A NEW FLIGHT OF STEPS AT A UNIVERSITY

There is a dangerous sharp edge to the steps, and no handrail.

'... the imposition of mandatory regulations from outside might have the effect of encouraging reliance on the legal minimum precautions as a substitute for intelligent appreciation and application of the principles at issue.' (Committee of Vice-Chancellors and Principals' evidence to Robens Committee, 1972b).

SAFETY IN ESTABLISHMENTS FOR FURTHER AND HIGHER EDUCATION

With Special Reference to the Teaching of Practical Skills in Further Education

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SUMMARY

The thesis - that safety is not seen by establishments of further and higher education as an explicit objective in their work, despite many recommendations that it should be - is established within the limits of the investigation. The special attention given to engineering workshop procedures shows that the failure to see safety as an explicit objective is particularly relevant to the teaching of practical skills to further education students.

Eight questions are judged to be key questions in determining whether or not safety is seen as an explicit objective.

The questions are as follows :

(i) Are substantial efforts being made to implement the principal official recommendations on safety and to carry out activities generally thought to be beneficial to safety?

(ii) Is knowledge of accidents occurring in the establishments adequate for steps to be taken to improve safety in work activities of staff and students, and to show where improvement is required in the teaching of safety?

(iii) Does the practice of safety display to students at first hand proper concern for safety and what to do about it?

(iv) Is the practical significance of classroom teaching demonstrated to students at a personal level?

(v) Are the necessary steps being taken to ensure that precautions known to be essential to safety in work activities are being observed?

(vi) Are service staff competent to carry out safely the tasks required of them?

(vii) Is safety taught in a positive way, particularly in connection with skills which students will use in industry?

(viii) Have safety activities in the establishments been effective in improving the teaching and learning of safety?

Answers to these questions are obtained from the results of a postal survey, and personal investigation, of safety activities; a survey of accidents; and the administration of a questionnaire/checklist to students. These answers provide the evidence to establish the thesis. Implications and applications of the research are drawn up from the findings.

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CHAPTER 1

INTRODUCTION

In modern times as general diseases have declined, injury and ill-health from occupational causes have come to receive more attention. This has led to demands for more and more to be done to reduce accidents and occupational diseases. And establishments for further and higher education have been expected to play their part.

My concern is that the establishments have not seen their part clearly.

Horne (1940) defined safety education as the art of cultivating those knowledges, skills, and attitudes that make for safety. I believe that in further and higher education the need for knowledges and skills for safety has been overshadowed by the emphasis that has been placed on inculcating the right attitudes, particularly the attitude of 'safety consciousness'. Because of this emphasis, establishments have failed to see safety as an explicit objective in their work. As a result, safety education is not meeting the needs of the student, of industry, nor of the world at large. Moreover, safety in the various spheres of work of staff and students in the establishments is not of the standard to be expected.

An example of the emphasis placed on inculcating attitudes is to be found in the evidence given by the Committee of Vice-Chancellors and Principals of the Universities of the United Kingdom to the Committee of Inquiry on Safety and Health (the Robens Committee, 1972b) on safety in universities.

The Vice-Chancellors' Committee said :

> 'Universities have a responsibility not only for ensuring the protection of their staff and students but also for instilling into each succeeding generation of undergraduates a measure of safety consciousness which they can carry forward into subsequent careers in industry and elsewhere. The ultimate objective of safety arrangements in university laboratories is thus the creation in both staff and students of an attitude of mind about safe working.'

The Association of Teachers in Technical Institutions (1971), when they gave their evidence to the Committee, put forward a similar point of view. They said that if safety training was linked with lectures much would be achieved because 'true interest in safety is merely the development of a frame of mind'.

The tenet of 'safety consciousness' and the associated phrases 'attitude of mind' and 'frame of mind' were brought into prominence in educational circles in 1958 by one of the pioneers of safety in educational establishments, the late Dr. L. J. Burrage. They have penetrated not only further and higher education establishments but also schools. For example, the booklet 'Safety in Practical Departments' (Department of Education and Science, 1973) asks 'Are all in your workshop sufficiently safety conscious?'

The extent to which safety consciousness has been seen to apply is shown by the inclusion of the words 'make up your mind that you are not going to get hurt or take risks and chances' in a draft handbook recently produced by a committee of further education college representatives in the West Midlands.

This approach is at variance with attitudes to danger esteemed by our society. Linton (1947) drew attention to the way that all societies try to establish in their members attitudes which promote brave behaviour because courage is necessary for the successful defence of the group. In the long term, courageous behaviour may cost a man his life. But in the short term it will reward him with the respect and admiration of his fellows.

Attempts to inculcate safety consciousness run contrary to educational objectives which seek to foster initiative and a spirit of adventure in students - the most obvious clash is on the sports field.

Nearly 40 years ago Vernon (1936) suggested that if people were educated to acquire safety habits in respect of large numbers of specific acts which they were frequently called upon to perform, they could continue to look upon life as an adventure without the impairment of a growth of overcaution such as might be caused by constant consciousness of safety. In Vernon's day the phrase 'safety habit of mind' was used rather than safety consciousness and Vernon held that most persons found it easier to acquire safety habits in respect of specific acts than to grasp the general principles implied by the phrase.

There can be little dissent from Vernon's view by teachers. In the teaching of a safe method of working it is possible to reproduce in the learning situation most of the cues which would be present when the student is called upon to carry out the work in a working environment, and transfer of learning is practically automatic. But as Kelman (1953) pointed out, in communications which are designed to change attitudes it is impossible to reproduce the multitude and intricate patterning of stimuli - the cues - which evoke the attitude in question. If a teacher wishes to inculcate an attitude of safety consciousness, he is unlikely to be effective if he uses direct teaching. Like sportsmanship in physical education, safety consciousness would have to be constantly aimed at but not taught.

An attitude of safety consciousness is most likely to be brought about by development of the knowledges and skills that make for safety - this is assuming of course that safety consciousness is desirable. Development of knowledges and skills is not likely to be achieved unless the requirements are made clear and all concerned understand the part that they should play.

The aims of my research are (i) to see whether establishments of further and higher education are failing to see safety as an explicit objective in their work, and (ii) to see what lessons are held for the future of safety in education itself and in the establishments that provide it. I start, in the next chapter, by examining the problems that need to be faced by the establishments.

CHAPTER 2

SAFETY PROBLEMS

In establishments for further and higher education the problem of safety can be broken down into smaller categories of problems: teaching safety, and ensuring safety in spheres of work of staff and students. There will, of course, be considerable overlap between these two categories. Within the categories there is need for further sub-divisions. For example, the teaching of safety can be sub-divided to give two categories: occupational health and safety, and product safety.

Occupational health and safety

In their teaching of occupational health and safety, the establishments are concerned with safety in the occupation that the student will follow when he has completed his studies, or if he is a part-time student, in the occupation he is already following. They need to teach health and safety at work for the chemist, the engineer, and so on, at the level appropriate to the craftsman, technician, technologist, scientist, or administrator. According to the level, the emphasis will vary. For the craftsman it will be on safety for the person himself, for the administrator it will be on safety for the workforce and the public.

The student should learn occupational health and safety by formal lectures or teaching, and also by his experience within the establishment: the activities that impinge on him and the example he is set.

Product safety

This requires the teaching of safety in the design of products. The aim in product safety is to prevent danger arising from the product. Members of the public as well as users (or consumers) of the product need protection. The designer should attempt to ensure the safety of persons in the use of buildings, transport, household appliances and other manufactured products. But product safety should extend beyond products that are manufactured. Anything that is produced for use or consumption should be included: fuels and food, for example.

There are problems in product safety in reconciling safety and economic factors and safety and styling. I did not investigate how establishments were dealing with these problems because of the need to limit the boundaries of my study. Previous investigations made by me (Sinnott, 1969 and 1973) raised questions about the appreciation of safety needs by architects. Whether the establishments are paying sufficient attention to product safety in the teaching of architects and other students appears to be a promising subject for further study.

Teaching occupational health and safety

The biggest problem faced by a lecturer when dealing with occupational safety is that he has to put across personal safety to young people, mostly men, at a time in their life when they are more willing to take risks and chances than at any other time. If the lecturer appears over-concerned with safety they may see it as a symbol of fearfulness and unnecessary alarmism.

The approach that was proposed a few years ago by Sir John Hunter (1967), then Chairman of the Central Training Council, seems appropriate. He said :

> 'Training, particularly in the early stages, can have a lasting effect on a man's attitude to accident prevention. Depending on the approach to the subject, a man can come to regard accident prevention as boring and rather unmanly or as a normal and sensible part of industrial life ... it is the positive constructive attitude rather than the negative preoccupation with safety that is needed, not the smug safety-mindedness of the 20 mile per hour driver at the head of the raving column, but the steady assurance of the skilled steeplejack, sure that he knows his job.'

Safety activities

The range of research studies that have been undertaken into accident causation indicates the multiplicity of factors, human and environmental, thought to have been involved. Effective counter-measures may be just as numerous; certainly it is generally accepted that there is no simple solution. Therefore, educational establishments face the problem of deciding what general steps to take to combat accidents and ill-health arising from work and other activities of staff and students. In the absence of established knowledge they have to make those provisions which have been advocated by official bodies and urged on them by practitioners of safety in industry - even though these provisions may be based on wholly inadequate evidence about their effectiveness in achieving health and safety.

