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APPLICATION OF "CODEVE" METHODOLOGY IN TRANSATLANTIC STUDENT DESIGN PROJECT

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ABSTRACT

COllaborative DEsign in Virtual Environment (CODEVE) is a teaching methodology developed within the European Global Product Realisation (EGPR) course over a number of years. It was developed to establish suitable teaching practice to educate students on efficient design methods in a distributed product realisation projects in conjunction with an industrial partner. Students work in international teams formed from multiple partner universities. Communication is primarily through video-conferencing and other synchronous and asynchronous means of communication to perform design tasks including the vision, conceptual design, detail design and prototyping. Students ultimately meet during the final workshop at the end of the course to assemble and test prototypes and to disseminate their work to the company and wider public. The CODEVE methodology was tested in the Erasmus+ funded project called Networked Activities for Realisation of Innovative Products (NARIP) from 2015-2107. It has been implemented in academic institution in Europe.

This paper discusses applicability of this methodology in the project which connects universities and industry across the Atlantic. Three universities are participating this year: Brigham Young University from Utah, USA with Industrial Design students, University of Technology and Economics of Budapest in Hungary with product design students and City, University of London from the UK with mechanical, aeronautical and electrical engineering students. The industrial partner is Black Diamond, a global company based in Utah, USA, while the manufacturing of prototypes and final workshop are hosted at City, University of London. Time difference, culture and the discipline of study make implementation of CODEVE methodology in this transatlantic project more difficult than if the project is kept within European Universities. This paper outlines challenges and learning outcomes of students on both sides of Atlantic. Recommendations to modifications in CODEVE methodology to suit transatlantic projects are discussed in the paper.

Keywords: Project based learning, virtual academic enterprise, new product development, multidisciplinary design, interdisciplinary design.

1 INTRODUCTION

European Global Product Realisation course (EGPR) originally started as Global Product Realisation (GPR) by TU Delft, the Netherlands, University of Michigan, USA and Seoul National University, Korea in year 2000. It ran for two years but due to lack of tools for distributed synchronous communication and time differences between three continents was converted into a European project in 2002 [1]. TU Delft, EPFL Lausanne, and University of Ljubljana joined to form the first project with the Slovenian company NIKO. Three more universities joined later, namely University of Zagreb in 2003, City, University of London in 2004, and University of Technology and Economics Budapest in 2009 [2]. In 2014, four European universities launched a joint educational project called NARIP (Networked Activities for Realisation of Innovative Products). The project was supported by ERASMUS+ funding [3]. The history of university participants on the programme is shown in Figure 1.

The project goal was to formalise, test and consolidate the methodology for collaborative new product development in a distributed environment by use of virtual tools. This teaching methodology was named CODEVE (Collaborative Design in Virtual Environment) and is explained in detail by Vidovics et al. [4]. It is based on the Virtual Academic Enterprise formed by participating universities along with a sponsoring industrial partner on a year-long product development project. The course objective is to expose students to effective methods in designing innovative products inside a distributed, collaborative, multidisciplinary, multinational and multicultural environment [5]. A wide variety of different projects with industrial partners have enabled a collection of broad and valuable insights and experiences over nearly two decades. The projects are unique each year and come from a variety of industrial sectors. They vary greatly in complexity, research and implementation as described by Pavkovic et al. [5] and Kovacevic et al. [2].

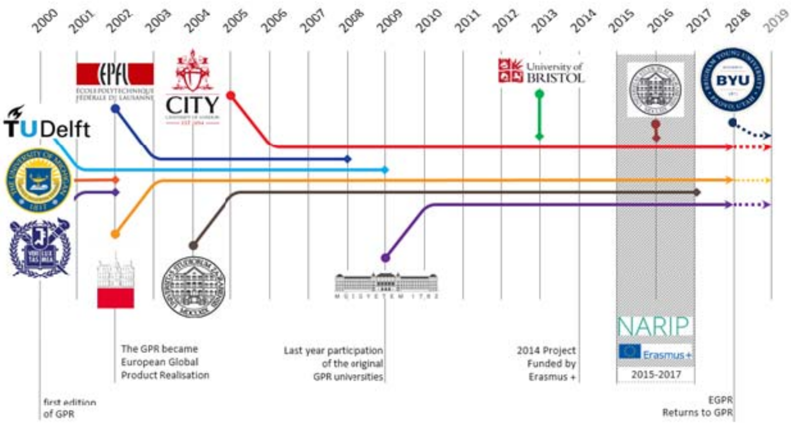

Figure 1. Timeline showing milestones and university participants in the European Global Product Realisation course

