LEARNING FROM EACH OTHER: A MANUFACTURING COMPANY COLLABORATES WITH UNDERGRADUATE DESIGNERS DURING THE -INITIAL STAGES OF IDEA GENERATION

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Abstract

The paper describes an exercise where a British manufacturer and a group of industrial design undergraduates worked together in developing initial ideas for 'blue sky' concepts. The aim was for undergraduate students to experience direct involvement with a product development team from a manufacturing company. The company, in return, wanted its team to become exposed to initial concept development work which is normally carried external to this team in a separate design department.

Students were placed in small design teams and worked together over an intense three-day period. Students from all years were invited to apply for a limited number of places and selected on the basis of enthusiasm for the project rather than expertise and previous academic achievement.

The exercise was evaluated by staff observation, student feedback questionnaires and questions to the company staff. Discussion concludes that there are significant advantages to operating concentrated design project work, whether it is team or individually based. Such techniques are highly intensive. Students rise to the challenge, outputs are good in terms of ideas and the positive experience for students. However, it is recommended that such projects should not be conducted too frequently, due to the intensity for both staff and students.

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Introduction

A constant theme of student feedback on industrial design courses in the United Kingdom is the value of experience gained by working with client companies. Typically this is conducted within final year projects. This paper reports another approach: that of a manufacturing company collaborating with a group of industrial design students in small teams over an intense, three-day event as an addition to their existing study programme. The relationship is symbiotic; in this case the client company recognised that the project could expose their product development team (engineering designers and marketing department) to a telescoped concept design process and enhance their ability to work with their own in-house concept design teams.

From this opportunity to work together grew a design event with many interesting features. The *aim* of this paper is to give an overview of the event and a qualitative analysis. The aims and objectives of the participants are described. The structure and the methods used to evaluate are outlined. Key factors emerging from the data gathered are identified and discussed. Advantages and drawbacks are acknowledged and suggestions made for aspects which could be incorporated in future coursework within industrial design programmes.

Literature Review

The event described incorporates a number of features: small design teams worked directly with an industrial client; initial concepts were generated over a short period of concentrated work (i.e. three days on the one activity). The literature review centres on

- collaborative learning
- the learning scaffolding necessary for concentrated learning
- team based design working
- students working directly with industry (situated cognition)

The development of collaborative learning has two main drives: external demands from industry and pedagogical advantages. Hoerr (1989), in a survey of companies in the United States where teamwork had been introduced, gave examples of productivity rises of 250%. This message has now been accepted by UK industry in general, for example Peacock (1989).

Companies now increasingly use forms of multi-disciplinary team working (concurrent engineering, simultaneous development, innovation cells etc) to develop new products. These techniques have been shown to produce a better range of ideas, reduce development time and so costs, and speed the process of bringing better products to the market (Lawrence 1995).

In addition to the above there are indications of other benefits from team working within companies. Buchanan (1989) showed that attitudes improve, personal self-confidence grows, people become more tolerant and their confidence in their own ability to learn new skills grows. This is an important point. A graduate should see his/her degree as a start point and then continue to develop within the profession.

The growth of small to medium size enterprises (SMEs) has lead to increasing demand for designers who are immediately able to work constructively in a team. Such enterprises have few resources for in-house training and a limited pool of designers, so the emphasis must be on making a team work rather than selecting a good team from a large pool. Because of the above companies now frequently ask for references which comment on a student's ability to work in a team. Lack of team working experience and understanding of the principles behind it may severely reduce the graduate's employment prospects.

Pedagogical issues

There are pedagogical advantages for the use of team working:

a. motivation: there is considerable evidence that team working can generate increased levels of student motivation, particularly when the project chosen has direct links to industry (Denton 1992, Parlett and King 1970).

b. performance: Peacock (1989), speaking as research co-ordinator of Philips Electronics (UK) stated that there was evidence that team performance is `infinitely` higher than individual. In turn Salomon and Globerson (1989) considered that team work can induce a greater mindfulness as well as helping groups to perform better. Gokhale (1995) considered that collaborative learning fosters the development of critical thinking through discussion, clarification of ideas and the evaluation of others ideas.

c. error cancellation: the most basic advantage of team work is that several minds are brought to bear on a problem. These can act to cancel errors that any individual may make so producing an `assembly bonus effect` as described by Driskell *et al* (1987).

