experts in the field. The topic of presentations was in line with the topic of lectures given at the university, in that particular week. For instance, the marine operations lectures were followed by a visit to a simulation center, the subsea lectures were followed a visit to a subsea pipeline production and pipe laying yard, the offshore oil and gas technology were followed by a visit to an important oil and gas operator. Figure 9 and Figure 10 show two of these type of site visits done by the OE Summer School students.

Figure 9. Industry visit as a part of RBL (Photo by S. Wang NTNU).

Figure 10. Industry visit as a part of RBL (Photo by T. Watanabe).

These visits brought to attention the necessity to bridge the marine engineering education to the marine engineering practice, and to develop the ability of students to engage with matters

related to their field of study in a practical manner. This added great value for students as they gained industrial insights and knowledge on practical things.They become more aware that they need to place a special emphasis on professional relevance and industrial needs. As an example, one of the students, decided to take his final project for the summer school in the field based on industrial insights which gained during a site visit. Other students become more aware about importance of integrating marine engineering education with marine engineering practice. The industrial insights has contributed to more job motivation among students.

5. Concluding remarks and recommendations

An integrated team-based (TBL), and research-based (RBL) learning approach employed for the Ocean Engineering Summer School at the Marine Technology Department, NTNU, in Trondheim, was demonstrated. The needs to adopt engineering education for modern marine industry call for innovative and adaptive educational methods to reflect the future industrial developments and requirements. The outcomes of Ocean Engineering Summer School demonstrated that RBL integrated with TBL shifts the students from being "audiences" in the class to "active participants". The participating students indicated very positive feedback on the learning methods employed in the summer school, in particular the TBL approach. They highlighted also the importance of the cultural program having a positive impact on the learning process during the Summer School. Their feedback have emphasized that cultural program helped them to harmoniously balance the intense academic program during the summer school. A great value was added to the practical knowledge for summer school by the industrial insights, contact with specialists and experts in the field and visits of industrial sites.

The multidisciplinary marine engineering asks for new adapted educational program and this article presented an integrated TBL and RBL program enriched with cultural activities which can offer a dynamic learning environment with successful outcomes.

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