In 2017, the students' experiences in realising the NARIP project were summarised to evaluate suitability of the CODEVE teaching methodology for different disciplines and types of projects ranging from industrial design to engineering design. Tasks to design large industrial devices, like the welding inspection device for nuclear reactors from 2015, require a number of student groups to work on subsystems of a common prototype. On the other side, consumer products such as 2016's lighting solutions for aging population and 2017's lightweight mobility scooter require each student group to design and manufacture their own prototype. The first type of project is focused on engineering design while the second one leans towards industrial and product design. As shown in Kovacevic et al. [7], it was confirmed that this teaching method was suitable for both and was ready for implementation in European collaborative projects. In 2018, a new partner, Brigham Young University from Provo in Utah, USA joined the EGPR community. Moreover, this year's industrial sponsor Black Diamond is based in Salt Lake City in Utah, USA and is a leader in outdoor climbing and skiing equipment. The project is hosted by City, University of London, marking the first time in the history of EGPR the partner company and the host university are not from the same country.
The paper reviews the effectiveness of the CODEVE methodology in this transatlantic project and expose the strengths and weaknesses of this methodology applied to teams consisting of industrial design, product design and engineering students collaborating within a globally distributed academic virtual environment.

2 CODEVE METHODOLOGY

The design process model applied in CODEVE originates from the model of Pahl and Beitz, [8] but is extended and adapted to suit the fuzzy front end of design projects performed in academic virtual enterprises. The differences are: i) the first phase will, depending on the type of the project, depart from the classical "Clarification of the task", and become a "Fuzzy Front-End problem definition and vision forming exercise." In this phase, the students primarily use methods developed and outlined by IDEO in their book *The Field Guide to Human Centred Design* [9] to inform their research methods and narrative development. Once the vision and direction are sufficiently defined and agreed to by the sponsor, the teams will enter the classical concept generation phase. ii) There is no clear separation between embodiment and detail design phase. iii) The prototyping phase is introduced at the end of the project. Eventually, the design process resembles the innovation model for product development as described by Roozenburg and Eekels [10]. The process is staged in four main phases, namely i) Vision, ii) Concept Generation and Validation, iii) Detailing and iv) Prototyping, each of which finishes with a written report and visual presentation to the project sponsor. The prototyping phase culminates in a week-long workshop where students meet in person for the first time to assemble, test and present their achievements. The CODEVE teaching methodology defines goals, recommended tasks, expected outcomes and deliverables for each phase. However, students are encouraged to select and incorporate methods and tools for each phase that best suits the project and the distributed nature of the process.

2.1 Organisational setup

The project group consists of 38 students from three partner universities and a single industrial partner: eleven fourth year students from the City, University of London in the UK from mechanical, aeronautical and electrical engineering programmes, seven fifth year students from University of Technology and Economics Budapest from the Department of Machine and Product Design programme, and seventeen third-year and three fourth-year students from Brigham Young University of Provo in the USA from the industrial design programme. In order to complete gaps in the knowledge and bridge the disciplines, several lectures and topic specific presentations are delivered throughout the course [1] by academic and external experts, professionals, and partner company representatives. Lectures are carefully selected and balanced in advance of the course start to provide required information and allow sufficient time for project work.

The main means of communication and collaboration is videoconference and computer communication, with Zoom videoconferencing and web conferencing system as the primary platform. Asynchronous data exchange and backup is hosted by the University of Ljubljana. Social platforms such as Conceptboard, Google hangout, Facebook and Skype are also utilised this year to manage teamwork and file sharing. More details on the methodology can be found in [1] [4] and [7].

2.2 Teams

Five teams consisting of one or two students from Budapest, two or three students from City and four or five students from BYU have been established for this year's EGPR course. These teams are autonomous groups responsible for setting up their own internal communication methods and timing as well as working protocols, project and data management solutions and timely prototype production. Because teams face challenges in communication, effective use of information technology tools discipline-centric processes and vocabulary, and varying teaching schedules, exam periods and holiday differences, clear roles in decision making, task distribution, and ownership can make or break the project. Each team is coached by an academic staff member or a professional designer who monitors team activity and helps students manage their teams effectively. The coach also assesses risks and initiates mitigation of issues in a timely manner. Academic staffs are responsible for project management, educational goals and interactions between the company and the student teams.

