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MANAGEMENT OF INDUSTRY LED COLLABORATIVE

MANAGEMENT V PRŮMYSLU VYTVÁŘENÝ VE SPOLUPRÁCI

Abstract

Undergraduate and Postgraduate courses in design engineering address not only the form and functional design of products but also the management of the design process itself. This apparently simple objective belies some of the real challenges faced in educating students on such courses. These challenges tend to relate to achieving a balance in the consideration of form, functional and design management issues in a manner appropriate to the product context being considered. One way this can be achieved is to invite industry to use students on a consultancy basis to solve real problems to a set time scale. Each year, DMEM runs the Product Development Partnership (PDP) scheme and post graduate team project, which enables companies to realize projects through collaboration with a team of $4^{th,}$ 5^{th} or PG year students made up from the product design engineering, manufacturing and management streams.

Abstrakt

Předměty vyučované v doktorském i inženýrském a bakalářském studiu projektového inženýrství se netýkají pouze formy a funkčního designu výrobků, ale také managementu celého procesu designu. Tento na pohled jednoduchý cíl skýtá některé problémy odrážející se ve výuce studentů těchto předmětů. Svým způsobem mají tyto problémy tendenci záviset na rovnováze formy, funkčnosti a managementu designu v souvislosti s uvažovaným výrobkem. Jednou z cest, jak jí dosáhnout je umožnit průmyslu, aby zapojil studenty do konzultací při řešení skutečných problémů. Každý rok se katedra DMEM podílí na spolupráci při vývoji výrobků (Product Development Partnership – PDP) a organizuje projekt pro tým doktorandů, který umožní podnikům projekty realizovat ve spolupráci s týmem studentů 4. a 5. ročníku nebo s týmem studentů v doktorandském typu studia speciálně sestaveném pro design, inženýring a výrobu, stejně jako pro spolupráci při managementu.

1 INTRODUCTION

The education of design within higher education at both undergraduate and postgraduate level requires students to address not only the form and functional design of products but also the management of the design process itself [1,2,3]. This apparently simple objective belies some of the real challenges faced in educating students on such courses. These challenges tend to relate to achieving a balance in the consideration of form, functional and design management issues in a manner appropriate to the product context being considered. One way this can be achieved is to invite industry to use students on a consultancy basis to solve real problems to a set time scale.

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Each year, the Department of Design, Manufacture and Engineering Management (DMEM) within the University of Strathclyde runs the Product Development Partnership (PDP) scheme for undergraduates (UG) and Team Projects for the postgraduates (PG), which enable companies to realize projects through collaboration with a team of 4th, 5th or PG year students made up from the product design engineering, manufacturing and management streams. Each team consists of four to five students. This paper will describe the student learning experience and give examples of the type of work undertaken and the factors affecting successful completion of the project.

2 BACKGROUND

A distributed design team is a multidisciplinary team containing the core skills required to undertake a project. A typical team would consist of a variety of engineers (e.g. design, mechanical, electrical, manufacturing), marketing, finance and other personnel. These individuals would interact synchronously or asynchronously supported by a 'collaborative toolkit'. To fully understand the requirements for this toolkit it is worth considering the nature of the interaction between team members in the design process in more detail. Design is a collaborative process involving communication, negotiation and team learning. Efficient communication is critical to achieving better co-operation and co-ordination among design team members. Fruchter [4] has made the following observations on conventional design team communication methods:

- Designers record background information and results of reasoning and calculations in private notebooks;
- Information in the form of text, calculations, graphics and drawings is captured in paper or computer based forms. Unfortunately, much of the design intent in a design dialogue is lost because it is partially documented. The final decision tends to be recorded but much of the interaction and developmental thinking of a design discussion is not;
- The process of identifying shared interests within a design team is ad-hoc and based on participants' imperfect memories and retrieval of available documents. This error-prone and time consuming process rapidly leads to inconsistencies and conflicts;
- Meetings are usually the forums in which inconsistencies are detected and resolved before a project can progress. Telephone conversations are also used to resolve conflict and inconsistencies within the design decision-making process as and when they occur. Discussion of graphic or numerical information by telephone, fax etc. is difficult and leads to misunderstandings/misinterpretations and eventually increased product cost;
- Time delays in fax and telephone based communication between design team members can cause significant delays in project timescales. Additionally, these communication methods tend not to develop a team ethos or a common sense of ownership of design decisions.

