Team-Based Design for Design and Technology Teachers

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Schools and universities are under pressure to develop team working capability in pupils and students. This pressure comes from (a) industry and commerce, as there are strong indications that well-designed team working improves performance (Hoerr, 1989; Saba, 1989) and working relationships (Buchanan, 1989); and (b) education, as there is evidence that cooperative work can support learning generally (Cowie & Rudduck, 1988).

This article reviews some of the relevant literature. The development of team-based design capability is illustrated over the four years of teacher training in Design and Technology at Loughborough University in the United Kingdom. Finally, issues in developing team-based design capability in schools are identified. In this article a team is defined as a number of individuals cooperating in the production of a single outcome; a group as individuals cooperating, but producing individual outcomes.

Background

Companies are increasingly using multidisciplinary 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 team-based work experience. 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, 1992, 1997a).

Performance: Team performance can be higher than the sum of individual efforts.
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The program in Industrial Design and Technology with Education is a three-year industrial design degree with a minor element studying design and technology in schools. This leads into a one-year postgraduate teacher-training course. Experience of team-based work is seen as important for students both as potential designers and teachers. For example, an important part of the department philosophy in teacher training is that teachers should learn to collaborate in both planning and teaching (Denton, 1998, Denton & Zanker, 2000). 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,
- and more efficient in use of staff time and resources.

Within the program there is a spine of formalized team-based design and planning exercises. These progressively expand student experience 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 ethnic groups living off the countryside each of a particular type which the students decide (e.g., warriors, priests, healers). The new students (120 in two groups of 60) are put into random teams of five and worked into some outstandingly beautiful local countryside (inspiration). Each team must design a sculptural shelter made from bamboo, polyurethane sheet, and string as in the example in Figure 1. The form of the shelter must also reflect their team type. 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 those in their 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 brainstorm possible assessment criteria. Teams peer assess each shelter on these criteria. Debriefing 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 cooperation 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 cooperative and other parts are individual.

**Year Two**

The major team-based exercise in year two involves the design and production of an injection molded device (see Figure 2). Self-selecting teams of four design a small injection molded “useful” product for use as a corporate gift. The team designs the product, make the molding tool, and produce moldings and promotional graphics. This project runs over five weeks at five hours per week involving lectures on injection molding, mold 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 coordinates these activities and ensures necessary information is pooled to enable the team to progress.

**Year Three**

During year three students pursue major design projects and gain the major-ity 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 (Denton, 1997a). This is an accepted 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 scoter and a remotely controlled underwater reconnaissance vehicle (see Figure 3). Readers may wish to refer to student portfolios at the department’s web pages:

http://www.lboro.ac.uk/departments/cds_dandt/prospectus/undergrad_home.htm

**Year Four (Postgraduate Certificate in Education)**

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 these, the university-based planning exercises is team based because we believe that team-based planning can have significant benefits.

The team-based exercise uses self-selected teams of four postgraduates 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 may be carried out through a team-based simulation called the “NAOS brief” based on Ginifer’s (1978) work to provide a shared experience as a basis for discussion. The session draws together a number of key factors and approaches that students can apply in their teaching practices during the year.

During the postgraduate year staff also use team-based work to explore the teaching of aspects of design and technology such as mechanisms and structures. Team-based work enables a greater amount of hands-on work to be covered in the time available, it boosts motivation, and it has a significant impact on students. An example is a team-based challenge to design and construct the longest cantilever beam from a one meter square section of wall at chest height using rolled newspaper and thread as structural members (typical team manage four to six meters). Another example is the use of paper to design a shell structure/mechanism in the form of a human arm that is articulated by thread and can grip a cup (see Figure 4). University-based work on team-based design is then reinforced by students employing these principles in their teaching practices.

**Issues and Principles**

This section examines issues involved in developing team-based design experiences for 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 article focuses on Key Stages 3 and 4. Team members in secondary schools must liaise with primary schools (Key Stages 1 and 2) to establish a logical progression. A long-term plan for building team-based design experiences and competence must acknowledge basic skills underpinning such activity. In reviewing a number of authorities on group and teamwork, the author identifies the following very basic framework:

- **Interpersonal skills**: Communications (including drawings)—explaining, clarifying, values; interpersonal sensitivity, general—reliability, reasonableness, cooperation
- **Team process skills**: Forming teams, establishing norms; procedural and task-oriented behaviors; membership—constructive interaction, encouraging others
- **Team and task management**: Task decomposition into subtasks; delegating; time management
- **Design skills**: Group “brainstorming” (mindmapping) for analysis, idea generation, and evaluation

Some authorities emphasize the issue of leadership. However, a focus on cooperative task management can be more useful. Within a cooperative
approach the team may find that individual s are able to offer leadership at different points, depending on expertise as well as personality. Recent work by Austin et al. (2001, section 3.1.4) with designers in civil engineering supports this notion of flexible leadership.