Setting an example

In the setting of an example by which a student may learn, the establishments have problems in ensuring that all categories of staff, not only academic staff, maintain a high standard. Establishments also have the problem of cost. Money spent on safety will not be available for what may be seen as the priority area - teaching, or teaching and research, according to the type of establishment. (Teaching by example will, of course, be overlooked.) At a time of financial stringency, as was pointed out by the President of Colorado State University, USA (Chamberlain, 1973) :

> 'Academic faculty and students, who at one time might have been in philosophic accord with the campus safety program, will turn against both the personnel of the safety program and the administration that supports it. Faculty will perceive that "their" salary and expense money is going for campus safety staff. Students will perceive their tuition is being diverted away from providing teachers, library books and classroom supplies.'

The example set by an establishment should extend beyond its students to industry and the world at large. Much of the example will depend on the 'activities' which I have mentioned. But it should go further than the mere carrying out of such activities, it should demonstrate how to do them properly. A parallel is found in the way in which a university health service (when it had among its duties ensuring that the university was a sanitary and safe place in which to work, study, play and live) could be an example to medical students. This was described in a World Health Organisation (1966) report: a safety organisation could provide the same sort of example to students preparing to enter industry. The report said :

> '... The presence in the university of a health service in which due emphasis is placed on the preventive measures outlined in this report, and the fact that the medical student is himself subject to them, serves to demonstrate, at a personal level, the practical significance of classroom teaching... It will permit the demonstration of some of the preventive principles of industrial and occupational medicine.'

Safety in work activities

Establishments have a straight-forward duty to provide their staff with a safe place to work and all that is entailed in that in the way of premises, equipment and materials. They also have a duty to see that technicians, maintenance staff, and porters are properly trained to carry out the variety of tasks they may be called upon to perform.

At the time when my study was being carried out, educational establishments were largely exempt from legislation concerning safety and health at work. Legislation that did impinge on them was that of the Offices, Shops and Railway Premises Act, 1963, which applied to their office premises, and legislation covering certain specific hazards e.g. the Radioactive Substances Act, 1960, and the Petroleum (Consolidation) Act, 1928. There were the rights of individuals under common law. The Factories Act, 1961 did not apply. However, it was sometimes advised as a standard of protection which the establishments might reasonably be expected to achieve.

If all that is practicable is done to make the workplace safe for the student, the problem then arises whether he will be unprepared for the dangers he is likely to meet in industry. For example, if he is used to operating a machine fitted with a shield to give eye protection, will he be unaccustomed to donning safety spectacles before commencing work and hence more likely to be injured when he comes up against an unprotected machine? Forssman (1974) said :

> 'An adolescent who is constantly over-protected will remain ignorant, defenceless and without reactions in the dangerous situations that he will not fail to encounter at some stage and which no protection, however perfect, can hope to eliminate entirely.'

Is it then desirable for an establishment to go further than what is reasonably good practice in industry so far as safe place strategies are concerned when its aim is to make the student a safe person?

Accident information

Part of the problem of ensuring safety at work for both staff and students is knowing what action to take, particularly in the case of safe person strategies. For this, information about accidents can provide knowledge, but in a single establishment this is limited because of the low incidence of accidents.

CHAPTER 3

THESIS, AND QUESTIONS TO BE ANSWERED

My thesis is that safety is not seen by establishments for further and higher education as an explicit objective in their work, despite many recommendations that it should be.

Absolute safety may be defined as a state of freedom from danger to health from accidents and occupational disease. Safety in my thesis is all that is involved in attaining a reasonable degree of that state.

By an explicit objective I mean an objective which is plainly stated in a way that is fully understood by those concerned in its attainment. For many people in education safety is an implicit objective rather than an explicit objective. My opinion is that its very implicitness means that insufficient attention is paid to it.

Questions

My examination (in Chapter 2) of the problems to be faced indicated the key questions to use to determine whether or not the thesis could be established.

The questions are as follows :

(i) Are substantial efforts being made to implement the principal official recommendations on safety and to carry out activities generally thought to be beneficial to safety?

(ii) Is knowledge of accidents occurring in the establishments adequate for steps to be taken to improve safety in work activities of staff and students, and to show where improvement is required in the teaching of safety?

(iii) Does the practice of safety display to students at first hand proper concern for safety and what to do about it?

(iv) Is the practical significance of classroom teaching demonstrated to students at a personal level?

(v) Are the necessary steps being taken to ensure that precautions known to be essential to safety in work activities are being observed?

(vi) Are service staff competent to carry out safely the tasks required of them?

(vii) Is safety taught in a positive way, particularly in connection with skills which students will use in industry?

(viii) Have safety activities in the establishments been effective in improving the teaching and learning of safety?

The research was designed on the basis that the answers to these questions are important signs of whether safety is being dealt with properly in an establishment for further or higher education. The presence or absence of the various matters covered by the questions is then taken as evidence to judge whether or not safety is seen as an explicit objective.

CHAPTER 4

HISTORICAL BACKGROUND

Awareness of a need to do something about safety in establishments providing education beyond school grew as further education (FE) and higher education (HE) expanded after the second world war. There is little record that this need was very much felt before then except for two occasions, which are of special interest because they were times when FE establishments were held up as examples for industry to follow. The first of the two occasions was as early as 1884. Alexander Redgrave, H.M. Chief Inspector of Factories and Workshops (Parl. Papers, 1885) praised 'the excellent shuttle guards in action in the Technical College at Bradford'. Thirty years later, an effort was made to make use of the machinery and appliances in certain of the technical schools in Lancashire as a permanent exhibition of adequate fencing and safeguarding generally (Parl. Papers, 1914). There the matter appeared to rest until a conference of H.M. Factory Inspectorate with officials of the Association of Technical Institutions in 1929 (Parl. Papers, 1929-30). At the conference it was felt 'most desirable' for technical colleges to introduce a certain amount of education on safety into their curricula. Accordingly it was arranged for the Superintendent Inspectors of Factories to put themselves in touch with principals of technical colleges and similar institutions and for lectures on means of safeguarding machinery to be given in the colleges. These lectures were not, however, incorporated into existing courses but were put on as public lectures.

Making the establishments safe places for work activities

The lectures on accident prevention appeared to satisfy both H.M. Factory Inspectorate and the education service for several years, at least in so far as FE and HE were involved. When interest revived after the war, attention was again focussed on the safe-guarding of machinery, particularly the protection of students using machinery or engaged in processes which might be dangerous. The Committee of Enquiry on Health, Welfare, and Safety in Non-Industrial Employment (The Gowers Committee, 1949) considered it desirable that places where instruction involving the use of dangerous machines, tools or processes was carried on should be brought within the scope of the Factories Act. This was desired so that there would be an obligation on the establishments to fit and maintain the usual guards and safety devices and take the precautions required by Regulations made under the Act. The Committee recommended that the use of guards and safety devices be subject to the proviso that they might be removed from machines when in the opinion of the competent instructor it was necessary to do so for the purposes of tuition.

Very few of the recommendations of the Gowers Committee were implemented; and none for education establishments. As part of the campaign to get the recommendations adopted conducted by the labour movement, a motion for implementation was introduced in the House of Commons in 1957 by the then Labour M.P. Mr. Alfred Robens (Hansard, 1957). As Lord Robens he was later to be Chairman of the Committee of Inquiry on Safety and Health at Work which reported in 1972.

Safety education and training

In his report for 1956, G. Barnett, H.M. Chief Inspector of Factories (Parl. Papers, 1957) wrote 'It cannot be said at the time of writing that the Technical Colleges are, as yet, showing much interest in safety training...' This contrasts with the situation in the days when colleges had been held up as examples to industry. Burrage (1963) reported that principals had told him that they rarely, if ever, had a serious accident in their colleges and inferred that there was no need for safety training. It was surprising that the principals had not by then seen the safety role of their colleges. For many years there had been concern with safety training for young people entering industry. In 1934 Sir Duncan Wilson, then H.M. Chief Inspector of Factories, had drawn attention to the excess of accidents among young workers (Parl. Papers, 1934-35). He campaigned for safety training for young people entering industry and continued his campaign until the outbreak of war.

Sir Duncan thought that the lessons on road-traffic dangers, which were then being given in the schools, should be extended to include industrial dangers. He does not appear to have suggested specifically the need for safety training in FE and HE, although he did record that one 'important education authority' had asked that when its technical colleges and schools were visited by an inspector, with a view to ensuring that all machinery was fenced up to the standard required by the Factories Act, 1937, the instructors should be made fully cognisant of the precautions which were required to be taken in factories so that they might incorporate safety training in the curriculum (Parl. Papers, 1938-39). It appears that the authority did not see safety training as going beyond knowledge of the Act.

Attention was given to the safety training of young people in some sections of industry (Anon. 1951) but apart from what has been mentioned already nothing was done in the education service on a national or regional scale. The advance awaited publication of the report by the Industrial Safety Sub-Committee of the National Joint Advisory Council (Ministry of Labour, 1956).

The Sub-Committee saw the need to equip students to protect themselves and others from danger throughout their working lives as well as during their education. It recommended that :

(i) The possibility should be examined for developing safety education as part of general education.