Those who have used `brainstorming` techniques would probably feel that assembly bonus cannot fully explain the improved flow and breadth of ideas in more `creative` tasks. The ideas of others can apparently be used to `leapfrog` to further ideas much as De Bono proposed (1982). This introduces the concept of synergy.

d. synergy: Hackman (1983) stated that synergy refers to group phenomena which emerge from interaction and affect how well a group is able to deal with a situation. The popular idea is that the team can generate more than the sum of its individual parts. It is a mistake, however, to see synergy only as a positive effect. When a group initially forms

much time and energy is spent establishing relationships and identifying a common aim. This is not straightforward and can lead to conflict within the team so that in the early stages of team activity little energy is actually spent on the task itself. Tuckman (1985) wrote that any team appears to go through stages of:

forming, storming, norming, performing

Only in the last stage is productive work done on the task itself. Nevertheless the earlier stages are important in establishing a team identity and preparing a base for further work. In an industrial context the team would develop and be better positioned for tackling the next task. In academic settings any team is usually dismantled and students go through the formation process again next time. Gaining such experience of forming is an important learning process.

e. idea generation: team working has obvious benefits in terms of improving the range of ideas generated in a design context. In addition, the process of working with others means that the individual student gains differing perspectives, helping them to examine their own values and pre-conceptions.

Homogeneous teams such as those typically generated by peer selection tend to be harmonious in the initial phases of the project. They lack, however, a range of different perspectives which may assist in error cancellation and the development of the type of active discussion which can promote innovative ideas.

The selection of teams to give a heterogeneous background can promote active discussion but means that the team tends to go more slowly through the forming, storming and norming stages. Only then can performance rise. Experience of forming groups appears to help individuals go through the initial forming stages more quickly and become productive sooner.

f. dealing with ambiguity: design usually deals with levels of ambiguity and unpredictability. Teams are better equipped for dealing with this because of the range of perspectives available.

g. critical thinking: as above, Gokhale (1995) reported that collaborative learning in teams fosters the development of critical thinking via the clarification of ideas and the evaluation of other members' ideas.

h. dealing with multi-disciplinary tasks: team working can enable individuals with a range of knowledge and skills to work together and solve problems or realise opportunities that an individual specialist could not.

i. dealing with realistic scale projects: more substantial and multi-disciplinary tasks may be set. These can simulate whole product design more effectively, and give the student a better idea of engineering in industry. This also means that companies may be more willing to be involved with universities as they are more likely to get something out of project work done by student teams.

j. self-understanding of team work roles and abilities: by evaluating their own performance students can be helped to develop their team working abilities. Staff can use various models such as Belbin (1981) where eight specific role types are proposed: shaper, chair, resource-investigator, plant, company worker, monitor-evaluator, team-worker, completer-finisher and possible extra: specialist. Note Belbin observes that teams are more effective and in positive synergy when members:

- have complementary rather than competing roles
- are aware of each others preferences and can adjust
- are aware of their own strengths and weaknesses and can allow team role sacrifices to promote overall team effectiveness

It is worth remembering that Belbin's work was based on setting up long term general office/administrative structures. This may not apply as effectively to undergraduate design teams.

A major issue identified by Denton (1997) in the context of undergraduate engineering design programmes, was that in each institution surveyed relatively few members of staff had experience of planning team-based design activity.

A basic principle of learning is that of iteration where the individual (or team) goes through an exercise, evaluates it and then tries again on a slightly more complex example. This process can be applied to building capability in team-based design work over the length of a course. The survey indicated a number of factors which should be considered in the long term planning for such development:

- team size and selection method
- task size and duration
- task type
- the use of roles and practice of leadership
- the degree of multi-dimensionality

Concentrated study

Staff may operate under a conventional timetable, or suspend the timetable for concentrated study. The literature on concentrated study is not comprehensive but the work of Parlett and King (1970) and Grimes and Niss (1989) indicated that endeavour and `concentrated effort` do increase when time is used in concentrated blocks rather than in conventional timetabling techniques.

