Team-based design work: developing an essential skill for pupils and design and technology teachers

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Team-based design work: Developing an essential skill for pupils and design and technology teachers

Abstract

Team-based design skills are generally considered an important aspect of the work of designers and engineers today. This paper explores the issue of training teachers of design and technology to be able to develop team-based design skills in pupils (age 11-18). Current thinking on team-based design work and its development as a skill is reviewed. The development of team-based design skills in the teacher-training course at Loughborough University is described. The paper then describes how this growing student experience is transferred into knowledge and practice in developing these skills in pupils as student teachers enter schools.
Team-based design work: Developing an essential skill for pupils and design and technology teachers

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Introduction
Pressures for the development of team working capability centre on the apparent potential in team working methods for better working relationships (Buchanan 1989) and performance (Hewit et al 1990). Similarly there are indications (Cowie and Rudduck 1988) that co-operative work can support learning generally. In relation to schools and teacher training, the National Curriculum (NC) for England requires teachers to give pupils experiences of designing in teams (NC D&T 1999 p 15).

This paper reviews some of the relevant literature. The development of team-based design experience on the industrial design and technology with education degree at Loughborough is illustrated. Finally issues in developing team-based design experience in schools are identified. A team is defined as a number of individuals co-operating in the production of a single outcome; group as individuals co-operating but producing individual outcomes.

Background
Companies are increasingly using multi-disciplinary team working. This has been shown to produce a better range of ideas, and reduce development time and costs. Buchanan (1989) showed that, with some exceptions, attitudes improve and self-confidence grows. Recognition of the potential value of team working in industry has meant pressure on universities and schools to give students experience of team-based working. There are also broad educational reasons:

Motivation: Team working can generate increased levels of student motivation, particularly when the project chosen has direct links to industry (Denton 1997 and 1992).

Performance: Team performance can be higher than the sum of individual efforts (Peacock 1989). Gokhale (1995) considered collaborative learning develops critical thinking through discussion, clarification of ideas and the evaluation of other's ideas. Team working brings several minds to bear on a problem. These can cancel errors; an 'assembly bonus effect' (Driskell et al 1987). However, this cannot explain the improved flow and breadth of ideas in more 'creative' team tasks. Hackman (1983) used the term "synergy" defined as phenomena emerging from interaction and affecting performance; it may be positive or negative. Initially time is spent on relationships and identifying the common aim. This can lead to conflict so that less energy is spent on the task itself. In industry a team may tackle tasks over extended periods and so are able to develop into a cohesive and productive unit. In education pupils teams usually short lived. Tuckman (1965) wrote that teams go through stages of: forming, storming, norming, performing. Only in the last stage is productive work done. The earlier stages, however, are important in establishing team identity and preparing for further work.

Idea generation: Team working can improve the range of ideas generated in any context as indicated above. In addition, the process means that the individual students see the perspectives of others, helping them to examine their own values and pre-conceptions.

Dealing with ambiguity: Design usually deals with levels of ambiguity and unpredictability. It can be argued that teams are better equipped for dealing with this because of the range of perspectives available. Minneman and Leifer (1993) saw ambiguity as a positive aspect of the designer's repertoire.
Multi-disciplinary tasks: team working enables individuals with a range of knowledge and skills to work together and solve problems that an individual specialist could not.

Realistic scale projects: more substantial tasks may be set. These can simulate whole product design more effectively, and give the student a better idea of product development in industry.

Team-based design at Loughborough University
The programme in Industrial Design and Technology with Education is a three-year industrial design degree leading into a one-year Post-Graduate teacher-training course. Experience of team-based work is seen as important for students both as potential designers and teachers. An important part of the Department philosophy in teacher training is that teachers should learn to collaborate in both planning and teaching. This can lead to:

- improved cohesion of approach to the subject within a school department
- teachers learning from each other in terms of both pedagogy and subject knowledge
- more efficient in use of staff time and resources

Within the programme there is a spine of formalised team-based design and planning exercises. These extend student experience progressively. In addition, when working on individual work, students are encouraged to form informal groups to extend each other.

Year one
Day one is a team-based exercise known as the Nomadic Brief (Denton 1998). A ‘fantasy’ context is used: small nomadic groups living off the countryside. The new students (120 in two groups of 60) are put into random teams of five and walked into the countryside. Each team must design a shelter made from bamboo, polythene sheet and string. Team working is used both as a design strategy and to help the year group gel in that, by the end of the day students will know four others well and, due to presentations given by each team, they will know something of all the sub-group of 60.