(ii) Information should be provided to teachers in technical colleges etc. about accidents in industry and suggestions should be made on how more advantage might be taken, in colleges, of opportunities to teach safety principles and safe practices which would benefit students in their industrial life.

(iii) Safety training should be integrated and given emphasis in theoretical and practical instruction in technical colleges and in courses in management studies and techniques.

(iv) There should be close liaison between the schools and colleges, industry, H.M. Inspectors of Schools, and H.M. Inspectors of Factories.

Additionally, the Sub-Committee suggested that universities which provided technical and business training should have regard to its recommendations in relation to technical colleges. The failure to give separate attention to the universities did not encourage them to take action, and the suggestion appears to have been effectively ignored.

In the sphere of FE the Sub-Committee's proposals were recognised as being constructive and were acted upon. The Ministry of Education (1956) issued a memorandum drawing attention to them. T. W. McCullough, H.M. Chief Inspector of Factories (Parl. Papers, 1957-58) reported considerable discussions between H.M. Inspectors of Factories and H.M. Inspectors of Schools on ways and means of introducing safety topics into the curricula of schools and technical colleges. Conferences for lecturers and others concerned with FE were held to discuss the need for safety training. Notable among these were the conferences organised by the Kent Education Committee held at Maidstone in June, 1958 (Anon. 1958) and that organised by the North West Regional Advisory Council for Further Education held at Blackpool in the same month.

At the Maidstone conference speakers revealed the general neglect of safety considerations in FE and HE at that time. Concern was expressed about students from technical colleges and universities having a complete lack of knowledge about the ordinary elements of safety. The point was made that the engineering equipment in education establishments did not compare favourably on safety with that of the modern progressive industrial firm. It was also said that the general standard of maintenance and guarding in technical colleges was low.

Safety consciousness

The Blackpool conference brought Dr. L. J. Burrage into the educational safety scene. From that time until his death in 1973 Dr. Burrage, who had previously been interested in industrial laboratory safety, championed the cause of safety in educational establishments. He shared his belief that it was the duty of the educationalist to inculcate safety consciousness in the student with the Chief Inspector of Factories in office in 1958 and his successor. H.M. Chief Inspector, T. W. McCullough, had been one of the speakers at the Blackpool conference. He believed that the teacher could inculcate a degree of safety consciousness which would be invaluable in factory life (Parl. Papers, 1959).

R. K. Christy, H.M. Chief Inspector of Factories from 1962 to 1966 defined safety consciousness as '... a form of foresight or alertness, a quality of mind which has to be developed and nurtured' (Parl. Papers, 1963).

The integrated approach

It is implicit in safety consciousness that safety training should be integrated with theoretical and practical instruction and not taught separately. This principle was first put forward to establishments by the Industrial Safety Sub-Committee of the National Joint Advisory Council. It is unlikely that the Sub-Committee felt that this principle should never be departed from. But it has been so often repeated that in some education circles it has become accepted as the only possible way for safety to be taught. The Association of Teachers in Technical Institutions took this to the point where they thought that safety should be slipped in to lectures almost unnoticed. In their evidence to the Robens Committee they said '... comments about hazards can be made casually in a normal lecture and the correct way of doing a job safely may be demonstrated to the student at practical sessions' (Association of Teachers in Technical Institutions, 1971). As the Robens Committee (1972a) pointed out, the concepts of integrated and specialist safety training are by no means mutually exclusive, and which is best will depend on circumstances.

The integrated approach can be used to put emphasis on the use of efficient procedures which avoid waste in human and material terms. This is something more than regarding safety in the way that Burrage (1971) described. He said that safety was 'very largely a matter of common sense' and maintained that safety training was the bringing about of 'a frame of mind about safety in each student.' A constructive, integrated approach is likely to be more successful than trying to inculcate Christy's 'form of foresight or alertness' which even if nurtured could not be relied upon unless maintained through every minute and every hour of the working day - assuming, of course, that the person concerned knew what to look for.

Official awakening in FE

In 1961 John Hare, then Minister of Labour, in reply to a question in the House of Commons (Hansard, 1961) had said that he was impressing on employers the need to train young people in safety methods and that he was consulting the Minister of Education to see what could be done in technical schools to ensure that safety training was given. Whether Mr. Hare had secondary technical schools in mind or whether he was thinking about FE colleges is not clear. In the event, later in the year, the Ministry of Education (1961) produced an Administrative Memorandum entitled Industrial Safety and the Education Service. This repeated that in FE safety should be developed as an integral part of the teaching, and said that the provisions for safety required by law in industry should normally be applied as a minimum.

The Ministry of Education (1956) had previously suggested that each college should have a safety training policy and possibly one teacher specially responsible for coordination of safety questions. It now suggested that a large college should have a safety committee on which several departments could be represented. It recommended consultation with H.M. Inspectors of Factories and collaboration with national and local safety organisations.

In 1962 the Ministry of Education (1962) issued a circular letter to FE establishments drawing their attention to the magazine 'Accidents' produced by H.M. Factory Inspectorate. This acknowledged the recommendations of the Industrial Safety Sub-Committee that information should be provided to teachers about accidents in industry. The circular was a repetition of the advice given previously in the circular of 1956.

The students' view

The views of the students were first heard in 1961. Primarily their concern lay in obtaining financial security for students injured in accidents, and in measures to ensure a safe place for work activities. The quality of safety education they received was not a matter for concern. The pattern of concern reflects the basic traditional demands of the trade union movement - improvement in the accident compensation system, and improvement and extension of statutory provisions. At the Technical College conference of the National Union of Students (1961a) a resolution was made that the Union should press the Government to require all colleges of higher education to have (a) a standardised accident insurance coverage for all their students in the course of their studies, and (b) all their equipment should be inspected by the local factory inspector and his recommendations implemented.

The National Union of Students (1961b) also produced a Memorandum on Safety in Institutions of Higher Education. This recommended the following :

(i) That the Factories Acts should be extended to institutions where advanced scientific and technical education is carried on.

(ii) That there should be a compulsory system of registering accidents.

(iii) That there should be compensation for students seriously injured in college accidents.

(iv) That colleges should be encouraged to develop research into the causes and prevention of industrial accidents.

(v) That staff and students should be properly informed about accident risks and safety measures.

(vi) That until legislation was in force every encouragement should be given to colleges and authorities to improve their standards voluntarily and to invite inspection by those qualified to advise them.

The emphasis was still on the protection of the student while he was in the college and the duty of authorities to do something about it. Presumably the recommendation that there should be a compulsory system of registering accidents was linked with the idea of compensation of injured students. There was no suggestion that the students saw the need for any research into safety in the establishments, although they did recommend research into industrial accidents. Nor was there any suggestion that they considered improved safety education in their courses of value to themselves, or to the community at large.

In 1966 the National Union of Students/National Union of Teachers/ Association of Teachers in Technical Institutions re-appointed a joint sub-committee which had first been formed after the publication of the National Union of Students' Memorandum in 1961. The sub-committee made various recommendations and the National Union of Students issued a questionnaire for completion by the student unions of all affiliated colleges. The subsequent report was published only by the National Union of Students (1969). It was argued that the average college student was not qualified to answer questions on safety provisions and the report quoted one vice-chancellor as saying 'students very often do not know what is being done for them'. But the National Union of Students had absorbed the educationalists' philosophy of safety and replied that as safety consciousness was a pre-requisite to safe behaviour, students who did not know what was being done for them were not participating in an effective safety system. In the report the Union repeated their former recommendations about safety in educational establishments with the exception of the most far-seeing of the recommendations - the development of research into industrial accidents - which was dropped.

Safety in universities

According to Burrage (1963) the breakthrough in universities came in 1961 when both Liverpool and Manchester Universities appointed full-time safety officers and followed up the appointments by providing a series of safety lectures for academic and service staff. In the following year, R. K. Christy, H.M. Chief Inspector of Factories drew attention to the need for some form of accident prevention in universities to ensure that acceptable standards of safety were maintained (Parl. Papers, 1963). In 1964 H.M. Factory Inspectorate made enquiries of universities about the arrangements they had for dealing with safety problems; and liaison was established between many of the universities and H.M. Superintending Inspectors of Factories (Parl. Papers, 1965). The Inspectorate stressed the importance of safety in universities in the interests of accident prevention among staff and students and also because of the influence which many of the students would subsequently exercise in industry.

The university teachers' view

In 1967, the Association of University Teachers (1967) produced a publication entitled 'Safety in University Laboratories (Recommendations and Select Bibliography)'. The recommendations made included the following :

(i) The safety committee's remit should include general supervision and coordination of the safety effort. One of its tasks should be to stimulate exchange of safety information between departments and the study of accident reports.

(ii) There should be compulsory registration of accidents and the onus of registration of accidents should be determined.

(iii) Safety booklets or leaflets produced by individual departments for their particular circumstances appear to be the best medium for general safety information. If special safety precautions are essential for work with a particular equipment or chemical, the appropriate instructions should be handed to the user in person. The mere posting of notices is of little value.

(iv) Night work out of reach of other workers should be prohibited unless by special and personal permission of head of department.

In contrast to the student outlook expressed in the National Union of Students' Memorandum, the Association of University Teachers appeared to view safety as largely a matter for individuals rather than the establishment. In common with the students, however, the Association did not look beyond protection of persons within the establishment. There was no indication that the wider application of safety education was considered - either in respect of duties to workpeople which the students would subsequently become responsible for, or in the products they might design.

