Critical point inputs within on-going design and technology project work

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Abstract
This paper is intended to explore an idea, developed from existing pedagogy, prior to fieldwork. The idea is that learning could be more effective within project based Design and Technology lessons if staff, at critical points, systematically used short 'inputs' to develop and extend subject understanding.
The starting point for the paper was the observation that many experienced teachers do not use the start and end of practical lessons in the way that student teachers are taught at Loughborough; that is, to link previous and future learning and to review the lesson. The start and end points of lessons have always been understood to be 'critical points' in established pedagogy in that recall is highest from these points. This is analysed in relation to learning theory and it is shown that critical points can be generated at other points within a lesson. The concept of critical point input is then defined. The importance of the role of the teacher in managing such inputs is considered. The potential for using critical point inputs is discussed in relation to both ad hoc and systematic applications in relation to subject knowledge with particular reference to application in on-going practical project work lessons. Some structural factors are considered and examples of potential topic and method are shown.

Project work will probably always be the major vehicle for learning in Design and Technology. Student teachers at Loughborough are taught to manage on-going project work lessons in such a way as to make maximum use of the 'critical' points at the start and end of lessons. These points are used to review previous learning, focus on the present lesson and then to review the lesson and look forward. Feedback from student teachers and direct observation in schools indicate that many experienced staff are making the decision to instead get children immediately to work and subsequently to pack away with only enough time to dismiss the class. The probable reason is that staff wish to gain as much actual working time for pupils as possible. This may be an effective costs-benefits analysis but loses many opportunities for teaching and learning.

This paper establishes a starting position for an action research project. This builds on the established pedagogy that the beginning and end of lessons are critical points for learning. This is developed by examining the potential of using short periods of time at various points within on-going project work lessons to advance the broad aims of Design and Technology. These short periods of time, used to impart information and/or to focus pupil thinking, are referred to as 'critical point inputs'. The paper shows that critical point inputs, used in a structured manner, can greatly extend the learning potential within on-going project work lessons, whilst developing pupils' work rate and attention within those lessons.

The paper firstly examines the concept of critical points in relation to some of the literature on learning theory. The potential of critical point inputs is discussed. Structural aspects of using of such inputs within Design and Technology are discussed and some examples of topic and method proposed.

critical points and learning theory

Recall is best from the beginning and end points of lessons (Buzan 1974). This may be because there is a boundary, a change in focus, which has an impact on the learner. This change in focus is the first descriptor of a critical point. The second would be that the input given within the point is short and self-contained. This relates to attention span theory; pupils can grasp the content of the input as a whole. Typically student teachers are taught to start a lesson with a sharp summary of the previous lesson and a link to the present. At the end of the lesson they should sum up the present lesson and look forward. Both these inputs should be brief as pupil attention spans are short and the essential aim of a practical lesson is practical work.

Critical points can, however, be created at other points of a lesson. Buzan (1974) stated that when items are repeated, associated, or are unique in some way then they are more likely to be recalled. This gives staff the opportunity to create a critical point input during a lesson rather than at either end. Such an input would need to be self-contained and made to stand out from the lesson. The very act of stopping on-going project work and quickly gathering the class fulfils the first criterion of making a critical point; a change in focus. If staff also use

repetition, association or other techniques the input is given further impact and the likelihood of recall is increased. If over-used during a lesson, however, the effect may be counter-productive preventing pupils from getting down to their project work.

Recall, however, is only part of learning. If learning is going to become operational recalled knowledge or skills need to be transferable into new contexts. Klauer (1989) and Hesketh (1989)showed that the transfer of learning both within and across subjects is improved if key points are explicitly linked by staff and learning is rehearsed a number of times. Voss (1987) showed the importance of teachers showing pupils 'cues' to assist in the recovery of information and subsequent transfer.

