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WHEN GLOBAL DESIGN MEETS EUROPEAN GLOBAL PRODUCT REALISATION -DESIGN TECHNIQUES AND CHALLENGES

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ABSTRACT
This paper explains the effect of group collaboration via distance communication with the emphasis on designing a new product. It furthermore highlights the challenges and barriers encountered during the design phase following the Tuckman model and the methods taken to overcome these challenges.
As a part of the European Global Product Realisation (EGPR) project students were placed in groups to conduct a project with the cooperation of three Universities: City University London with Engineering Design (ED) Students, University of Strathclyde with Product Design (PD) students and the University of Malta with ED students. Project participants were given the task of designing, building and testing an innovative airplane tray table while collaborating in virtual teams. The primary aim was to enhance student's team building experience and communication in order to provide an insight of real life work when undertaking a multidisciplinary design task.
Throughout the project, management and communication were closely recorded; various phases of the project had to be conducted to successfully solve the problem. The phases comprise of research, conceptualisation, detailed design, prototyping and testing. Through each phase students had to exchange knowledge and skills, by exchanging their design tools from their academic orientation leading to an application of combination of tools. This consequently caused some members to fall out of their comfort zone when utilizing unfamiliar processes.

Keywords: Design process, product design (PD), engineering design (ED), European Global Product realisation (EGPR)

1 INTRODUCTION

A multidisciplinary design task was to be conducted in a collaborative manner between City University London, the University of Malta and the University of Strathclyde.
Five groups of students made of ED and PD were challenged to innovate an aeroplane tray table such that it encompassed mechanisms and configurations that maximised the passenger's in-flight experience and satisfaction. The work had to be performed through distanced communication by employing methods such as video conferencing and social media. Difficulties arose, not just not only due to asynchronous teamwork but also by having different expertise, as students had to complete the task using unfamiliar design tools and processes.
This paper aims to exemplify students' experiences and attitudes towards working in teams of different disciplines; it also presents various phases of design undertaken by students to fully understand the requirements and hence successfully complete the project.

2 LITERATURE REVIEW

The EGPR/ Global design project has been running since 2002, and it encloses different design backgrounds including ED and PD. Each year students participating encounter diverse challenges by working with different people as well as performing unfamiliar design tasks, the details on the project and its evolvement throughout the years is presented in [1].
During the previous project, completed throughout the academic year of 2012-2013, students were assigned the task of developing a low cost solar thermal collector. Participants were placed in teams of ED and PD students where they were obliged to employ a wide range of tools and approaches to

complete the project. While conducting the project investigation, it was observed that ED students were more accustomed to analysing the technical aspects of the product while the PD students were more used to focusing on generating concepts and the innovative side of the design. Combinations of both areas of expertise have enabled participants to successfully complete the task. Figures 1 and 2 below highlight the engineering and product design approaches used during the project.

Figure 1. The engineering design approach [2]

Figure 2. The product design approach [2]

Although the project was successfully accomplished, students seemed to be working separately within their comfort zones and were not focussing on the learning of multidisciplinary approaches. After their initial experience, the students participating on the course for their second year running showed a better attitude towards the management and communication aspects. Participants are now often using various means of communications to facilitate the design tasks. Tools such as brainstorming ideas through video conferences or file sharing sites as well as sketches are employed to illustrate ideas and share knowledge between members.

The 2013-2014 project brief required participants to design an aeroplane tray table. At the end of the project an investigation was performed in which the highest proportion (35%) of participants identified communication as the main drawback in successful design. Further results of the study include difficulties with difference in approaches to design methodologies and varying personal outcomes, each represent 20% of the overall challenges. Figure 3 shows the results of the survey for students on the project challenges.

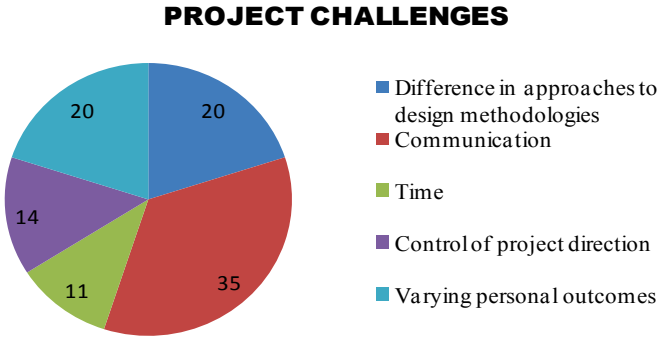

Figure 3. Challenges faced by students

3 AEROPLANE TRAY DESIGN

Five multinational teams of 8-9 students formed by representatives from each of the participating universities took part in the EGPR design challenge. Each of the teams were expected to develop concepts, detailed design and manufacturing drawings for a prototype of the airplane tray table. Different teams took different approaches to the design challenge opting for diverse design and communication tools and ultimately generating their own solutions.