Each team completes the design and construction by a deadline. They then give a presentation on their design to the whole group of 60. The group then brainstorms possible assessment criteria. Teams peer-assess each shelter on these criteria. De-briefing focuses on: team working, design methods, design detail, giving presentations and assessment.

In subsequent design exercises in year one students produce individual outputs but informal co-operation is encouraged for brainstorming and critical analysis at various stages. Students complete a design analysis exercise in teams and a design exercise where some sections are co-operative and other parts are individual.

Year two
The major team-based exercise in year two centres on the design and production of an injection moulded device. Self-selecting teams of four design a small injection moulded ‘useful’ gift for a company to give away. The teams design the products, make the moulding tool, produce mouldings and promotional graphics. This project runs over five weeks at five hours per week involving lectures on injection moulding, tool design, project management and costing. Individuals are delegated by the team to attend specific taught sessions and complete specific aspects of the work. The team co-ordinates these activities and ensures necessary information is pooled to enable the team to progress.

Year three
Year three is mainly major design projects where students gain the majority of their degree classification marks. Experience has shown that some students feel they may be disadvantaged if placed in a team with a weaker student or one who may not work as hard.
This is accepted as a difficulty of team-based work and so such work is not imposed in year three. However, if students wish to propose a team based major project staff consider it. Examples have included a fluid flywheel assisted scooter and a remotely controlled underwater reconnaissance vehicle (see - http://www.lboro.ac.uk/departments/cd/).

**Year four (Post Graduate Certificate in Education - PGCE)**

The aim for this year is to develop the graduates’ ability to teach design and technology in UK schools. During the year students complete two long term planning exercises in the university and others on teaching practice. One of the university exercises is team based because we believe that team based planning can have significant benefits (see above).

The team based exercise uses self-selected teams of four to plan a teaching and learning experience lasting between 7 to 12 weeks in a school. Teams have four weeks to produce a scheme of work, lesson plans, visual aids and exemplar outcomes. In addition to this exercise a session examines approaches to using team-based design work in schools. This is done by working through a team-based simulation (the ‘NASA brief’ Ginnifer 1978) to provide a shared, experience as a basis for discussion. The session draws together a number of key factors and approaches which students can apply in their teaching practices during the year.

Team-based work is also used when teaching aspects of design and technology such as mechanisms, structures etc in schools. Team based work enables a greater amount of ‘hands-on work’ to be covered in the time available, it boosts motivation and has a significant impact on students. An example is a team-based challenge to design and construct the longest cantilever beam from a one metre square section of wall using rolled newspaper and thread as structural members. University based work on team-based design is then reinforced by students employing these principles in their teaching practices.

**Discussion**

This section examines issues involved in developing team based design experience in pupils. The principles also apply to students training to teach. Within the UK the only guidance given by the National Curriculum is that pupils should be given experience of team-based design work at each Key Stage. This paper focuses KSs 3 and 4, but teachers in secondary schools must liaise with primary schools (KSs 1 and 2) to establish logical progression. A long-term plan for building team-based design experience must acknowledge basic skills underpinning such activity. In reviewing of a number of authorities on group and teamwork the author identifies the following very basic framework (to be expanded in future papers).

*Interpersonal Skills:*
- Communications – explaining, clarifying, values
- Interpersonal sensitivity
- General – reliability, reasonableness, co-operation

*Team Process skills:*
- Forming teams, establishing norms
- Procedural and task orientated behaviours
- Membership – constructive interaction, encouraging others

*Team and task management:*
- Task decomposition into sub tasks
- Delegation
- Time management

*Design skills*

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1 Key Stages: 1=ages 5-7, 2=ages 7-11, 3=ages 11-14 and 4=ages 14-16. Ages 16-18 are non-compulsory in the UK and are not covered by the National Curriculum.
Some authorities emphasise the issue of leadership. This author would prefer to focus on co-operative task management. Within a co-operative approach the team may find individuals offer leadership at different points, depending on expertise as well as personality.

Basic interpersonal skills can be developed in most design and technology learning contexts and do not require specific team-based work. For example pupils may be encouraged to act in informal groups when brainstorming and discussing and evaluating individual work. Developing pupils’ basic interpersonal skills underpins subsequent team-based design skills.