The majority of communication within the design process is of an asynchronous nature with information being relayed between design partners in a sequential manner. For certain forms of design communications this means of operation is not satisfactory and direct interaction between design participants, in synchronous mode, is necessary [1]. It is the communication and management aspect of the design process that cannot be taught from a book but must be acquired through experience. It is found that student group work, especially design and make projects are a good design educator [2], giving students a chance to gain an insight into not only the design process but also the additional communication, management and people skills they also require. Liaising with a company is usually the first time the students undertake a 'real' project where there performance not only affects their academic standing but their professionalism becomes an important aspect as well as peer ranking within the group. There are many different learning styles that can be employed within group work [5, 6, 7] however in this instance the approach is very much as a guiding supervisor but still monitoring the meeting of milestones. The students have a relatively free reign during the project, however each group has a brief to meet and milestones dictated by their project deliverables. To ensure that the students are moving towards meeting there milestones and deliverables weekly

meetings with the supervisor are encouraged and seen as the students stand on professional behaviour.

Communication within teams and with the client (industrial supervisor in this instance) and with the academic supervisor are also key aspects to the success of any project whether industry [8] or academic [9]. If students can learn to see the signs of a communication breakdown and learn the techniques for repair they will gain invaluable experience.

3 PROJECT DESCRIPTION

The group projects (UG and PG) benefit companies in several ways, including: access to university equipment, resources and cutting edge technologies and techniques. As well as new products and product concepts from eager young designers; and opportunities to experience the latest design methodologies with a view to improving company design processes. The students' themselves benefit from exposure to real industrial experiences. For the fifth year undergraduate students it would be their second time at undertaking a group project and so these teams could learn from experiences gained in the forth year.

The undergraduate PDP projects normally run from October to May, and are based on 100 hours per student for 4^{th} years and 200 hours per student for 5^{th} years. There are three stages to each project: product brief /market analysis and product design specification; concept design; and detail design, and three feedback points, two milestones and a final presentation and formal report. At the conclusion of each stage (the milestones) formal feedback is required of the company. This can engage the student teams in presentations / meetings to reach formal decisions. Each project has different goals and objectives, some may be new product development others may be product redesign others may be market opportunities or manufacturing considerations, and thus each team has a unique management path to consider and will use different design and management tools to address these issues.

The postgraduate Team Projects run from January to May and are based on 300 hours per student. Again the students are expected to follow set stages for the design process: product brief /market analysis and product design specification; concept design; and detail design. The PG projects have two milestone presentations, one early on to give the teams interpretation of the brief, market research and the project and time plans, and a final presentation. Regular meetings with the industrial partner are recommended but with the PG projects the management industry meetings are left more to the students' discretion.

It was found that projects were best realised through commitment and active involvement both from the students and the industrial partner. All participants must meet first to gain a rapport otherwise communication can be difficult through telephone and, especially, email only [9].

The role of the industry representative was to act as the client and not lead the team to a specific conclusion but to let the team guide them as if it were a 'real' consultancy being undertaken. Some industry representatives achieved this scenario better than others. Each team had a University Lecturer and in the case of the UG projects, a Royal Academy of Engineering Visiting Professor to act as mentors and provide support and guidance when necessary.

Because of the nature of the project there are a number of stakeholders involved each with different needs. These stakeholders are:

Industrial supervisors who require the project completed to a satisfactory conclusion from the companies point of view;

Academic requirements where it is essential students meet learning outcomes and that the project finished to a good academic standing, and;

Students professional development, the most complicated of all since students wish to fulfill both industry needs and meet academic requirements as well as gain confidence and improve their transferable skills.