The early steps of the aeroplane tray design assignment involved carrying out a detailed investigation and gaining an understanding of requirements and desires for passengers. In order to do this, surveys were carried out to reach a large audience, aeronautical engineers from Firefly and Airasia were consulted and research on patents, existing competitors and other factors was undertaken.

Results conveyed that when designing a solution, an emphasis had to be placed on the stabilisation of the meal tray and on maximising space and thus the comfort of the passenger. Besides this, the aim

was to develop a multi-functional tray and incorporate aspects of in-flight entertainment to make the system as 'smart' as possible. Currently there are airplane trays such as the ones established by 'Smart-Tray' which integrate a tablet holder in their designs, meanwhile other competitors have focussed their designs on the folding mechanisms of the tray such that the personal space for the passenger is maximised. This is analysed in further detail in the subsequent sections.

4 TOOLS AND APPROACHES

4.1 Project management tools

Different teams took alternative approaches. Some opted for the traditional organisational structure whereas others chose to share management responsibilities and incorporate a flat/circular management structure. The tools used to effectively manage the project remained consistent with all teams. See management tools in table 1 below.

Table 1. The design tools used to effectively manage the project

Phase	Design Tool	Traditionally Used By	Used To
Management	Work Break Down Structure	ED	Outline all the tasks required and decompose them down to smaller manageable tasks
	Gantt Chart	ED/PD	Set appropriate time-scales for the work that has been broken down
	Team Calendar	ED/PD	Highlight important deadlines and dates

4.2 Design phases and tools

ED and PD have grown accustomed to different design processes and most groups throughout the duration of the project adopted methods out of their comfort zone and accommodated methods they were unfamiliar with. Table 2 below shows the general methods used during the design process.

Table 2. The design tools used to achieve the final product

Phase	Design Tool	Traditionally Used By	Used To
Problem Definition	Causal Map	PD	Globally brainstorm general user requirements and establish relationships between them
	Objective Tree	ED	Order the requirements and rank them in order of importance. Each institution conveyed the weightings of the objectives which were then averaged.
	Functional Model	ED	Graphically represent the overall functions of the Airplane Tray Table. These were then broken down into sub functions.
	QFD	ED	Establish relationships between user requirements and engineering characteristics.
Concept Generatic	6-3-5 Brainstorming	PD	Generate ideas which were further developed by other team members, over 100 concepts were generated. For some teams this was their primary method for generating concepts, others used the morphological chart.
	Morphological Chart	ED	Generate solutions to sub-functions obtained from the functional model. Concepts were then made by using the solutions.
Concept Selection	Dot-Sticking	PD	Allow team members to express their preferred concepts by placing dots and narrow down concepts produced in the earlier stage.
	Decision Matrix	ED	Rank concepts with respect to the objectives. Each institution collectively filled in the decision matrix constructed and the values were then averaged.
	Technical vs. Economical	ED	Further illustrate that the final concept was the best balance between technical aspects (such as performance and reliability) and economic aspects (such as maintenance and installation and operation)

The methods summarised in table 2 were utilised by all participating groups. One group however chose to experiment with combining available methods and to examine affects the design process itself. This group used the 6-3-5 brainstorming method to generate initial concepts which were then narrowed down using a survey and a decision matrix. The concept chosen was then refined and

optimised through the use of a functional model and a morphological chart; the functional model was constructed in the concept generation phase.

4.3 Communication tools

One of the most important parts of the project was to effectively manage the synchronous and asynchronous communication methods, to ensure that the team held regular meetings and could share documents while keeping a personal log throughout the duration of the project. The forms of communication used by participants are summarised in table 3 below.

Table 3. The communication tools used throughout the project

Communication Type	Communication Tool	Used To
Synchronous	Video/Audio Conferencing	Meet with all team members to discuss issues and take the project forward
Asynchronous	Texts	Instantly notify members of the group of an update. This was mainly used more when it was more difficult to access social media.
Asynchronous	Social Media	Raise any issues encountered. Used heavily for polls when opinions were needed
Asynchronous	Email	Initially communicate with team members. This was the least used due to social media and texts
File Sharing	Cloud Storage	Share files and manage information. This allowed team members to work on the same files at different times

5 CHALLENGES AND CONSTRAINTS

5.1 Difference in approaches to design methodology

On one hand Mechanical Engineering students were more familiar with the ED Process with its sequential nature and tools, which they normally used such as Gantt chart, Work Breakdown Structure, Objectives Tree, Functional Model, Quality Function Deployment, Morphological Chart and the Decision Matrix. On the other hand the PD students used more of an 'artistic expression' approach which focused on group brainstorming using the 6-3-5 method to generate design concepts. Many PD students found the ED Processes too technical and tedious. In some groups, especially evident during the 'storming phase' [4], this resulted in an impasse when it came to intra-group team working and defining the project direction. One common and detrimental result, which was noticed, was that students formed sub-team based on their location and though work was being done, there was a lack of overall team cohesion.