Parlett and King (1970), working with a group of undergraduate physics students, experimented with ‘concentrated study’. They defined this as full time study of a single subject for a short period with no concurrent academic commitments. They observed that the majority of students became fully involved and seemed unable to leave their work alone. Similarly the staff concerned report that the teaching itself was more rewarding and that it was possible to get to know individuals better.

Parlett and King were careful not to claim that the students learned any more than those following conventional courses but there were clear indications that the levels of effort

increased. They pointed out that the experimental group may have developed higher levels of laboratory skills and conceptual insight through concentrated study, though these were not established. The majority of students were reported as appreciating the value of a concentrated study model. Concentrated study was proved to be more efficient; generated more participation and encouraged a greater degree of questioning from students. From a student point of view worries and 'rush' appeared reduced, confidence grew and students reported enjoying the style of study.

The aims and objectives of the company and university

Within the company, the product development team tended to feed data to and from the design team (geographically located in another part of the country) who work on conceptual design separately. The company *aimed* to improve their team's understanding of, and empathy with the process of conceptual design. This was to be achieved by the team working closely with student designers as they tackled a 'blue sky' project.

The university staff *aimed* to provide students with an opportunity to work directly with a major manufacturer's product development team and to become exposed to alternative and challenging ways of thinking and working.

University objectives were to:

a. provide students with the experience of working directly with the product development team from a major manufacturer
b. expose students to the levels of professionalism required within the industrial design profession (including team-based design skills, close liaison with client, and intense work levels to meet short deadlines).
c. explore, imaginatively, the nature and future of domestic appliances in 10 years time (a blue sky approach)
d. develop scenarios whereby the functional requirements and aspirations of UK users of kitchen appliances may be explored
e. develop product specifications and design solutions which satisfy these scenarios and identified needs.

Intended **outcomes** were:

a. sketch scenarios, visualisations of social and cultural changes over the next 10 years such as green issues, recycling, legislation and developing technology
b. product design specifications based on predictions of users' lifestyles and domestic environment
c. sketch design and development of product solutions through storyboards, mood boards, sketch models, visualisations rendered and blue foam 3D models

As the university teaching programme could not be re-worked to fit the exercise the event was run in the week after the university year finished. In practice this fitted well with objective (b) of professionalism. Students needed commitment by giving part of their holiday to the event.

Structure of the event

All student year groups in the department were first informed of this opportunity in March, 3 months prior to the event. A briefing was held in mid April. Interested students were required to show commitment by submitting a CV together with a self-appraisal of their design skills and a 200 word statement on 'why I want to do this event'. In mid May teams were allocated and briefed on information gathering for the event (done in parallel with normal coursework and examinations).

Each of the three days started at 08.00 and ran into the early evening (except the final day). Each was split into a series of short working sessions with individual deadlines. These included inputs from company staff on their role, goals and their perceptions of the market in the future. Teams generated ideas and gave presentations on, for example, the socio-economic context, user-profile designed for, interim design presentations and a final presentation.

All students in the department were invited to apply for the event and eleven teams of four individuals were established. Teams selection was by either of two methods: students could make up their own teams, or staff would allocate membership on the basis of a balance of experience and talent. Many student-selected teams were peer groups but some were a mix of year groups and were not, normally, close friends. This enabled staff to observe differences in working practices and effectiveness.

Each team had a 'base' of a few tables and display boards which could be used in whatever way they wished. The bases were concentrated in two open areas. This meant that whilst there was some privacy the general 'buzz' was very apparent. The company staff were based in an area adjacent to the team bases. This allowed easy movement of either company staff to the team bases or team members to the company staff for consultation. The university staff acted as both co-ordinators and consultants. The output in terms of design concept work were agreed to belong to the company on the basis of the time and support put in.

Teams were tasked to generate 'blue-sky' concepts for mainstream consumer products (kettles, toasters etc.) for the year 2050. The main focus was idea generation rather than problem solving. Prior to the event teams had been briefed to collect visual and textual research data. The designing process was relatively structured and idea generation was supported by inspirational talks from company staff and joint brainstorming (Cross 1994), concept generation through to selection, refinement and presentation which include renderings and 3D blue foam model. This process was supported by a series of inputs by company and academic staff. For example, the company had commissioned a professional market researcher to explore the overall commercial climate within the consumer product market. These findings were presented to the students.