2.3 Partner company and project types

The industrial partner plays a critical role in the success of a project [5]. This year's project partner is Black Diamond, a global leader in producing outdoor skiing and climbing equipment based in Salt Lake City in Utah, USA. The main design team and company management are based in Utah while many manufacturing facilities and special product development departments are located in other American cities, Asia and Europe. This year's topic explores mobile outdoor illumination products that enhance outdoor experiences for current and future Black Diamond customers. It is envisaged that each team will create a number of narrative driven product concepts, select one direction in conjunction with Black Diamond and finally develop and manufacture a "looks like, works like" functional prototype. Prototypes are tested and presented to the public in the final workshop week.

3 SURVEY RESULTS

Surveys conducted with 2016 and 2017 participants established a benchmark for the analysis of this year's transatlantic course. Two previous projects were evaluated, 2015 in Zagreb and a 2016 cohort in Hungary. The surveys were reasonably comprehensive and the full results were published in [7]. Here we only use elements of the survey related to the execution of this project. In 2015 most students participated in the survey (33 of 35), while in 2016 only 30% of students returned the survey (12 of 39). The response was given on the scale 0 to 5, 0 meaning ‘no influence’ with 5 meaning ‘heavy influence’. Despite the relatively low response rate in 2016, the standard deviation for year 2016 was similar to that from 2015 and ranges from 0.5-1.1.

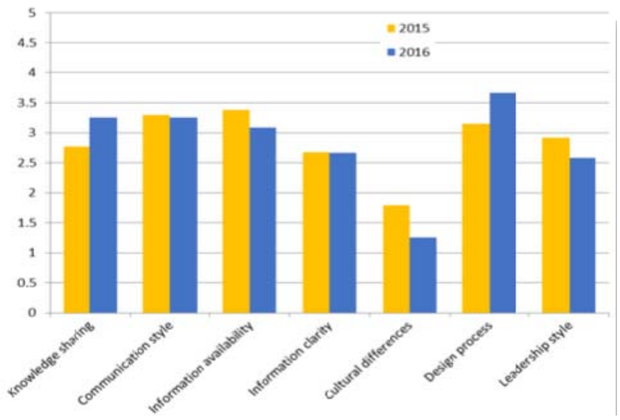

Figure 2. Survey results for factors affecting team work in the European Global Product Realisation course

The survey results from previous years showed that the lowest impact on project success was due to the difference in cultural background, while the highest impact was within the difference in processes and tools which have a different focus between product and engineering design traditions.

This year, 53% of students (20 of 38) completed an online survey, in combination with randomised interviews with students. Results indicated the process vocabulary differences between the different disciplines are more pronounced than in previous years when projects were organised within longer-term collaborating European university partners. While underlying goals were similar, there were frustrations as students tried to understand the vocabulary of other disciplines. Additionally, the general clarity of the fuzzy front-end methods and outcomes was low due to different starting times at three locations with more than 3 weeks start between each university, causing issues transferring knowledge within teams. Documenting and presenting the work in different phases was also a challenge, as students are comfortable using virtual tools such as Google docs for asynchronous communication but are reluctant to use the blackboard-type system provided by the universities that allows monitoring of team progress. Varying methods of credit allotment between universities also caused stress as students discovered some disciplines valued certain phase components higher than the others, a phenomenon caused by deviance from the requirements of CODEVE methodology. Finding common meeting times in 3 different time zones that are 7-8 hours apart was also an enormous challenge; only one meeting with all participants took place in each phase. However, most students reported they either participated in or watched the majority of lectures and meetings as they were recorded and saved in the cloud for future viewing. Because students were distributed unevenly between universities, it is difficult to distribute tasks and follow the procedures evenly. Often team members from one university would meet and make decisions amongst themselves and neglect to share those decisions with team members in a timely manner, who continued operating on an outdated path.

A number of positive outcomes were also noted. The students enjoyed learning about the processes and values of other disciplines and felt interdisciplinary collaboration creates more meaningful and complete products than individuals or single disciplines can. They also gained a respect for the challenges of working in different time zones, the importance of thoughtfully planning consequential communication, and the need to compromise and have patience with co-developers.

4 PROJECT OUTCOMES

Despite the identified up and downs of the project, the products finally realised are meaningful for the brand, uncovering new challenges and opportunities in addition to novel prototypes. Furthermore, student and staff observations identified both frustrations and insights that would not have been possible without the course.