Safety activities in universities

In 1968 an industrial safety officer, Leggett (1968) was sharply critical of universities for their outlook on safety; one of the points he made was that only six establishments then had a safety committee or employed a safety officer. However, interest was slowly growing and by

1971 representatives of universities formed an Association of University Safety Officers. Some indication of the recognition given to safety in universities by that time is shown by the number of full-time safety officers who were present at the meeting; from the 33 universities represented, there were nine - one of whom held the wider post of Health Protection Officer, and one who was also Security Officer. Also present was a Safety Training Officer and a Safety, Security and Fire Assistant.

The setting up of the Robens Committee in 1970 had stimulated interest in university safety. When the Committee of Vice-Chancellors and Principals presented evidence to the Robens Committee (1972b) it said that universities had taken a number of steps in recent years to promote 'safety consciousness' among staff and students. Dr. Burrage was one of the four persons who represented the universities before the Robens Committee and it is clear from the published evidence that his thinking had influenced the universities' orientation on safety.

At the time that the evidence was presented, the Vice-Chancellors' Committee set up a working group to formulate a general code of safety practice for universities. The Committee felt that a code would be preferable to legislation in that it could be more quickly introduced and more easily kept up to date. Atherley (1975) suggests that this preference reflects a desire to preserve universities' sovereignty against Government intervention.

The influence of industrial training

In the FE sector there had been a major step forward following the publication of Training Memorandum No. 2, Industrial Training and Training in Safety, by the Central Training Council (1965). The need for safety precautions as an integral part of relevant FE courses was stressed. In accordance with this, safety was given greater emphasis than hitherto in the new FE courses which were developed by the

City and Guilds of London Institute and other technical examining bodies to complement the training given under the auspices of industrial training boards. The Central Training Council gave weight to the need for FE colleges to emphasise in their teaching on what the Council described as the fundamental precept - that a worker must act in a safe way at all times.

The Sub-Committee on Safety Training of the Industry Safety Advisory Council of the Department of Employment and Productivity instituted a sample survey into aspects of safety in industrial training courses held in training centres and FE establishments in 1968 (discussed further in Chapter 12). This survey was the inspiration behind a Department of Education and Science (1970) circular letter drawing attention to the direct responsibility falling on lecturers on craft training programmes for ensuring that safe procedures were thoroughly understood and practiced by students.

New FE craft courses in engineering were designed for the Session 1969-70 after publication of the CTC Memorandum No. 2. These gave greater emphasis to safety. Construction craft courses with a similarly enhanced emphasis on safety aspects commenced in Session 1973-74. The orientation was to the student's responsibilities to himself and his fellow workers, and in the engineering syllabus the point was made that the theme of safe working practice should run through the educational syllabus, just as it was expected to run through the complementary training programmes.

Legislation

The Robens Committee reported on hospitals and educational establishments together. The Committee was not satisfied that the maintenance of standards of safety and health for employees in the two kinds of establishment was so uniformly satisfactory that it was unnecessary to bring the employees within the ambit of new legislation. It was recognised that improving the conditions of employees would necessitate improving conditions throughout the premises of an establishment. The cost of raising the lighting standard in schools and FE establishments up to standards laid down in the current legislation was estimated to be in the order of £55 million. This high estimate is open to question; but it reveals that a low standard has been accepted. In the HE sector, it was estimated in 1969 that it would cost £2 million to bring all university premises where people were employed up to the standards laid down in legislation at that time.

The Committee recommended that legislation dealing with specific hazards such as dangerous machinery or electricity should apply to educational establishments in the same way as to any other place of work. It recommended that general health and amenity matters affecting the structure and use of premises, such as lighting, heating and ventilation, should be covered by an approved code of practice. A comprehensive code, or series of codes was recommended for educational research laboratories. It was felt that the code covering radioactive substances in research and teaching (Ministry of Labour, 1964), which had been in use for several years, provided a good precedent of arrangements for supervision by an inspectorate.

The Health and Safety at Work Act 1974* which was based on the recommendations of the Robens Committee, applies to educational establishments from 1st April, 1975. The employing authority has to ensure the health and safety of employees at work by maintaining safe plant, safe systems of work, and safe premises; and also by ensuring adequate instruction, training, and supervision. Persons who are not employees but use non-domestic premises as a place of work or use plant or substances provided for them have protection under the Act. Persons other than persons at work have to be protected against risks arising out of the activities of persons at work.

The status of students under the Act, especially those in employment, is not wholly clear. In one of the first publications giving comments on the Act, Jackson (1974) is inclined to the view that persons in 'do-it-yourself classes at night schools and the like' are at work. The Department of

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* Health and Safety at Work etc. Act, 1974 Eliz 2 C 37

Education and Science (1974) states that students are not persons at work but come into the category of persons other than employees liable to be affected by the Act. If doubt persists it can be removed by regulations made under the Act.

It is expected that in due course codes of practice, as recommended by the Robens Committee, will be prepared for approval by the Health and Safety Commission. The draft code prepared by the Committee of Vice-Chancellors and Principals in support of their evidence to the Committee has now been revised and published.

Responsibilities of educators

Professor Sir Brian Windeyer (1973), a member of the Robens Committee and formerly Vice-Chancellor of the University of London, stated the needs of good teaching and good standards of safety within the establishments in a succinct and admirable summary of the responsibilities of those who were educating the younger generation, he said that the students :

> '... should be orientated towards a proper appreciation of safety and health as they will go out to industry and commerce and inevitably provide an example to many others. They will only appreciate the standards that they are taught and have seen to be maintained by their seniors and instructors.'

Summary

Throughout the period under review there have been many recommendations from both inside and outside the education service for progress in safety within establishments and in the education they provide. No awareness has been shown of the situation in respect of accidents within the establishments. Industry no longer looks to the establishments for examples of good safety practice.

Emphasis has been placed on the attitude and ability of the individual because it is through the individual that the education service expects to play a part in the improvement of occupational health and safety.

CHAPTER 5

SAFETY ACTIVITIES IN ESTABLISHMENTS

To obtain evidence to answer my question on the efforts that establishments were making to (i) implement the principal official recommendations on safety, and (ii) to carry out activities thought to be beneficial to safety, I made a survey of establishments to see how many had set up safety committees and how many had appointed safety officers.

These two functions were chosen because they usually mark progress in safety in areas of technological development. There comes a time when it is realised that it is no longer sufficient to exhort the people to take safety precautions. Additional special efforts are required to see that standards of safety are maintained. Safety committees and safety officers are two functions tokening the recognition of the need for special effort. It has also become apparent that it is necessary to get people to appreciate that they have a personal responsibility for the safety of themselves and others. When this has been realised, one of the first steps taken is often the formation of a safety committee, apart from the legal enforcement of safety requirements. In Britain the value of safety committees in industry was first seen by the H.M. Factory Inspectorate in the years before the First World War (Parl. Papers, 1913). A considerable reduction in accidents in the works of the United States Steel Corporation between 1906 and 1912 was attributed to the formation of safety committees in these works. In 1912, Arthur Whitelegge, H.M. Chief Inspector of Factories said that experience had shown that in addition to legal safeguards, reduction of accidents could best be secured by obtaining the interest and cooperation of operatives and their officials through safety committees (Parl. Papers, 1913). After years of complaining that workpeople would not use guards provided for their protection nor would they observe rules made in their interest, H.M. Factory Inspectorate have from that time to the present day seen safety committees as a means of securing the positive involvement of workpeople in accident prevention and have urged their formation.

In an extensive survey, Williams (1960) quoted numerous examples of authoritative approval of safety committees. He concluded that successful voluntary committees could reduce accident rates considerably. Sullivan (1973) came to a similar conclusion; he reported the results of research on joint consultation on safety and said that a number of benefits, not necessarily confined to accident prevention, could be derived from effective safety committees. Atherley et al (1974) said that in general it was by no means clear what safety committees in factories did, nor how effective they were.

When Burrage was pioneering safety in education circles in the North Western Region, one of his first achievements was the formation of safety committees in certain colleges. The one which he initiated at the Liverpool College of Technology was approved by the then Chief Inspector of Factories, T. W. McCullough, as a model for other colleges (Burrage, 1963).

Williams wrote in 1960 that because voluntary committees, after 45 years of effort, had been set up in less than 2 per cent of factories, there must be many critics of safety committees but they would not come into the open.

A leading safety officer obliged, Harvey (1963) disbanded the safety committee in his works because he felt that much more could be accomplished very much quicker by a determined and effective management. He said that the educational effect of participation was so restricted in a large works to be almost negligible. However, he did accept that in forming a safety committee, management could make known their determination to get to grips with the safety problem and to seek the cooperation of employees.

From the earliest days the approval of safety committees has gone hand in hand with an appreciation of the value of safety officers. At the first International Congress for the Prevention of Industrial Accidents held in Milan in 1912, their employment in a large works was described as

TABLE 1

Types of FE establishments providing information about their safety organisation

Type	No. approached	No. providing information
Colleges of Technology, Technical Colleges, Colleges of Further Education	92	65
Colleges providing Commerce only	2	2
Colleges providing Art only	14	8
Agricultural Colleges	5	4
Adult Education Colleges	4	1
Specialist Colleges	4	2
Total	121	82

a 'paying proposition'. In FE establishments the appointment of a member of staff as safety officer had been recommended by the Department of Education and Science. In HE the appointments of the first safety officers in universities had been regarded as heralding an awakening in safety matters in that sector (see p.19).