The monitoring of these needs being met was through weekly meetings for the PG and UG teams, and the UG teams were also required to keep personal logs and minutes that are then handed in at the end of the project and form part of the assessment as detailed above.

4 CASE STUDIES

Postgraduate Projects, Case Study 1: Team PG1 was assigned to Company A, which was within the medical sector. The initial brief was to design an assessment chair to be used in the process of designing and manufacturing wheelchairs for patients with spinal or related disabilities. The chair was to be used to assess the most comfortable position for the patient and to generate the mould for the wheelchair seat. Company A required the assessment chair to be transportable to a number of different locations out with the company premises.

PG1 undertook the following stages within the design process, market research (competition and customer use analysis), brainstorming, concept development and evaluation, embodiment and detail design.

The team undertook a classic methodology with respect to concept development. An example of their early work, investigating the transportability issues to determine best size and shape to allow for transportation by hand or in the boot of a car, can be seen in figure 1.

A final design was chosen through concept evaluation matrices and the final design was then optimized through use of finite element analysis and through creating assemblies within IDEAS, the parametric CAD package available through the department. The final design can be seen in figure 2 below.

The students collaborated well, meeting regularly to discuss the project and using the shared network space to store research material, electronic files created for the project and scanned design work.

Company A was local to Glasgow and so the industrial supervisor and the group were able to meet face-to-face to kick-off the project and regularly throughout the course of the semester. The company also facilitated market research and enabled the students to meet with the users of the chair. Further communication was also carried out through email and telephone use.

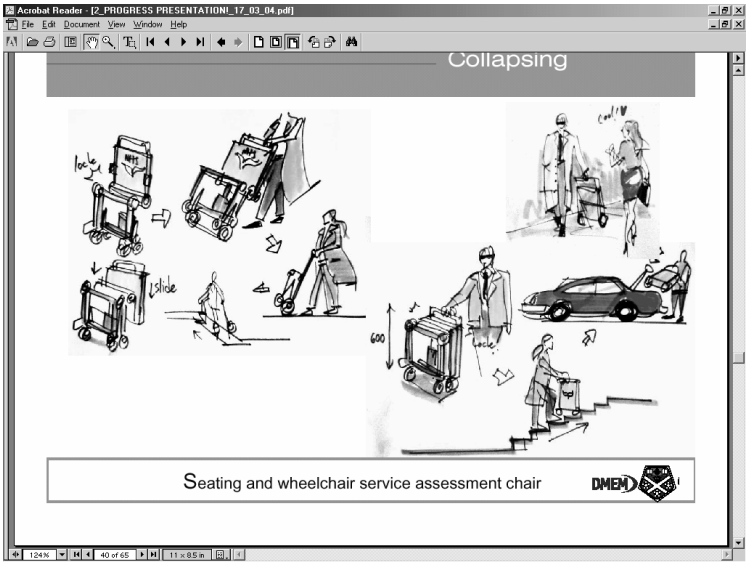

Fig. 1 Story board investigating transportation issues

Fig. 2 PG1 final design solution for the assessment chair

Company A has been a regularly user of the DMEM Group projects either undergraduate or post graduate and as such a good rapport has built up between the staff within DMD and the company. The company also has understanding of the project within the student context i.e., just one part of the course and that students have other commitments and thus the expectations of the company are reasonable. They kept to the brief they gave in the first instance and there were no cases of the company changing requirements during the project.

Undergraduate Projects, Case Study 2: Team UG1 (4^{th} years) was assigned to company C a local company supplying bathroom solutions for the special needs market. The company at the start of the project had no products of their own and no manufacturing facilities. Therefore the project focused on the design of a shower cubical that was easy to install for all user groups, easy to interact with for both customer and careers and finally that was easy to clean. But most importantly the

components must be easy to manufacture either in a soon to be establish in-house manufacture area or manufacture sub-contracted and assembly undertaken in-house.

This project worked well due to the good rapport quickly established between the group and the Industrial supervisor, visits were facilitated when required, and all emails and telephone calls were responded to quickly and all information that was required was quickly conveyed to the students. The company kept to the brief, but allowed the students a good degree of creative freedom. This quickly resulted in progress on the concepts with one idea being outstanding from the start.