These can be drawn together to show that to develop transfer, rather than simply recall, the teacher has an important role in identifying key points, summing up and drawing links explicitly. These vital actions cannot be left to pupils to organize themselves. The Cognitive Advancement through Science Education project (CASE, Adey1990) looked at developing 'thinking skills' through science education. There are broad similarities between this work and that referred to above. Adey looked at four key principles extracted from the literature on the development of thinking skills: cognitive conflict, reflection, bridging and reasoning patterns. Cognitive conflict refers to the need for pupils to confront and struggle with problems in order to develop thinking skills. This does not mean 'difficulty for its own sake' (Adey 1990, p2) but does require careful planning by staff. Reflection refers to encouraging pupils to think about their own thinking. Bridging refers to staff consciously linking concepts in new contexts, as with Klauer (1989). Reasoning patterns are described as being characteristic of higher level thinking and include aspects such as control of variables, proportionality, cause and effect and so on. The important point is that the CASE project claims to have established reliable evidence that lessons taught using these principles have real effects on pupil intellectual development both in the short and long term.

The research on transfer and that done by CASE have ramifications for thinking on critical point inputs. Again the role of the teacher in managing the learning process is vital. The concepts of cognitive conflict, reflection, bridging and reasoning patterns can all be transferred to Design and Technology learning and used to establish critical points and enhance learning at these points.

Also of interest is the concept of Academic Engaged Time (AET). This focuses on pupil application to a task and positively correlates with achievement (Leech and Ingram 1989). AET rises when children recognise the relevance of specific learning to their own future (Denton 1992). Staff need to take the time to build this perception of relevance. This can be done by using critical point inputs to show links and emphasise relevance.

Myers (1990) discussed teacher behaviours that promote AET. These include time spent discussing and explaining work; questioning; stimulating cognitive processes; circulating around a classroom and checking work. Leach and Ingram (1989) pointed out that feedback is a particularly strong factor in increasing AET. The CASE project (Adey et al 1990) emphasised the value of stimulating cognitive processes with challenging exercises, claiming this improves learning transfer from one context to another. Together these works support the concept of staff using critical point inputs to offer feedback, to challenge and to discuss work done in the lesson and possibly to introduce ideas from beyond the classroom.

Fisher and Berliner (1986) pointed out that student engagement with learning tends to be higher when the class is taught as a whole. Critical point inputs are equally suited to whole class work, though such inputs do not need to be whole class.

the potential of critical point inputs

As indicated above short inputs at critical points can be effective in helping children recall and transfer previously learned knowledge if correctly managed by staff. In addition these points can be used to pull lessons together and help children engaged on individual or group projects to share developments and so learn from the work being done by others in parallel. Public discussion of a pupil's work can also be a considerable motivational factor if handled well. In long practical lessons flagging attention can be identified by staff and a critical point input inserted in order to re-focus attention and to boost motivation.

Moving beyond what is established pedagogy it is possible to see the potential of critical point inputs in relation to the broader aims of design and technology. Staff could use these points, in a structured manner, in two ways. Firstly, they could be used to focus on particular aspects of designing in relationship to the project being undertaken. For example, staff could use a series of short critical point inputs to discuss the role of different modelling techniques. This could be done by showing examples from professional practice. Secondly, staff could plan a series of critical point inputs on broader issues which grow from the project:

discussion on the social control of technology, ecology and technology, energy conservation, or local issues relating to design and technology. Such points could be used to lead into homeworks in order to expand the time available.

With the developments of the May 1994 National Curriculum Design and Technology proposals (SCAA 1994) and the requirement to teach 'knowledge and understanding' there may be a move towards schools establishing 'theory' lessons in Design and Technology. Certainly a well designed, resourced and appropriately challenging theory lesson could help children understand 'the difference between ferrous and non-ferrous metals and their uses' (SCAA 1994 p16). It is worth also considering the potential value of five minutes 'critical point input' - perhaps two a week over a whole year or key stage. This could easily add up to seven or eight hours per year. This would be time in the 'critical points' which is potentially far more valuable than time spent in a whole lesson. If staff were then to identify those elements of 'theory' and broad objectives which are amenable to coverage in critical points it would be possible to cover a great deal of valuable work at potentially high levels of efficiency.

structural considerations in using critical point inputs

Critical point inputs may be used on an ad hoc basis. For example, staff may demonstrate a new technique to one pupil as it may not be relevant to the whole class. Then two or three minutes may be used at the end of the lesson to show the whole class without actually taking the time to fully demonstrate it. The objective would be awareness rather than capability. Staff would differentiate the input from the rest of the lesson, keep it brief, make links with the other pupils' work and eventually refer to it again to achieve repetition.