It seemed that the existence of a safety organisation consisting of a committee or committees and a safety officer or officers, as appropriate, in an establishment, could be regarded as a pointer to the intention of the establishment to see that safety was given the consideration which various bodies had urged, despite the reservations which have been expressed by various people about their value.

Further education

In the FE sector I asked a 20 per cent sample of establishments in England and Wales to provide information in respect of their safety organisation in Session 1971-72.

The sample was selected by taking every fifth establishment listed in the Education Authorities Directory (1972) excepting those establishments which had previously been approached to take part in a pilot survey of accidents and had declined. In the few cases where one of these was the fifth in the list, the next name was taken.

The 121 establishments in the sample so obtained were of the types shown in Table 1. Of this number 82 (68 per cent) provided the information requested.

Every type of establishment listed in Table 1 might be expected to have a safety organisation, with the possible exception of the colleges providing commerce only. In fact, the two colleges of this type that were approached each had a college safety officer; one college allowed 2 hours remission of teaching hours for safety duties and also had a safety committee.

Establishments were asked to state how many full-time lecturers they had in order that an idea of the size of the establishment could be obtained.

TABLE 2

Number of FE establishments with certain provision for safety

No. of full-time lecturers in establishment	College safety offr. only	Safety comm. only	Safety offr. and comm.	(Time allow'n for s.o.	No college organ.	Total of estab.
Up to 20	1		1	(1)	12	14
20 - 40	1	1	5	(2)	1	8
40 - 60	2	2 (1)	3	(4)	-	7
60 - 80	-	1	5	(4)	3	9
80 - 100	3	3	1	(1)	1	8
100 - 150	2	3	6	(5)	2 (2)	13
150 - 200	-	2	7	(3)	-	9
Over 200	1	4 (3)	3	(3)	-	8
Unspecified	-	2	1	(1)	3	6
	10	18	32	(24)	22	82

(1) One establishment also had a departmental safety officer with time allowance.

(2) Two establishments each had a departmental safety officer. One granted time allowance.

(3) Three establishments each had a departmental safety officer without a time allowance.

This was more accurate than using enrolment figures where the heads counted may be those of full-time students at one end of the range and one-evening-a-week students at the other end.

Despite a reminder, approximately one-third of the establishments in the sample did not respond to the enquiry. Hence the information obtained may not have been truly representative of safety organisation in FE at that time. However, it is likely that the establishments that did not provide information had done less about safety than those that did. I surmise that the provision for safety was probably less overall than that revealed by my enquiry.

Table 2 shows the extent to which establishments that responded had a safety organisation for the establishment as a whole. Within the terms of the enquiry that meant a college safety officer or a college safety committee, or both. Some establishments had a departmental safety organisation in addition. Where this departmental organisation was not duplicated by a college organisation, notes have been added to the table so that as complete a picture as possible is presented. It shows that there is a wide divergence in the provision made. One would not expect to find a great deal of formal organisation shown in the very small establishments and this is so. The average provision, taking departmental organisation into account as well as college organisation, improves as establishments grow larger until a size of 40-60 lecturers is reached, then it falls until it gets to the 80-100 category whereupon it improves again until the very largest category of establishment is reached and here a slight fall back is seen.

The returns from establishments revealed little pattern in the remission of teaching hours granted to safety officers to allow them time to carry out their safety work. The total time allowed to both college and departmental safety officers in establishments is shown in Table 3. Only in the case of the 40-60 category did a majority of the

TABLE 3

Total time allowance (college and departmental) for safety duties in FE establishments

No. of full-time lecturers in establishment	Total of establishments (1)	No. of estab. giving allow. (2)	Range of allowances per estab. in col. 2 Hours (3)	Average allow. per est. in col. 2 Hours (4)
Up to 20	14	1	-	1.5
20 - 40	8	2	-	2.0
40 - 60	7	5	2 - 4	3.2
60 - 80	9	4	2 - 4	2.9
80 - 100	8	1	-	1.0
100 - 150	13	6[a]	1 - 5	2.9
150 - 200	9[b]	4	2 - 3	2.3
Over 200	8	4	5 - 9	6.8
Unspecified	6	1	-	2.0

(a) In addition, in one establishment the vice-principal acted as safety officer.

(b) In addition, one establishment had a non-academic member of staff as safety officer (college premises officer).

establishments make a time allowance. When an allowance was made this bore little relationship to the size of the establishment. It was greatest in establishments of the largest category that made an allowance; but half of these made none whatsoever.

The pattern revealed by the investigation was extremely patchy. It showed that in FE there was no generally agreed level of provision for safety organisation.

Higher education

The population from which the HE sample was taken was composed of the universities of England and Wales. Colleges of the University of London and of the University of Wales with more than 1,000 students were treated as though they were separate universities. The establishments were placed in the following categories: old universities, London, 19th century-tradition, new, technological. The sample was then obtained by listing the establishments in alphabetical order and taking every other one. Two technological universities not selected volunteered information; this was accepted.

The 'new' and technological universities were the best respondents: this factor, and the two extra returns, biased the results in favour of technological universities. It was probable that because of the concern of technological universities with industrial operations they were more likely to have safety committees than the other universities. If this was so then the picture shown by the sample was brighter than that for the universities taken as a whole.

All but three of the universities in the sample had safety committees for the whole establishment. Of those that did not have committees, one was a technological university, the others were 'new' universities. The chairmen of the university safety committees were, in 13 cases, academics of high status in the establishments (the lowest was a reader); in the other five cases there were two registrar/bursars and three council members or governors.

University safety officers were found in 12 of the 21 establishments in the sample. Only five of the safety officers had been appointed solely in the post; the others combined safety with other duties. Their principal functions were concerned with such matters as engineering and building superintendence; cleaning and portering; maintenance, security, policing, and traffic control; and fire prevention. This was not a satisfactory situation. G. Barnett, H.M. Chief Inspector of Factories (Parl. Papers, 1951-52) pointed out the difficulties faced by part-time safety officer appointments. The pressure of work from non-safety usually means that the safety work suffers.

All the establishments had persons designated as departmental safety officers, in at least one department. The majority of these persons were members of the academic staff but there were a number who held technician appointments.

There were 14 establishments with departmental safety committees in at least one department. A number of establishments also had radiation protection officers and two had committees concerned with radiation protection.

As a whole, the provision in universities varied from leaving safety in the hands of the head porter (apart from a departmental safety officer) to a comprehensive and coordinated organisation which the establishment concerned held up as a model of its kind.

Detailed safety provision in selected establishments

I made a more detailed investigation of safety activities in a sample of ten FE colleges. All these colleges were in the West Midlands region and all were of a broadly similar type. Each had an engineering department. They assisted my research by allowing me to administer a checklist/

TABLE 4

Ranking of safety provisions by four judges

Judge	Policy body	Comm-ittee	Coll. s.o.	Dept. s.o.	Saf. trng.	Acc. proc.	Insp. & ap.	Not-ices	Book & leaf.	Fire prec.
A	1	7	3	8	4	6	5	10	9	2
B	2	8	1	3	6	7	5	10	9	4
C	2	8	1	4	5	6	3	10	9	7
D	7	2	1	5	6	8	3	10	9	4
Total of ranks	12	25	6	20	21	27	16	40	36	17
Final rank	2	7	1	5	6	8	3	10	9	4

TABLE 5

Percentage weighing of final ranks of Table 4 by four judges

Judge	RANK									
	1	2	3	4	5	6	7	8	9	10
	Coll. s.o.	Policy body	Insp. & ap.	Fire prec.	Dept. s.o.	Saf. trng.	Comm-ittee	Acc. proc.	Book & leaf.	Not-ices
A	20	20	20	15	10	5	5	2	1	2
B	18	16	15	13	11	9	7	5	4	2
C	20	18	15	12	10	9	8	5	2	1
D	16	14	14	12	9	9	8	7	7	5
Total	74	68	64	52	40	32	28	19	14	10
Final weighting	18	17	16	13	10	8	7	5	4	2

questionnaire to their students (as described in Chapter 12). The colleges were chosen for the sample because of the nature of their courses and because they were readily accessible from the University.

Safety in the colleges was evaluated by rating safety organisation and safety procedures in accordance with the checklist shown in Appendix 3 The items of the checklist were those which FE colleges had been recommended to implement by various bodies together with items generally accepted as good safety practice (De Reamer, 1958; Fletcher and Douglas, 1970). Similar methods of evaluating the potential of educational establishments to perform certain of their functions have been used previously on several occasions. Barton (1961) gives examples which show how the physical facilities of an organisation have been taken as a measure of its capacity to do its job. School studies have scored such items as the presence of encyclopaedias in classrooms, the existence of art materials and whether a class library shelf had been provided.

When the checklist had been compiled it was submitted in draft form to four judges (members of the Safety and Hygiene Group) who were asked to place the 10 items of the checklist in rank order, placing first the item that they felt should carry most weight in the evaluation. Their rankings are shown in Table 4. The column headings of this table are in the order that they were listed in the draft. The coefficient of concordance between the judges was 0.7.