This final concept, a modular system, was developed and prototyped, with the resulting success of final design that completely fitted the company requirements. Further to this patents are being applied for, for parts of this modular system thus no more detail of the product can be given at this stage.

This team communicated well between each other but had a file sharing issue, it was felt by some members of the group that designs were not always shared and with held from group members to be shown to the company first before other group members. The group also failed to use the network space and error they regretted when their laptop and memory stick files were discovered to be corrupt.

Undergraduate Projects, Case Study 3: Team UG2 (5^{th} years) was assigned a project with a high quality sound system company, Company D. Company D was local to Glasgow but was very high profile with high expectations with regard to product development. The project was based around the design of a device to be incorporated into speaker stands to assist with leveling once the speakers were installed and then the system to be locked off and would not be used again unless the speakers changed location.

Initially the design was required to be minimalistic and automatic in function, as the Chief Designer, the assigned industrial supervisor, had said that this was what the customer would require. During the early stages of the design, the group realized that the industrial supervisor had very clearly defined ideas on how the product would develop. He demanded that the students investigate a hydraulic means of leveling and did not take too kindly to the students developing concepts that were simple mechanical ideas that were effective, cheap, clean and above all minimalist.

The industrial supervisor also kept changing requirements throughout, initially stating the design should be enclosed within the casing then later demanding to know why the leveling device had not been made into a feature. Prototypes were requested but no money was assigned to the students and no facilities made available through the company, therefore the prototypes that were developed demonstrated functionality only and did not convey aesthetics, however since the designs were to be placed within a casing and not seen by consumers UG2 were quite shocked to hear the prototype being belittled because it did not meet the company standard. No images can be shown in this paper due to confidentiality forms being signed on the request of the company.

Correspondence between UG2 and company D was through face-to-face meetings or email. The email correspondence proved a problem with the industrial supervisors phrasing and language causing severe de-motivation in the students. The students themselves collaborated well and used the shared network space to its full advantage.

Finally the students completed the project to excellent academic standards and received the prize for best project; unfortunately the company did not think the project had met their objectives. It is clear from this project that effective communication between the company and the students is essential and that once the brief and product design specification have been agreed there should be no changes to the companies requirements.

5 DISCUSSION

Industry Supervisor: For student projects with industry to work successfully to the benefit of the students then it is requirement that the whole company is behind the project. When one industry

supervisor left his or her company half way through a project it resulted in the team having no company liaison or guidance, thus the team did not fully benefit from the experience. In some cases the company came back each year or alternate years with projects. In some cases companies had two or three projects running at the same time.

Some Industrial Supervisors (IS) used the teams well: These supervisors had a clear understanding of all needs of stakeholders and of what the company wished to get out of it. Generally the projects that worked satisfactorily were more blue-sky investigations. If it was something the IS was working on as well there was a tendency for the students to feel that goal posts moved as IS changed his / her mind with regard to the requirements and outputs. Other problems arose if IS thought he / she were there to support academic goals and moved goalposts just to see how the group reacted or as in one occasion decided that the original brief was far too easy and added more objectives and tighter timescales for deliverables. Groups found it disheartening if IS promised to support the manufacture of a working prototype and then backed out when asked to pay for materials or if parts required to be made out with the university, as in the case of Case Study 3.

For some of the more technical projects that were real time and not blue sky, the industrial supervisor tended to be more of a guiding force working well with the groups and also sharing the analysis with them. The students were then working more as specialist consultants / contractors. These projects usually motivated the students more because they could see how motivated the IS was and the regular feedback and appraisal built up the groups confidence resulting in more being achieved than originally expected.

Expectations of IS over result can be worrying as well. The PDP is a non-charging programme, all companies have to do is pay for prototypes. It is not, however, a cheap means of gaining expert results. The students take the projects to final layout but do not produce engineering drawings ready for manufacture. The learning hours for the class do not always permit time for this activity' as it is dependant on the complexity of the product.