Data sources

Staff were sensitive to the dangers of being over-intrusive in gathering data. During each day company and university staff made unstructured/non-controlled observation notes (Frankfort-Nachmias and Nachmias 1996 p 206) on any points observed which they felt would be of relevance. A formal observational structure was not employed as this would be difficult for non-research trained company staff to use and would be unnecessarily limiting in focus. Each evening staff met and compared notes on their observations and

informal discussion with teams and individuals. Staff notes were collected for subsequent collation and analysis. At the end of day two, students were asked to give non-structured feedback notes on one side of A4. Again, this was non-structured to enable students to raise issues that they felt important rather than responding to issues raised by staff. All students were required to do was to make any observations they felt would be useful in evaluating and developing future events. After the event individual students completed a questionnaire (37 responses from a possible 44).

The questionnaire asked:

- How their team was selected
- Satisfaction with the team before and after the event
- Aspects they enjoyed/disliked
- Three ways in which they gained from the event/company/staff
- Value of staff and company inputs
- Difficulties of working in the team
- How the event could be re-structured

In addition to the above the university kept all drawings and models. These are not analysed in this paper but will form the basis of future work.

Data management and analysis

The data gathered is qualitative, consisting of many pages of observational notes, the individual students' notes and the individual questionnaires. As such, within the constraints of this paper, it would not be possible to present the raw data.

The data was triangulated by methods (observational notes, student feedback and questionnaire) and observers (3 academic staff and 10 company staff). The staff team met and discussed the triangulated the data, identifying the main categories emerging. Rather than follow convention it was decided to present this refined data and discuss it directly in each category as this would help the reader relate data and argument easier. Three sub-sections are used: the perspective of students, university staff and company staff.

Results and discussion

Students' perspective

1. Team selection and process**.** Six of the eleven teams self selected. As expected some used existing peer groups as a basis; but some tried to achieve a spread in background, e.g. year group, gender, areas of expertise. Five teams were staff allocated; some from single year groups and some mixed, all were otherwise random. With the relatively small numbers it is difficult to draw conclusions as to the most effective method. The literature (Denton 1997) indicates that staff selection of team membership to ensure a comprehensive mix of expertise is more likely to bring effective design outcomes than peer groups. Peers groups often have similar backgrounds and interests meaning there is

less breadth of experience to bring to the work. It is interesting, however, that several of the student teams recognised this and deliberately set up a mixed background. This demonstrates a level of maturity and understanding of the issues.

Responses to the questionnaire on whether individuals were initially happy with the choice of team, happy at the end of the event and whether they would work again with that team, were predominantly yes. Only one individual was unhappy initially as his team was uniformly students returning from industrial placements. He wanted more variety of backgrounds, skills and experience within the team. All were happy with the team after the event and would work with those individuals again. Two individuals (from different teams) reported conflict within their teams. Nevertheless, both still reported themselves happy with the team. Hackman (1983) noted that discord in a team does not necessarily mean under-performance. These results also tend to support Buchanan's (1989) observations that team-based work can promote a positive attitudes, personal self-confidence, tolerance and confidence in the ability to learn new skills.

Whilst some teams were non-peers the students were, nevertheless, all from the same department. This eased the usual difficulties of team development (described by Tuckman 1965 as *forming, storming, norming and performing*). The observation that all were happy with working in their team, (on that task and for that duration) reflects findings by Denton (1992, 1997). The structure of the week followed recommendations made by Hackman (1983) in terms of establishing effective teams.