When the final (or average) ranks shown in Table 4 had been determined, the items were numbered in the order of their ranking. The judges were then asked to award a percentage weighting to the items. Their responses are shown in Table 5. The final weighting of each item is the approximate mean of the four individual weightings. Sub-scores for parts of the items were assigned by me. These sub-scores were based on 20 points for each item. The total of points awarded was then expressed as a fraction of the percentage weighting. In the checklist the actual

TABLE 6

Assessed scores for safety provision in establishments

Estab. No.	Coll. s.o.	Pol-icy	Insp. & ap.	Fire prec.	Dept. s.o.	Saf. trng.	Comm-ittee	Acc. proc.	Book. &leaf.	Not-ices	Total
	Maximum Score										Max.
	18	17	16	13	10	8	7	5	4	2	100
1	16	5	12	10	0	2	6	3	1	1	56
2	0	5	6	7	6	1	5	1	0	1	32
3	0	3	0	7	0	1	0	1	1	1	14
4	8	12	0	7	6	1	4	4	0	1	43
5	13	0	0	7	0	1	0	1	0	1	23
6	18	11	16	6	0	3	0	4	2	1	61
7	0	7	7	8	10	1	5	2	0	1	41
8	18	12	4	7	7	6	7	5	0	2	68
9	0	7	0	7	7	1	6	1	0	1	30
10	8	9	3	8	7	1	4	1	0	1	42
11	18	17	14	13	0	6	7	5	4	2	86

Establishment No. 11 was an apprentice training school in a works, the other establishments were FE colleges.

weighting of the sub-scores is shown.

The evaluation of a college in accordance with this checklist was carried out by interviewing the head of the engineering department and the college safety officer where there was one. Scores awarded are shown in Table 6.

For the purpose of comparison an evaluation was also made of the apprenticeship training school of an engineering company situated in the vicinity of one of the colleges.

In this case the items of the checklist were interpreted to suit the different organisational structure of the works where the school was situated. The results of the evaluation are shown in Table 6. Had points been awarded for a departmental safety officer, then the score of the school on the evaluation scale would have almost reached the maximum possible. A slightly more liberal interpretation would have allowed the points to be awarded. The school was in a works which had a full-time safety officer, and he had assistants who could cover the work of a departmental safety officer in a college. In any event, the school came out well ahead of the colleges in the safety evaluation.

The evaluation showed that the effort on the part of the colleges was generally weak and that in some colleges very little in the way of accepted safety activities was taking place. Even the best in the education service fell well below good practice in an industrial situation.

CHAPTER 6

AVAILABLE ACCIDENT INFORMATION, AND ACCIDENT REPORTING IN ESTABLISHMENTS

In pursuit of evidence to answer my second question - whether knowledge of accidents in the establishments was adequate (i) for steps to be taken to improve safety in work activities of staff and students, and (ii) to show where improvement is required in the teaching of safety - I looked at first at publications giving accident information and then at reporting systems.

There is no centralised collection in the United Kingdom of information relating to accidents in educational establishments and hence there is no publication to show the national situation. Some details about the overall pattern of accidents in schools were obtained by the Department of Education and Science (1969) in 1965 but no similar information has been collected from FE or HE establishments.

Further education

In the north west of England the Regional Advisory Council for Further Education analysed accidents reported to it by FE establishments in the region. Statistics for the sessions 1967-68 to 1969-70 were published (North Western Regional Advisory Council, 1971 and 1972). Accident rate was defined as number of accidents expressed as a percentage of number of students at risk. In view of the different modes of attendance in FE establishments - full-time, part-time, evening only, short course, etc. - the weakness of these statistics is apparent from the start. The accident rate was calculated for 'departmental subjects' in each college. The subjects were categorised as mechanical engineering, electrical engineering, science, building/civil engineering, art, others. A great variation was shown in the accident rate of different colleges. In session 1969-70 it ranged from 0 to 79.9 per cent for mechanical engineering: the overall rate for all students taking this subject was 2.19 per cent. The Council believed that colleges differed considerably in their efficiency in recording accidents and that, although they were asked to report all accidents, many minor accidents were omitted from the records.

Under the usual conditions operating in FE establishments it is unrealistic to expect all slight injuries to be reported an any system of collection of such reports from a large number of different establishments is almost certain to break down. A further weakness in the accident rate statistics obtained was caused by grouping together all students taking a departmental subject. Worthwhile comparisons between establishments cannot be made unless account is taken of the period and degree of risk to which students are exposed. For example, in the category building/civil engineering, we need to know how many students were taking carpentry and joinery, how many plumbing, etc., how much time they spent in the workshops, whether any were taking national certificate or similar courses, and hence did not do any practical work, and so on. Factors like these can vary considerably from one college to another.

In the London and Home Counties Region the Advisory Council for Technological Education (1969-1974) has an annual publication dealing with accidents in FE establishments. It gives summaries of pertinent accident reports and advice on the avoidance of similar events. The reports are obtained from establishments in the Region, checked by HMI (Further Education) concerned, and then sent to H.M. Factory Inspector, who is a member of the Council's Safety sub-committee, for his comments. The specificity of the contents and the expert advice given not only draws attention to dangers to students and staff but also explains how to avoid them, or at least minimise them, in the future. This publication appears to provide valuable information to college safety officers in a way that would be relevant to their problems. A copy of 'Accidents in Further Education Establishments 1973/74' is included in Appendix 1.

The reports so far published by the London and Home Counties Regional Advisory Council reveal a number of weaknesses in safety in the colleges; lecturers and students suffered eye injuries because they failed to wear eye protection; there were several cases of failure to observe precautions taken with chemicals of a kind which would be expected to be followed in industry; a student was injured during a demonstration of a cartridge operated tool by a lecturer; safety clothing was not worn. Three accidents were caused by manufacturers' faulty design of machinery, which was not corrected until after an accident had occurred. A student caught his long hair in the lead screw of a lathe, another student had his hair entangled with the spindle of a drilling machine. Accidents occurred in engineering machine shops because of failure to use isolating switches when adjusting machines and because of failure to make checks before starting machines. Ineffective guarding of woodworking machinery led to serious accidents.

Almost every year there was a report of injury to a person who had attempted to walk through a glass door without opening it, or who had mistaken a window with floor-to-ceiling glazing an as opening. The reports also showed that technicians and other staff were inexpert in their handling of heavy machinery.

Higher education

Although there is no national information about accidents in universities, some statistics internal to particular universities have been presented for general consideration.

Edmonds (1969) analysed injuries using medical room reports from one university. He found that among the service staff, accidents classed as 'severe' (undefined) occurred at the rate of, roughly, 30 per 1,000 employees per annum, and that among academic staff and students they occurred at, roughly, 2.5 per 1,000 per annum. Edmonds compared these rates with those for factory workers (as given by the H.M. Factory Inspectorate) and office workers. As the criterion for reporting an accident to H.M. Factory Inspectorate is injury leading to absence from work of more than three days, Edmonds apparently assumed that his 'severe' injuries approximated to these. There is no evidence that probable absence was considered when he classified an injury; even if it had been, it might have differed substantially from the actual absence.

A survey by the British Steel Corporation showed that 30 per cent of persons who were absent from work following an injury had suffered an injury which had been categorised by medical staff as being 'very unlikely (or 'unlikely') to lead to injury absence' and that 13 per cent of those with injuries categorised as 'almost certainly (or 'very likely') to lead to injury absence' did not absent themselves from work (Shipp and Sutton, 1972). As the figures for factory workers, etc. are also subject to error - 27 per cent of the injuries reportable under the Factory Act, 1961, were found not to have been reported in a sample of 8,000 investigated by H.M. Factory Inspectorate (Parl. Papers, 1970-71) - the value of making comparisons between Edmonds's rates and any obtained in a different way is questionable.

When he considered all injuries reported in the seven-month period he studied, Edmonds found the reported injury rate per 1,000 employees per annum to progress in size from 20.0 for clerks through to 34.3 for porters, 37.5 for laboratory stewards, 45.3 for refectory staff, 59.4 for technicians to 117.1 for tradesmen. No details were given for accidents to clearners, possibly because they were not classified as staff. Among student groups studied post-graduates from the Chemistry Department reported the most injuries: they had a reported-injury rate of 1,000 per 1,000 per annum. Chemistry undergraduates had a rate of 300 per 1,000. In educational establishments, factors affecting recorded-injury rates will include: proximity to medical centre, first-aid facilities in laboratories, and whether sports injuries are included. Powel et al (1971) found a gross difference in the effectiveness of injury recording depending whether or not there was a fully staffed surgery associated with factory workshops. In three workshops with a fully staffed surgery, between about 55 and 70 per cent of injuries were reported. In a workshop which did not have a fully staffed surgery nearby only about 5 per cent of total injuries were reported.

Afacan (1970) analysed accident records at an English university college and found reported-injury rates that differed considerably from those given by Edmonds. The rate, in 1969, for administrative and office staff, 20.0 per 1,000 employees, was the same as that which Edmonds gave for clerks, but the rate for refectory and kitchen staff was 12½ times as great as that which Edmonds gave for refectory staff. The rate for technicians was over three times as great. For post-graduate students in all departments Afacan found the rate to be only 11 per 1,000.