As indicated above, however, it would be logical to use critical point inputs more systematically. Some content and methods are more amenable and examples are discussed below. In planning systematically is would be important to recognise the context of the lesson itself. If the teacher is running a project in which the class is designing and making a soil moisture detector it would be logical to link any critical point inputs to the work being done. An example may be to look briefly at the mass production techniques for soldering up PCBs. This could include slides, diagrams and examples of mass produced PCBs; this would all be possible within five minutes.

In planning systematic use of critical point inputs it would be important to establish the broad pattern of project work and any 'theory' lessons together with exercises in developing skills or evaluation tasks. This provides the context base. It would then be possible to establish appropriate content and methods of critical points. In many lessons these will be used to directly support work done in the lesson, as in the example above; flexibility must be maintained to some degree. Nevertheless it should be possible to plan one specific critical point input per lesson which, while based on the lesson, takes it further. Staff would look at the programmes of study for the course and identify those areas which could be addressed by critical point inputs. By linking this list to the project contexts it would be possible to build a systematic scheme. End of lesson critical points could also be linked to homeworks.

The methods used to teach within critical point inputs may vary. Examples should include methods which give 'impact' such as slides or other audio/ visual methods. Examples may include:

teacher led discussion or small group discussion; this may focus on an aspect of the lesson or link with current events, local developments, or an aspect associated with the project.

thinking exercises (for example based on De Bono 1982); these could be treated as 'warm-up' exercises at the start of a lesson. With young children over a period of, say four lessons, staff can introduce an object such as a brick, peg, paper-clip or biro and ask 'how many uses can you think of for this?'. A short deadline can be given and then the results analysed and grouped by the teacher on the board/ OHP. Children quickly get the idea of such 'lateral thinking' (De Bono 1982) and enjoy producing more and more ideas as the exercises are used each week. After doing this exercise singly it is useful to move into small group work to explore the potential of group synergistic effects (Hackman, 1983; Cowie and Rudduck, 1989).

mini-simulations; really another form of thinking exercise. They could be defined as exercises where pupils react to and learn from a scenario which in some way attempts to link learning to 'real world' situations. An example would be the 'oil-rig'. This uses four tin cans and a stock of up to 15 sticks such as short garden canes. Three cans are placed equidistant as legs of an oil rig in the sea. The distance between each leg exceeds the length of the canes by a short amount. The task is to build a structure which will support the fourth can, as a platform, in the centre of the three legs. Contact can only be made with the legs. Pupils are arranged

in small groups and each is given a chance for about four minutes at the end of the lesson, but only one group per lesson. The group's performance is analysed by the rest in terms of the minimum number of sticks used and how cooperative they were in doing the exercise. This is best done with key stage 2 and 3 pupils. Usually the first groups fail to reach the deadline; then some succeed with many sticks; eventually they realise that it can be done with three sticks only. Staff objectives are groupwork in design and structural redundancy. The exercise can be more fun if scaled up using litter bins and larger canes.

short demonstrations; often linking work in the lesson to homework. An example may be exercises in rapid sketching techniques for modelling. Used effectively the combination of five minutes demonstration followed by homework can generate very considerable time over a secondary age range course.

conclusions

This paper has attempted to establish that the potential of critical point inputs for teaching and learning can be considerable. This is particularly the case when used within on-going practical lessons in a systematic way. Recent developments in the National Curriculum in England (SCAA May 1994) have introduced the idea of three types of activity: design and make assignments (ie on-going project work); focussed practical tasks intended to practise particular skills and knowledge; and activities in which pupils investigate and evaluate products. These are interesting developments and go some way to removing the emphasis the previous Technology Orders placed on learning through project work. However, the renewed emphasis on a knowledge base may lead to unimaginative 'theory' lessons being used extensively. It is hoped that this paper will go some way to showing there are alternative, and effective, ways of covering at least some of this work.

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