2. Many factors were reported under aspects students **enjoyed.** A simplified summary is provided which does not represent frequency or priority of responses:

- A different type of working environment
- The marketing input from professionals
- The intensity of the event, working to short deadlines
- Working on a user profile
- Team working (including working with unfamiliar colleagues from different years)
- Generating concepts in teams
- Working with a company
- Thinking 'Blue Sky'

As indicated above the physical output from each team is not being evaluated in this paper. The question on enjoyment could, however, be said to have a positive correlation to effort and achievement. There was certainly a novelty effect which would promote motivation (Denton 1992, Cohen and Manion 1994)

3. When asked to report **dislikes** there was far more commonality:

- Long working day and getting up early (long evening working did not appear to be a problem)
- The perception of uncertainty at the start – often reported as 'vagueness' of the brief
- The tight schedule – some disliked staff inputs which they saw as a disruption to their work
- There was an even break on too much/too little staff/company interaction with teams
- Some felt the feedback from the company too vague

The long working day was specifically set to simulate a design team working to a short deadline. The context is somewhat artificial; it is not intended to give the impression that all working days are like this in the profession. The point on uncertainty is an interesting one and shows that the students do tend to want very clear guidelines. Nevertheless the 'vagueness' was a deliberate part of the company strategy in order to promote free-thinking 'blue-sky' ideas. The point on students finding staff inputs as disruptive is, again, interesting. Staff had found that, in normal university design work, short working sessions interspersed with staff inputs which add data but also re-focus their direction helped students manage time better and produced more work in a given time. Generally, if given long sessions to manage their time the students in the department often drifted before they had managed to internalise time management skills.

4. When asked to list three aspects they **gained** from the event:

- Experience of working with a company staff (17)
- Team working experience (14)
- Working at speed and with intensity (13)
- Better understanding of user needs (7)
- Experience of concept generation in teams (6)
- Developing communications/presentation skills (5)
- Time management experience (4)
- Numerous other aspects were covered but only mentioned once or twice – e.g. confidence, enthusiasm, the working style, endurance, insights

These are self explanatory. It is noticeable that working with company staff was the highest rated factor. This ties with academic staff observations below and supports other work (Denton 1997), which indicates the high esteem students place on direct work with industry.

5. When asked on the **value of the company input** the results were more variable. The majority reported that they found the company staff extremely or very helpful. Some pointed out that their value varied depending on the point in the event and that in day one they were 'too vague' in objectives setting'. A small number found the company staff to be of little value to their design work. Several pointed out that it was necessary to ask specific questions of the company staff to gain useful feedback. Some company staff were frequently distracted by company work over mobile phones. This supports work by Denton (1997) which showed that university engineering design staff in the UK were wary of the value of integrating industry staff in their courses as these staff may not necessarily be effective in an educational context. Certainly, experience by the authors of this paper shows that very careful coordination is required between the academic and company staff.

Academic staff perspective

The students, particularly those in their final year of study, were certainly exhausted after completing their major projects and examinations prior to this event. Whilst no more marks accrued from this project, they were nevertheless, keen to gain the experience and enhance their Curriculum Vitae (résumé). Equally, for the academic staff involved, the project came after an intense academic year and this project, and its planning, were

additional to the usual work load. Nevertheless, it was extremely clear that all participants became fully involved, despite or perhaps because of the intensity of the event.

It was evident that students were highly motivated. Discussion with students during the three days, and triangulated by several academic staff, showed that there were two main contributory factors.

- Firstly, students responded extremely positively to working directly with company staff. They appeared to place a higher regard on any input from the company staff compared to that of the academic staff. In some ways they were familiar with academic staff, but saw them as removed from industrial practice (despite consultancy work), whereas the company staff had 'street credibility'.

- Secondly, the structure and nature of the event was different to the mode of working they were accustomed to. This generated a novelty effect which boosted interest and motivation. One of the authors has previously reported on novelty effects and the way they can be used to boost motivation (Denton 1992). It was also considered that the effects would diminished if used too frequently (i.e. no longer novel).

The event provided an opportunity for the academic department to further develop and nurture the working relationship with the manufacturing company. This has led to benefits beyond the event itself, such as support for final year projects, support for design research activities and so on.

Company staff perspective

The Marketing Director had intended the event to bring his team closer together and felt this objective was achieved. He had several new members of staff and hoped that allowing them to interact with students would be beneficial as individuals and for the team. It was also hoped that there would be new product development 'unfettered by the constraints of the in-house process'.