Team process and team and task management do require pupils to experience team-based work rather than simply co-operative work. Pupils must gain experience of forming teams, establishing norms, co-ordination, encouraging others and ensuring delegated work comes together as a whole. Experience can assist pupils in managing the stages of ‘forming, storming and norming’ prior to ‘performing’ suggested by Tuckman (1985, above). Similarly student teachers need to experience team-based design work and analyse the process in order to be able to manage the process with pupils. It is important that staff manage the team-based learning process so that pupils gain success. ‘Failure’ in a team task (ie the task is not completed by the deadline) can be difficult for pupils and lower their self-esteem.

A survey of team-based work in undergraduate engineering design (Denton 1997) showed that, when briefing teams, staff focused on task related objectives only and failed to promote team skills as learning objectives. This is an important point: staff, whether at university or school, need to make team process objectives as clear in planning and briefing/de-briefing as the subject based learning involved. To develop team-based design skills staff need to establish a long-term strategy based on a number of learning experiences. Experiences can be structured around: task, time scale, team selection and size, support and assessment. Each element must be considered in relation to incremental progression over time.

**Task:** The task must be suitable for team-based design at the age range being considered. Around a shared core, sub-tasks can be delegated to individuals or sub-groups. Different sub-groups may form, act and feed back at various times. Increased scale and complexity can improve motivation as the final outcome has greater impact. An example at age 11 might be a puppet show, possibly planned in co-ordination with the English department. The team designs the overall show/theme. Individuals or sub-groups are delegated to produce various puppets, the stage, equipment or effects: together the impact can be impressive.

Team-based design work may be based on tasks supplied by industry. There are indications that pupil motivation improves when working with industry (Denton 1992). Success in such pupil-valued work can promote self-confidence. Such tasks tend to be ‘high-profile’ and can promote the subject in a school. Design and technology teachers in many countries complain of low subject status: a well-planned team-based design project centred on an industry led topic can be powerful in developing positive status.

Team-based design can also be developed by simple ‘micro-tasks’, for example the development of team-based brainstorming skills in year 7 pupils via sharp five-minute sessions over a series of lessons. For the first five minutes of the lesson the concept of team-based brainstorming is introduced with the classic exercise ‘how many uses for a brick?’ (DeBono 1982). The exercise is de-briefed, the class is ‘warmed-up’ and then the normal lesson continues. In subsequent lessons the class is put back in the same or different teams and asked to quickly brainstorm other contexts, for example: uses for a clothes peg, or ways of fitting a lid to a wooden box. The class is de-briefed each time, showing techniques such as non-critical acceptance of ideas in a brainstorm and branching a brainstorm diagram.
Similarly staff can focus on inter-personal aspects. These exercises can be repeated with other year groups using brainstorming tasks pitched at appropriate levels.

Another commonly used approach to team-based design is the "Egg race". These are more abstract tasks, typically involving teams designing a vehicle to carry a raw egg over a specific course using materials such as a balsa wood, wire and rubber bands.

**Time scale:** Team-based design skills can be, partly, developed in tasks lasting minutes, as above. Increasing the scale to one lesson staff may consider team-based production line simulations. Examples include: design the most efficient way of assembling identical vehicles made from Lego kits or a production line based on identical paper aeroplanes (re-cycle used paper). These simulations usually involve a period of team discussion and experimentation followed by a five-minute production run. This is analysed and improved for a second iteration and possibly a third. The class must be debriefed in relation to both the production line design and the team work aspects.

For longer-term team-based projects staff should be particularly aware of Tuckman’s (1985) stages of ‘forming, storming and norming’ before teams start to ‘perform’. As longer time scale projects are usually more complex and, typically, require a stage of clarification this important stage typically happens when a new team are in the ‘storming’ stage and far from productive. This problem can be minimised by some form of warm-up before the main task begins. As indicated above experience of forming teams and team-based design can assist in progressing through the storming and norming phases more quickly.

**Team selection and size:** In terms of progression the simplest strategy is self-selection by pupils; the most sophisticated is to ‘socially engineer’ teams that is staff select on the basis of factors such as balancing abilities, gender, or culture. Between these we may have team selected on a random basis, typically position in a class list. Random methods may have hidden effects; pupils with surnames beginning with ‘A’ frequently work together and there may be cultural effects such as ‘Singhs’ always finding themselves placed in teams together.