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. Garner (2001) emphasised the importance of sketching as a communication tool for designers and not simply as a recording/design tool. Stumpf and McDonnell (2002) provided a discussion on the role of “argumentation” in the early stages of design processes. While they were referring to professional designers, there are some interesting points for educators to consider. Developing pupils’ basic interpersonal skills underpins subsequent team-based design skills.

Team process and task management require pupils to experience team-based work rather than only cooperative work. Pupils must gain experience of forming teams, establishing norms, coordinating, encouraging others, and ensuring delegated work comes together as a whole. Experience can assist pupils in managing the stages of “forming, storming, norming, and performing” guided to “performing” suggested by Tuckman (1985) above. Similarly, student teachers need to experience team-based design work and analyze the process in order to be able to manage the process with pupils. It is important that staff manage the team-based learning environment so that pupils gain success. Failure in a team task (i.e., 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 at a number of UK universities and a university in Japan (1997b) 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: whether at a university or a school, need to make team process objectives as clear in planning and briefing/debrieﬁng 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, size, support, and assessment criteria. 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 subgroups. Different subgroups 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 and presented in coordination with the media department. The team designs the overall show/theme. Individuals or subgroups are delegated to produce various puppets, the stage, equipment, or effects: together the impact can be impressive.

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 staff management of pupils. These exercises include designing a vehicle to carry a raw egg over a specific course using materials such as 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 staff management of pupils. These exercises include designing a vehicle to carry a raw egg over a specific course using materials such as balsa wood, wire, and rubber bands.

Another commonly used approach to team-based design is the “egg race.” These are more abstract tasks, typically involving teams designing a vehicle to prove them in a race. These exercises can be repeated with other year groups appropriate levels.

Self-selected teams, once through the possibly traumatic process of selection (e.g., individuals not wanted by any team), tend to be more harmonious (Perry & Euler, 1988). Such teams are usually similar in ability, for example, gender, ability, or interests. However, such teams may lack a range of perspectives that would assist in idea generation (Hackman, 1983). Bradshaw (1989) observed that teams composed of high intellect members do not always perform as well as heterogeneous teams because members tended not to accept alternative views and argued strongly for their own ideas.

Staff-selected teams may be less harmonious and less productive. 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. There are indications that when making up teams staff should avoid creating an unsupported minority. An example would be one boy with a class of girls; better, two boys and two girls.

Small teams are easier for younger pupils and better for the development of team-based design. Once pupils have gained experience in smaller teams 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 individuals drifting off-task. Experience shows that teams larger than seven, in a school, can lead to coordination problems. This is particularly the case when pupils are not experienced. It is possible to have a whole class as a team if staff act as leader and coordinate the 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. When staffmember is responsible for 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” teams, staff need to plan warm-up exercises to support the teams in the initial phases. Warm-up exercises may take a variety of forms: introductions by individuals who describe their interests and expertise to the short team-based exercises lasting a few minutes enabling analysis and iterative improvement.

The biggest issue for the teacher is ensuring success for each team, that is, 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 simpler tasks. Start team selection techniques and build experience iteratively.

Assessment: Assessment is probably the most difficult problem in managing team-based design work. In the UK, examination boards often state that team-based projects are acceptable providing that indicated above, experience what the task 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. Simpler, but consider:

a. Team-based design is an approach that is not used all the time. 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 monitored can be very valuable training.

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

d. In evaluating the project it is possible to use a profile form to focus the members of the team on their performance and then ask the team what weighting they would give to each member. In most cases the weighting is not equal, but not always.

Staff will have to monitor this carefully. Hodkinson and Patel (1995), working with engineering undergraduates, considered such peer assessment comment...
pare well with that of academic staff. This may not be as close with pupils in schools, but it 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 pressurising universities and schools to develop team-based work skills and experience. In addition, there is a good deal of evidence that team-based work can promote learning as well as offer pre-vocational experience of teamwork.

This article presented some of the ways in which the Department of Design and Technology at Loughborough University approaches 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 from 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 cooperate with others in team-based design work.

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Notes

1 Key Stages: 1 = ages 5-7, 2 = ages 7-11, 3 = ages 11-14 and 4 = ages 14-16. Ages 16-18 are noncompulsory in the UK and are not covered by the National Curriculum.

References