5.2 Communication

It is vitally important for the success of a project that the team members get to know and understand each other from the very beginning. A multitude of asynchronous modes of communication were at the disposal of all students including e-mails, social media platforms such as Facebook and Whatsapp, SMS, Google Drive and The Box. These were quite trouble free in all groups. Synchronous communication methods were also vital and these included Jabber as the primary means and also some groups made use of Skype and Google Hangouts to establish video conferencing, which was necessary because of team members being in different geographical locations. However the groups reported technical difficulties establishing a good connection, especially on Jabber, due to poor hardware connections at one of the universities. A tight booking schedule for Jabber meant any time lost was nearly impossible to make up for. Of particular note, team-forming meetings were badly affected. Skype and Google Hangouts were both used extensively in all the groups but usually suffered poor connectivity. Therefore the bulk of group communications was asynchronous and this adversely impacted on group dynamics and subsequent work that followed.

5.3 Time

The project duration was scheduled for ten weeks. For all students involved in the Global Design project, this was just one of a number of academic commitments. Outside of the timetabled lectures it was quite difficult to find additional time that suited everyone's other commitments, both personal and academic. To varying extents in each group, particularly during the 'performing phase' [4], this slowed down progress and affected the quality of work produced.

5.4 Control of project direction

This proved a challenge due to different approaches to the design process. Since students from the University of Strathclyde outnumbered all others in every group their influence in the decision making process was thereby strong and they tended to dominate the major aspects of strategic planning. This sometimes led to discord in finding common ground to merge the different design methodologies into one effective process; hence the project progressed with a two-pronged approach with little collaboration. This counter-productive situation happened in most groups during the 'storming phase' but was resolved later and allowed the group to progress to the 'performing phase' [4].

5.5 Varying personal outcomes/objectives

This had quite a serious impact on the project outcome. Students at different Universities had varying academic weighting to the project i.e. the number of academic credits attached to the project. For most it was part of their final year module set and carried significant academic weighting but for others, the project did not carry any academic credits. Though the overall project deliverables were the same for all students, Strathclyde students evidently felt they would be assessed primarily on generating concepts through brainstorming and then developing the best concept without much focus on the more technical detail of the product. Naturally this affected group dynamics because levels of students' commitment to the project as a whole and to certain aspects within the project greatly varied. This difficulty was not totally solved but the level of student's engagement to the design tasks increased after the forming phase. Many participants have mentioned that this was one of the major issues and academics are considering having equal weighting for all universities in future projects.

6 OUTCOME

Upon completion of the conceptual design phase, the concepts, which had the best potential for becoming a high-calibre product, needed to be identified from the assortment of generated concepts. This was done by comparing each of the concepts with the objectives/requirements set in the problem definition phase. The dot sticking and decision matrix were the main methods employed to evaluate how well a concept fulfilled the requirements. The dot sticking method was based on preference while the decision matrix was based on quantitative evaluation of each concept. The PD students predominantly used the dot sticking method but the ED students preferred the decision matrix. Figure 4 shows the final design of all the teams, it can be seen that the final designs tended towards multi-functionality and in-flight entertainment.

	Team 1	Team 2	Team 3	Team 4	Team 5
Final Design					
Main Features	Eating and being able to operate an e-device simultaneously	Increased surface area for extra storage, contemporary style with an acrylic finish	Extra shelf on top for holding personal items, lamp may be fitted under shelf	Separate tier integrated with main tray can be folded out	Adjustable tablet/book holder for optimised comfort

Figure 4. The final designs

The students participating in the global design project grasped the different ways of approaching a problem as they were exposed to design tools used outside of their respective disciplines. Resolving conflicts effectively helped to build a foundation of trust and mutual respect between team members. The project also provided the students with a valuable opportunity to improve their communication skills by actively listening to team members, expressing their own ideas and providing constructive feedback.

7 CONCLUSION

The challenges of designing, building and testing a new product were faced and successfully overcome through the collaboration of students working in decentralised teams. It was discovered that students experienced some anxiety when confronted with new, unfamiliar techniques and faced various challenges while working distantly through means of virtual communication. This has contributed to the students learning and development.

Working in virtual teams is a vital aspect of academic learning and experience; participants expressed that this group project has enhanced their knowledge and skills essential for tackling the challenges of future employment, particularly when confronted with working in multidisciplinary and multicultural environments and when adopting unfamiliar tools.

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