Self-selected teams, once through the possibly traumatic process of selection (eg individuals not wanted by any team), tend to be more harmonious (Perry and Euler 1988). Such teams are usually of similar backgrounds eg gender, ability and interests. However such teams may lack a range of perspectives which would assist in idea generation (Hackman1983). Bradshaw (1989) observed that teams composed of high intellect members do not always perform as well as heterogeneous teams as members tended not to accept alternative views and argue strongly for their own ideas.

Staff-selected teams may be less harmonious but offer a better range of perspectives. Harmony does not equate to good performance. Experience shows that if pupils are briefed carefully on the value of learning to work with people outside their friendship group they tend to accept the position. Staff may mix teams in relation to gender, ability or culture. There are indications (Bennett and Cass 1988) that, when making up teams staff should avoid making an unsupported minority. An example would be one boy with three girls; better two boys and two girls.

Small teams are easier for younger pupils; handling inter-personal aspects and design decision making is easier. Once pupils have gained experience in smaller numbers staff should work towards pupils being able to work productively in larger teams selected specifically to mix ability etc. The size of a team should match the task; enough work to delegate and ensure all members can contribute. Large teams working on simple tasks risk individuals drifting off-task. Experience shows that teams larger than seven, in a school, can lead to co-ordination
problems. This is probably a sensible limit even for experienced pupils. It is, however, possible to have a whole class as a team if staff act as leader and co-ordinate activity.

**Support:** Team-based work can be very threatening for some pupils. Staff need to exercise their knowledge of individuals in setting teams and supporting them. One advantage of team-based design is that staff will find that they spend less time responding to requests and have more time available to observe individuals and teams in action and intervene selectively.

On longer projects, particularly when teams are ‘socially engineered’, staff need to plan warm-up exercises to support the teams in the initial phases. Warm-up exercises may take a number of forms: introductions by individuals who describe their interests and expertise or short team-based exercises lasting a few minutes enabling analysis and iterative improvement.

The biggest issue for the teacher is ensuring that success for each team in that a suitable outcome is achieved by the given deadline. This requires considerable skill in handling team-based project work. Those with little experience of such work would be advised to start with simple exercises and team selection techniques and build experience iteratively.

**Assessment:** Assessment is probably the biggest difficulty for staff in managing team-based design work. In the UK examination boards often state that team based projects are acceptable providing staff can identify who did what. This demonstrates ignorance of the nature of team-based design work. For example, when designing one member will often act as ‘scribe’ while others make verbal suggestions. There may be no hard evidence of design thinking other than by the ‘scribe’ who, in fact, was primarily noting points made by others.

Assessment of team-based design work requires a pragmatic approach: mark the team outcome as a whole and award identical marks to each individual. Simplistic, but consider:

a. Team based design is an approach which is used relatively infrequently. Staff have many other assessments on which to base an individual’s overall grading.

b. When setting up teams it is important that pupils know how work will be assessed at the start and it is made clear that *they* must manage the team to ensure all contribute. A series of progress meetings in which delegated tasks are minuted can be very valuable training.

c. Staff may mark the outcome as a whole and then apply an individual weighting according to their observations of workload or achievement.

d. In evaluating the project it is possible to use a profile form to focus the team on their performance and then ask the team what weighting they would give to each member. In most cases this will be equal, but not always. Staff will have to monitor this carefully. Hodkinson and Patel (1995), working with engineering undergraduates consider such peer assessment compares well with that of academic staff. This may not be as close with pupils in schools but can be valuable evidence for staff in making decisions.

**Summary**

Team-based design approaches are becoming prevalent in industry for good reason: if managed correctly they appear to bring better results in terms of the speed and quality of the product and the quality of the working relationships. It is hardly surprising that industry is pressuring universities and schools to team-based work. Having said that there is a good deal of evidence that team-based work can promote learning as well as offer pre-vocational experience of teamwork.

This paper attempted to show something of the ways in which the Department of Design and Technology at Loughborough University approach training teachers to manage team-based design and to plan for the development of team-based design skills and experience in a
secondary school. The issue is complex but the potential rewards in terms of learning are worth the effort. The major issue preventing some school staff adopting such approaches is that of assessment. There are no easy answers, but to fail to develop team-based experiences because of this would be a serious abdication of responsibility. Rather than focusing on assessing only the easily assessable we must look more broadly at a pupil’s ability to design. One important feature of that is how that pupil is able to integrate and co-operate with others in team-based design work.

References