Student perception: Students were required to act in a business like manner with regard to industry liaison, project management and fulfilment of the assigned task.

Each team had a different product and outcomes therefore it chanced that a team would consider the other teams having an easier time, due to lack of understanding about content. Other teams had more technical projects requiring detail design and analysis while others may have been required to design and build functional prototypes or even undertake styling and ergonomic exploration through concepts.

Trust: If one group member is felt not to be pulling their weight the rest of the group will pull away and block information from this non-committing member. One strong person would try and do more work than others but not share it fully. Therefore the PDP was a group mark but did have an aspect of peer assessment included so that the non-committing students were marked accordingly. However, this could also have the effect of giving the project an air of competition resulting in some students trying to out do their colleagues in what work they could achieve. This could result in conflict within the group and at times require intervention by supervising staff. Trust was said to be an issue with the student groups of case study 2.

Student management of design process: Groups had a tendency to write the product design specification (pds) to company requirements and then not look at it again resulting in students struggling to realize design outcomes. This was usually due to students making the product (or project) more challenging than was originally required or focusing on one requirement to the detriment of others. Other problems arose when concepts were not fully developed before a concept evaluation process [3] being undertaken, therefore, the chosen concept to take to embodiment could cause problems later either from difficulty to achieve functional aspects or due to manufacturing considerations. It was also realized that students saw the design process as a sequential activity and were not good at iterations, and in some cases refusing to accept problems in their design.

Students were not always confident enough to stick by their decisions if they thought the IS was misguided. This often resulted in groups being resentful of the project especially if the concept chosen to go forward was not the one they had presented as best. On occasions this was due to students failing to revisit the pds before writing their criteria for evaluation or failing to weight said criteria effectively. Or finally in some cases not exploring concepts enough before evaluation and therefore evaluating on gut feel rather than evidence of behaviour.

On the whole those students who undertook the group projects with industry did learn from the experience and as such gained a degree of maturity with respect to the management of a design project.

Group management: This differed from group to group and from fourth to fifth to PG years, although all had been encouraged to have a rotating group leader so that each student could have the experience. The groups that opted for no leader tended to drift slightly and 'discuss' issues more before coming to an agreement, while those who opted for definite leadership whether rotating or one continuous leader tended to keep to there project plan. Groups tended to use a voluntary basis for taking on work as the students did not like to order people to do things but more hoped that ownership of the tasks would lead to better motivation. This could lead to personality clashes if someone 'volunteered' more than others. Occasionally academic supervisors were required to discuss people management within the group – this was more the case if the students within the group felt they were either competing against each other or felt one weaker student was pulling affecting their chance of a good mark. In some instances a weaker student could be isolated from the group because students had the misconception that this would increase their marks as opposed to it reflecting badly on their management skills.

The fifth year groups tended to work better together and be better at managing the project and much more prepared to take on a leadership role. Motivation was not a problem and all students were noted to participate as was found from academic supervisors feedback and through the student's individual reports.

The PG students were generally on a par with the 5th year students however problems would arise due to cultural or language problems, the PG courses having a higher percentage of none UK students. The academic supervisor could assist in tackling this problem if the student group did highlight communication or perceived accountability as a problem during group meetings.

Communication with company: In some instances a group hotmail account was set –up, this tended to be by the more proactive groups (5th years). This resulted in a seamless interface for the company; therefore as management changed the address for correspondence from the company stayed the same. Other forms of communication were phone calls and visits either by the industrial supervisor to DMEM or the students visiting the company. It was found that face-to-face meetings were required before the students felt comfortable with phone calls or emails. The amount of time an industrial supervisor could spend on contact depended on the company and workload each supervisor had. It has been noted that a quick turn around to questions was good to keep the students motivated and not result in lost project time. It was noted that the fourth year and PG groups put off initial contact with the company and were less likely to use the telephone and as such email was preferred. All 4th year students communicated better after an initial face-to-face meeting with the client had taken place as a result telephoning or emailing became easier. The face-to-face meetings are also important for all parties to understand the objectives of all the stakeholders and to reach agreement as to what is feasible within the project in accordance to the time allocated to the students and their academic requirements. The 5th year groups were more proactive to get the project moving and to discuss the objectives with the industrial supervisor, this was because they had previous experience of industrial projects and realized the problems that wrong assumptions could make.