4.1 Innovation

The final products have a global characteristic which is a direct result of collaboration between students with different cultural, disciplinary and geographic backgrounds. For example, there is large difference in outdoor experiences between the university cities. Provo, a town at the base of the Wasatch mountain range has an abundance of outdoor opportunities within a 30-minute drive of campus, while such activities are limited in cities like London and Budapest. As the city-based students uncovered and explained the lighting issues found within a city, the eyes of the students in Provo were opened to unmet needs and opportunities they would not have considered independently. Students learned their varied backgrounds enabled innovation to flourish as their varied perspectives were able to supplement and critique ideas in a unique way.

4.2 Vocabulary Barrier

Students found they were limited by the vocabulary of their respective disciplines resulting in the team members struggling to articulate their product and discipline values. One possible solution to improve this would be for students to physically meet and establish relationships early in the process and explore their disciplinary differences. Online communication tools are effective in exchanging words long distance, but are less effective in developing emotional, contextual, and collaborative bonds with teammates. This age group has also shown to have different bonding needs then their older instructors recognise [11].

4.3 Ambiguity and Indecision

When students are placed on interdisciplinary teams they often assume their teammates to be more knowledgeable and skilled than they are in their respective fields, and consequently they make assumptions about what each will contribute. Unfortunately, these assumptions tend to lead to the belief that each can only contribute in specific ways. Conversely, teammates also assume what others are less skilled at, and tend to take charge in some tasks and follow their own thoughts over the suggestions of others. This exposes leadership and decision-making issues within the CODEVE methodology as it is assumed that students will understand individualities of each discipline before the start of the project. It is realised that in future transatlantic courses it would be useful to involve only students who are in their final year of their study, who have experience in interdisciplinary collaboration and also introduce more lectures on disciplinary specific design processes and values.

4.4 Timing

Advanced planning is required to allow all universities to start at the same time and have all lectures conducted at times suitable for all parties which will enhance the student's experience.

4.5 Multiple Bosses

Participating universities each have different teaching schedules, credit systems and requirements for their students. CODEVE methodology specifies the structure of the academic virtual enterprise, and provides the means of communication and deliverables which, if followed would align expectations and outcomes for all participants.

However, due to the ambiguous nature of the fuzzy front end, unfamiliarity with the process for new university participants, and the distance and looseness of communication, some students struggled to understand who to report to or ask for clarification. Despite methodology specifying hierarchy, students tend to seek help in decision making or process steps from either their team coach or their local teacher, which makes it difficult for students to understand, respect and trust the insights of their team members whom they should be primarily relying on.

4.6 Communication Tools

Similar situations arise with a lack of common tools for asynchronous communication. Having a common blackboard type tool where all materials are stored and are readily shared makes the CODEVE process easy to implement and follow. However, due to the lack of commitment to the guidelines of CODEVE methodology specifying communication tools, this year students faced difficulties staying abreast of deadlines because they used tools they considered easier to use or more familiar, such as Google Docs. Additional communication problems may stem from use of tools aimed at social interactions, such as Skype, Google hangout, and Facebook for design activities. Development of specialised communication tools for design education could be an interesting topic to address in future as these tools are rare.

4.7 Expanded Vision

Many students stated that working on an interdisciplinary team expanded their vision of the product development process. For example, Garrett, who is training to become an industrial designer, says that our "programme has dialled in its focus on consumer research, human factors, aesthetics, and concept development. I often don't take into account the components that actually make a product function, like electrical or mechanical components and how they fit into the final product". Each discipline is focused on teaching a specific set of skills, but that comes at the expense of understanding the broader vision of developing a product from initial conception to market introduction.

5 CONCLUSIONS AND FUTURE WORK

This year's transatlantic CODEVE project was emotionally and cognitively polarising, with students experiencing both elation and frustration with the course. The industrial and product design students were pushed beyond their traditional boundaries by including engineering practices that bring a product into a functional, operational reality. This will prove beneficial and distinguishing in their future employment applications. The engineering students were exposed to the values of a human-centred design process, the role of brand, and the importance of emotionally and functionally meaningful product designs, which will be equally useful for their future employment applications.

The CODEVE teaching methodology encourages students to understand and explore methods which they may not use regularly in their existing design courses. Similarly, communication style, relationships with teammates, and the availability and clarity of shared information play a crucial role in the realisation of the project. Such factors multiply the impact on student projects with participation from universities is different time zones, necessitating careful planning of process language and expectations, alignment of timing, simplification of tools and common understanding or phase deliverables for less dramatic transatlantic projects.

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