All company staff reported the event to be 'dynamic and exciting'. They felt the students reacted enthusiastically and worked quickly. The company staff felt students were highly influenced by their inputs and opinions. One described the students as 'like sponges' in comparison with his professional work where he has to justify his opinions to a far greater degree. Some staff found it difficult to stop themselves over-influencing students. The interaction during the working sessions was reported to be positive with students eager to ask questions of the company staff. The staff were sure that students had learned something of professional life, manufacturing and marketing strategies, though it was clear that this was not specific and depended on individual interactions.

It should, however, be recognised that company staff are not trained in pedagogy and are unlikely to understand the need for very careful thought in interaction. One example may be that a company staff member may give immediate answers to student questions. An academic member of staff, in contrast, may ask questions back and make the student think rather than give answers 'on a plate'.

The design brief given to the students after liaison between academic and the head of the company team was deliberately 'open' and not constraining. All staff recognised the

limitations of what was achievable in three-days and aimed to limit the project to the initial conceptual stages of design. The project was 'blue sky' in that they were not be constrained by existing technology or manufacturing process, but to 'suspend reality' and design for the home of the future. This was particularly relevant to the company in that (a) they had identified the opportunity for 'fresh thinking' beyond their company design teams, and (b) it this area of interaction, between concept design and the product development team, that the Design Director wished to improve.

In practice, company staff participating perceived the open brief as too futuristic and unstructured. Several referred to impractical or 'un-manufacturable' ideas for products. Similarly some ideas were not seen as original, but they were reported to be 'challenging'. This illustrates the difficulty the product design engineers within that team were experiencing in relating to concept design work. Nevertheless, the Marketing Director reported that they 'came away with some really good ideas'. He also later reported that whilst none of the ideas have been used specifically by the company they have provided inspiration for further company-based thinking, and design triggers for future projects.

Conclusion

The planning required for the event was considerable and, in this case, above and beyond the workload of the academic staff involved, as the event was supplementary to the degree programme. A particular feature was the need for close, on-going liaison between the academic and company staff, which was time consuming. Nevertheless, once an event like this has been developed and run, subsequent events can follow the same template and protocol so improving efficiency.

This event was a positive experience for all involved. This effect appeared to be centred on the increased motivational effects students perceived in working with company staff and the novelty effect of the intense three-day, team-based event. Whilst the academic staff were pleased with the results they were sensitive to the point that this mode of working could not be used frequently if the positive effect is to be maintained.

Final concept renderings were displayed alongside blue foam models.

An important aspect of the professional teaching role of academic staff is knowing when and how to intervene in an on-going project. Experience working with students on project work enables academic staff to develop these particular skills. The event showed one limitation of direct involvement with company staff: they do not have this experience of working directly with students. Two factors emerged, firstly, there was a danger of over involvement by company staff. Secondly, students tended to be overawed by the company staff and adopted suggestions made without necessarily evaluating or challenging them, as they would with suggestions from the academic staff. There is an art in the way in which experienced and experienced academic staff offer suggestions to students in such a way that it promotes synthesis of ideas, rather than *simple* adoption. By this time the students were well accustomed to the academic staff and did not feel pressured to immediately react to an individuals' suggestions. They now knew that could gain different perspectives from individual academic members of staff and their role was to synthesise this advice and produce their own direction. When exposed to company staff, they appeared to regress from this ability.

Observation showed that all teams, which ever selection method had been applied, appeared to adopt a cooperative model of management rather than establishing specific roles (e.g. Managing Director). This was interesting as the company had in the first day provided inputs on their structures and methods of working which did include relatively specific roles. The data available from the event does not enable judgments to be made on the most effective selection and composition of student teams.

The event used small team bases, each with an adjacent display area, yet the overall effect was similar to an open-plan design studio. A certain amount of privacy was possible, but

the ‘buzz’ was evident and staff involved consider this to be a positive feature of the design of the event. This is particularly significant because this student body do not normally have access to such dedicated space, as they operate within a ‘hot-desk’ environment. Academic staff are dissatisfied with the normal practice, caused by limited resources and space. Students often prefer to work at home and this reduces the synergetic effect. The improved synergy created in the event was partly due to the way in which the design environment was set out.

Overall, this event provided an ideal opportunity to develop and nurture a working relationship between academia and industry. Since this event was conducted a similar activity has been integrated in to the main study programme of the final year students.

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