The wide variation in rates from these two sources shows how necessary it is for the safety problem in FE and HE establishments to be clearly stated. Neither of the two reports gave information of direct application to safety in HE establishments.

Accident reporting

As a first step in my examination of accident reporting systems in operation in establishments, I looked at report forms. These were provided by certain establishments in response to a request addressed to those who had previously agreed to assist in the research project.

The forms used in FE colleges for reporting accidents to students that I examined numbered 34: all of them different. Four polytechnics provided forms. These were all different and had been designed only for use in the respective polytechnics. FE colleges that are under the same authority usually make use of a common form; additionally it may be used

TABLE 7

Comparison of accident report forms
of two county authorities

Form A	Form B
Heading of form	
Accidents to students in further education establishments	Accidents to pupils and staff
Particulars of student required	
1. Name	Name
2. -	Address
Questions about accident	
1. Date and time?	Date and time?
2. During normal college hours?	-
3. Entered in college accident record book?	-
4. How accident occurred?	Details of accident
5. Sketch (where appropriate) of location	Place?
6. Cause?	-
7. Injuries?	-
8. Names of witnesses?	Names of witnesses?
9. Student under supervision of teacher?	-
10. Student acting under instructions of teacher?	-
11. Student acting under express orders or rules?	-
12. Student's previous experience in field of work?	-
13. Conditions of premises, etc. contributing	-
14. Action taken about contributing conditions?	-
15. First-aid treatment?	-
16. Student sent to doctor (i) with consent of parents? (ii) accompanied?	-
17. Investigated by college safety officer?	-
18. Any other remarks?	Other relevant information

by a college of education if the authority has one. A large town or city, or a county authority may have several FE colleges and perhaps more than one college of education; the 34 forms from FE were, therefore, in use in many more than that number of colleges.

The lack of consideration which had been given to the possible uses of accident reports in colleges generally was emphasised by the fact that 12 of the 34 forms had been designed for use in schools. These were headed 'Report on Accident to Child', 'Notice of Accident to Scholar', 'Accident to Pupil' and similar. Some contained questions about playground supervision, one asked 'What was done with the child immediately after the accident?'

In another 12 authorities, separate forms were used for reporting accidents to students and accidents to staff. In the remaining ten a combined form was used, generally with some questions directed specifically to staff. Some of the forms used for staff only had been designed for reporting accidents under the National Insurance (Industrial Injuries) Act. Others were forms supplied by an insurance company.

The variety of information the forms for student accidents were intended to elicit is shown by a comparison of two of them in Table 7. These forms were selected because they represented the two extremes of the range of questions asked - one the most, the other the least. Each form was from a county authority and in use in a number of establishments.

In spite of the number of questions asked in Form A, it is quite likely that a completed form will not reveal information such as the part of the body injured. This is important in indicating where protective apparel may be required. When the question asked is: 'What is the nature of the injury?' or something similar, I have found from examination of completed forms that the answer given is often confined strictly to a description of the injury, e.g. 'cut', 'burn', 'bruising'.

I looked through completed report forms at three FE colleges, going back nine years at two of them and one year at the other. I also looked through the records at a university going back five years. I found that where an FE college had put a question such as 'Details of accident', as asked on Form B, the answer often provided little information, if indeed any, about what actually happened. Frequently answers such as 'cut finger' were given. This exemplifies how to many people the words injury and accident appear synonymous; they do not distinguish between an error and its consequences. A report form is unlikely to identify the error component in an accident but it should at least ensure that the respondent distinguishes between the accidental happening and the injury resulting from it.

University forms were generally of a design for reporting accidents to staff rather than students, although most of them contained provision for student accidents. Many of the forms were modelled on the prescribed form for the notification of accidents under the Offices, Shops and Railway Premises Act, 1963. As I have stated previously the Act applies to office accommodation in education establishments but not to parts of their buildings used for academic purposes.

In FE colleges the onus for reporting accidents to students lies usually with the lecturer reponsible for the class where the accident occurs. If an accident occurs outside a class period then the report would probably be made by the course tutor or the lecturer called in to deal with the incident. Many of the FE forms I examined contained a space for the signature of the lecturer in charge of the class. In contrast, in universities the onus for reporting usually rests on the injured student. Minor accidents are, presumably, likely to be relatively under-reported in universities.

One university that I looked at had separate forms for reporting minor accidents and hazards. These forms were widely distributed throughout the university in first-aid boxes, enquiry desks, and with supervisors, so

TABLE 8

Coverage of accident report forms

Information required	No. of forms likely to produce information FE (N = 34)	Univ. (N = 14)	Poly. (N = 4)	CofEd. (N = 2)
1. Nature of injury	30	13	4	2
2. Part of body affected	5	6	Nil	Nil
3. Source of injury	Nil	Nil	Nil	Nil
4. Accident type	34	14	4	2
5. Hazardous condition	15	1	2	1
6. Unsafe act	7	1	1	1
7. Location of accident	28	14	4	Nil
8. Activity of injured person at time of accident	2	7	Nil	1
9. Treatment given	16	8	3	2

that any member of the university could make use of them. In another university I was told that usually only major accidents were reported but this varied from department to department. Eight of the forms from FE colleges bore a rubric worded 'To be completed in respect of any accident resulting in injury', or similar wording; two forms had the words 'however trivial' in addition. Four of the university forms and one from a college of education carried similar instructions. No other definition of the sort of accident or injury that was to be reported was given in any of the forms I examined.

None of the universities required sports injuries to be reported. FE colleges and colleges of education reported sports injuries in the same way as any other injury.

Both FE and HE forms used for reporting student accidents were examined by me to see whether their structure was such that they would be likely to elicit statements useful in accident prevention. The categories thought by me to be useful and the extent that each was at least partially covered by the forms is shown in Table 8. Discussion of the value of the categories is deferred until Chapter 7. Meanwhile I shall proceed on the assumption that omission of a requirement to specify the source of injury and the activity of the injured person revealed that there was little attempt to identify the primary cause of the accident. Failure to allow for a description of hazardous conditions or unsafe acts showed that investigation of the accident by a person having special technical or safety knowledge was not expected.

Information was obtained from the establishments that had provided forms, and some others, about who received (or saw) completed forms. Details were given by 28 FE colleges, two polytechnics, two colleges of education, and 16 universities.

What happened to the FE forms is shown in Table 9. It is remarkable how few heads of department and college safety officers saw the forms.

TABLE 9

Accident report procedures in FE establishments

Who receives copies of reports	No. of colleges (N = 28)
Education office	19
Other local authority department	4
Insurance company	2
Student's employer	2
Senior administrative officer of college	13
Who sees reports (even if not retained)	
Principal	12
Relevant head of department	6
College safety officer (No. of colleges with s.o. = 14)	8

A head of department is traditionally responsible for the teaching in his department and I feel that he would wish to ensure that accidents are reported to him so that if the fault lay in the teaching he could take remedial measures. A safety officer who does not know what accidents occur is not seen by me to be doing his job. In one college it was the chief administrative officer who decided whether an accident which was the subject of a report should be further investigated. In another college, where accident reports were entered into a book in the college office and then copied onto a form for transmission to the education office, the safety officer admitted in response to my question that he had not looked at the accident book for some time.

The polytechnics and colleges of education passed their reports through the relevant head of department, to the director or principal, then to the registrar (polytechnics) or city treasurer (colleges of education).

The university procedures cannot be summarised as readily as those of FE colleges because of the more complicated structure of the universities. For the purposes of this chapter it is sufficient to note that five out of the 16 that provided details said that their reports were seen only by the registry, accounts department or similar administrative department.

It seemed that the reporting systems in both FE and HE establishments had not been set up with safety in mind. The information required about accidents was deficient in detail and there was little uniformity in reporting procedures. The nature of the forms and the use that was made of them indicated that the systems were designed to meet insurance requirements and to constitute a record in case of claims; they were not expected to provide information for use in accident prevention.

CHAPTER 7

PREPARATIONS FOR THE ACCIDENT SURVEY

Information about accidents in establishments was compiled by me to obtain evidence relevant to the questions on :

(i) the demonstration of the practical significance of classroom teaching;

(ii) steps taken to ensure that precautions in work activities are being observed;

(iii) the competence of service staff;

(iv) the positive teaching of safety.

In addition to providing evidence for specific questions the data enabled a picture of the accident situation to be built up. Moreover the data enabled common features of accidents to be compared. The information about the general situation and the comparison of accidents was useful in connection with the question about the positive teaching of safety, as well as being of value in answering the other questions.

To provide further evidence in respect of the teaching of safety, I obtained lecturers' opinions about the ability and attitude of students who had accidents.

The way in which the data were collected is described in this chapter.

Definition of an accident

The first problem facing a researcher who wishes to investigate accidents is defining an accident. There is no generally accepted scientific definition of the word. In general use, injury or damage is usually a prerequisite of an event described as an accident, but the term is also used to describe an unforeseen event with a favourable outcome. Fleming's discovery of penicillin, for example, has been described as an accident because he did not come upon it by design. The terms 'happy accident' and 'positive accident' have been used to describe such events (Shaw and Skolnick, 1971). In this context an accident with an unfavourable outcome would be described as a negative accident.