5 CONCLUSIONS

As can be seen from the case studies, the industrial supervisor and the attitude of the company can make or break the experience for the student groups. A good supervisor and solid backing from the company can see advances in product development as in the case of UG1 where a patent is being sort to cover the development they achieved. However, bad industrial supervision can turn the student experience into one of confusion, anxiety resulting in de-motivation and the students not showing their full potential and the company not achieving the innovation that is possible from student groups.

The students benefited from the combined efforts of a coaching and evaluation team both from industry and university. The evaluation data gathered from the project has provided us with invaluable insights relating to the students' management of the design processes and their preconceptions. Of particular note was the students' difficulty in isolating the key requirements of the project and ensuring that these requirements were met.

The difference in attitude to management, of both the project and of the design process, between the fourth, fifth year and PG groups highlights the fact that the skills required to manage an industrial project cannot be taught but are acquired through experiential learning. The same can be said of the shared network space, students needed to have a negative experience to realize how beneficial it was. It was interesting that the students had an inherent distrust of it and saw it as another hurdle being put in their way instead of an aid to accomplishing their tasks. As can be seen from the case studies it was the student groups that had been through the project before who used it well. It appears that the students need to determine the need for the shared workspace either through loss of material, etc before they understand the need for it. Therefore the students require the industrial project in consecutive years to initially learn the skills and then the next academic year to put them into practice and consolidate that learning.

In conclusion the industrial group projects are a vital part of student learning about the product design process giving the students the academic and professional experience required to make them competent designers with respect to form, function and management of the design process. However, as can be seen from the case studies, the industrial supervisor has a significant effect on the student experience and so great care must be taken to undertake that the first face-to-face meetings go well and that all stakeholders are understanding each others' objectives.

REFERENCES

[1] ION, W. J. & NEISON, A. I., 1997. The use of shared workspaces to support the product design process. In *Proceedings of the International Conference on Concurrent Engineering*; University of Rochester, Detroit.

[2] STONE, A., WHITWORTH, D. & CHESHIRE, D. 2001. "A Collaborative Virtual Design Technology Learning Environment". In *Proceedings of the 8th National Conference on Product Design Education 2001*, Derby, UK.

[3] PUGH, S. 1991. 'Total Design' Addison-Wesley, 1991, ISBN 0 201 41639 5.

[4] FRUCHTER, R. 1996. Interdisciplinary communication medium in support of synchronous and asynchronous collaborative design. In *Proceedings of the First International Conference of Information Technology in Civil and Structural Engineering Design (ITCSED)*; University of Strathclyde, Glasgow. 14-16th August.

[5] ERIS, Ö. & LEIFER, L. 2003. Facilitating Product Development Knowledge Acquisition: Interaction between The Expert and The Team, In *International Journal of Engineering Education*, Vol. 19, No. 1, p. 142-152, 2003.

[6] CARRIZOSA, K. & SHEPPARD, S. 2000. The Importance of Learning Styles in Group Design Work, Presented at *The 2000 Frontiers in Education Conference (FIE 2000)*, Kansas City, Missouri, 18-21 October 2000.

[7] LOWE, C. A., MCMAHON, C. A. & CULLEY, S. J. 2003. A comparison of alternative approaches for the automated organisation of design information. Presented at the *International Conference on Engineering Design (ICED) 2003*, Stockholm, Sweden 2003.

[8] MACGREGOR. S. 2002. *Describing and supporting the distributed workspace – towards a prescriptive process for design*. PhD thesis University of Strathclyde.

[9] SCLATER, N., GRIERSON, H., ION, W. J. & MACGREGOR, S. P. 2001. Online collaborative design projects: overcoming barriers to communication. *International Journal of Engineering Education, special issue on Virtual Universities and Engineering Education*, Vol 17, No. 2, pp 189 – 196, 2001.

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