In accident research some definitions demand that an accident shall result in an injury, others accept damage as an alternative to injury, still others allow almost any unplanned event to be included. However, in the majority of research papers the words accident and injury are almost synonymous (Hale and Hale, 1971). They cannot be entirely synonymous because deliberately inflicted injury is not considered to be an accident, also some accidents do not cause injury. In this present work I excluded the deliberate infliction of injury and considered any event which caused injury to a person as an accident. A similar event which caused unintentional material damage, rather than unintentional injury to a person, is described here as a damage-accident.

Examination of epidemiological approach

Consideration was given to the advisability of working to a conceptual framework. The epidemiological approach appeared to be the most suitable.

Leavell and Clark (1965) defined epidemiology as '... a field of science which is concerned with the various factors and conditions that determine the occurrence and distribution of health, disease, defect, disability, and death, among groups of individuals.' Its application to accident research and the identification of the 'orthodox trichotomy' of the science, host - agent - environment, as accident victim - agent of injury - environment, probably started with Gordon (1949). He argued that the systematic study of all factors and the interactions between them, with control measures directed at one of the factors - an approach which had proved effective in combating dieases - could be applied to accident prevention. As Gissane (1953) explained :

> 'The virulence of the noxious agent applies equally to the bacterium as to the ... production machine...' and 'The introduction of a new virulent agent or combination of agents may cause an epidemic of accidents...'

Gissane also said :

> 'The resistance of the host has its equivalent in the varying liabilities to accidents in different stages of training and in different age groups...'

Epidemiology has been previously used in studies of accidents in educational establishments in the sense that epidemiology is the study of factors and conditions in a population that may affect the origin of the health state or its distribution in the population, but without the application of rigorous epidemiological theory and techniques.

In an early study concerned with technical education, Ade (1938) investigated accidents in industrial school-shops in Pennsylvania. In the school year 1933-1934, the participating schools were asked to report each accident to students separately on a specially-prepared form. This form required answers to 44 questions. Additionally, schools were required to give particulars about the number of hours spent in workshops by all students so that the exposure per accident could be calculated. An accident was defined as a mishap that caused injury. The number of usable reports received was 1,041. The study was not carried out with scientific rigour and cannot be regarded as more than an inconclusive test of the procedure. It is, however, interesting to note one of the conclusions was that a general interest in eliminating school-shop accidents would finally call for a common system of reporting, tabulating and evaluating accident data. Such a call was echoed in the United Kingdom by the National Union of Students, (see p. 18) nearly 30 years later.

The epidemiological approach to accidents in educational establishments has also been explored by Parrish et al (1967) who said 'A well designed accident report form and good reporting are keys to the epidemiological control of accidents'. If it is necessary to rely on reports, and it is difficult to see how data can be collected otherwise, it is undoubtedly true that a well-designed form and good reporting will be necessary;

at least it will go some way towards ensuring uniformity in the standard of reporting from different sources. Whether the quality of reports provides the key to control has yet to be tested.

A study of 409 school accidents by Dale et al (1969), using methods proposed by Parrish led them to the conclusion that there had been a 'shocking' lack of serious studies of school accidents and that a study of 'accident facts' could lead to preventive measures. Certainly when mechanical dangers are revealed this can be so.

Suchman (1961) said that the epidemiological model (host - agent - environment) was useful as a simple descriptive scheme for classifying various factors associated with accidents, but it was not altogether helpful for analysing why accidents happened. Beyond the use of the terms 'agent' and 'environment' to label certain factors, the model did not appear to be useful in my work so I did not pursue the idea of using a rigid conceptual framework for the accident research.

Design of report form

I collected reports from establishments on a specially-designed form. Existing accident records are available, as we have seen (Chapter 6), but because of the lack of uniformity in the system of reporting, they are unsatisfactory for combinational or comparative purposes. Points of interest in the design of the form and the information it was intended to elicit require explanation.

When I designed the report form (see Appendix 2) my aim was to make it as simple as possible to complete with the minimum of instructions. I felt that to secure willing cooperation from respondents it was essential that questions and answers should be confined to one side of a single sheet of paper. It was intended to get the form completed by the same person who made the internal report. To avoid trying his patience by asking him for yet more writing, the use of the check-box type of form was considered.

These have been found to be popular with accident form users (Spencer, 1956). The difficulties with this were: determining what boxes were required when there was little information available about much of the accident data to be covered, the large number of boxes that would be required, and the fact that the check-box procedure would force the reporter to perform the accident analysis. The latter procedure would be undesirable when the reporters could not be trained. It has been found that different people tend to check different items when reporting the same events (ANSI, 1962).

The form eventually developed (Appendix 2) called for descriptions in the reporter's own words but also there were some items of the check-box type. These were by way of explanation rather than a fixed choice e.g. 'Treatment by doctor/nurse/hospital accident dept./name other:'.

Under the main heading of the form 'Accident Report' was placed the instruction 'Use also for occupational diseases'. It was not expected that this would produce much response; not only was the incidence of disease believed to be small but the reporting was likely to be unreliable. In premises covered by H.M. Factory Inspectorate, the proportion of occupational diseases reported, in comparison with occupational injuries, is only 0.1 per cent (Shipp and Sutton, 1972). By including occupational diseases, doubts were removed whether cases of dermatitis should be reported and the opportunity was created to receive notice of any other diseases which might be thought to have arisen from work carried out in the establishments.

Pilot survey

Before the final draft of the form was prepared, a preliminary draft was used in a pilot survey. This covered the work of one term in eight FE colleges. In total 144 forms were completed. Additionally, two university safety officers commented upon the form without actually making reports. The pilot survey showed that minor alterations only, insufficient to demand further testing, were necessary.

Severity of injury

A definition of the severity of injury to be reported was required. This had to take account of the sort of accident which was already being reported internally by establishments because it was unlikely that they would report to me accidents that they were otherwise ignoring. My preliminary studies had shown that slight injuries were seldom reported. A threshold for reporting had to be established. This was set as simple on-the-spot first aid; cases to be reported were those that required more than this in treatment. The definition was accepted without question and apparently did not cause difficulty in interpretation. There were, of course, differences in the severity of accidents reported according to the facilities available in different establishments but this difficulty was unavoidable. It was one of the factors which prevented comparison between one establishment and another.

The person

In this work, I have generally used the term 'person' to describe the victim of an accident. Victim is the term generally used, rather than 'host', in the epidemiological approach. It seems rather an emotive description of someone who has bumped his head or cut his finger. In accident reporting generally the term 'injured person' is used, shortened sometimes to IP. I think it will be sufficient to speak of 'the person' unless the context makes a more precise description necessary.

The person with whom this research was concerned was a student or member of staff. Visitors, contractors' workpeople, window cleaners and others, may have accidents while in the establishments but to aid simplicity, no provision was made for them on the form. One or two reports were subsequently received with the word 'visitor' substituted for 'staff' and these proved to be of interest.

Sex

There is some descriptive value in knowing whether the persons who figure in accident statistics are male or female. Generally, for most purposes, it is not possible to make valid comparisons between men and women who have accidents in industry because they do different work. Estimates of the comparative rates for domestic accidents to men and women show that, with the exception of the very old, men seen more vulnerable at all ages (Backett, 1965), but here again there are differences in the tasks undertaken. Road accidents provide some common ground, but it has been pointed out by Hale and Hale (1972) that although studies of road accidents suggest that the incidence of accidents among men and women is different, explanations of the reason would be of limited use when considering industrial accidents because the conditions are different. In educational establishments, men and women students on the same course are called upon to do the same practical work under the same conditions so perhaps some further research would yield data of interest about the different sexes.

In connection with accidents to women, the effect of the menstrual periods on 'accident proneness' is of interest. Dalton (1960) found a link between menstruation and accidents. Lecturers are conscious of it: a report, received during the present work, of an accident to a girl on a catering course who caught her finger in a food mixer, included the following note from the head of department :

> '... the female student had just commenced her period and we find accidents occur at this time.'

This observation suggests that further research would be worthwhile. It was not possible to explore this in an open survey; in the present work I asked merely for the sex of the person to be indicated.

Age

The age of students was asked for but not the age of staff members. The reason for the distinction was that I felt that there might be some reluctance on the part of staff to divulge this information. The value of knowing the ages of the persons did not balance the risk of dissuading them from completing the form. Students, even those of mature years, have to overcome such inhibitions: the keepers of records in educational establishments seem to have a great need for dates of birth. (One reason for this is the statistical sample in FE composed of students born on the 15th of the month.)

In a study of employees in a copper plant, Van Zelst (1954) found that older workers tended to have fewer accidents than their younger co-workers. He also found that age apparently exerted a greater influence upon accident rate than did experience once the 'breaking-in' stage of the particular work had been passed. The men he studied were, however, above normal student age. It would be difficult to separate the effects of age and experience in educational establishments especially as, with a few exceptions, the range of ages would be small. Some indication of a person's experience within the establishment could be obtained from knowledge of the stage of his course. This was asked for on the form.

Activity

Some importance was attached to the question about what the person was doing at the time of the accident and a good deal of thought was given to the wording used. I had found from my preliminary investigation of accident records that often it was not possible to tell what job or activity the person was engaged in when the accident happened. Yet this is a vital piece of information, especially in so far as students are concerned. Exactly what was being done was stressed in an attempt to avoid answers which merely described the general area of work, e.g. woodwork, cooking.

Interest, conduct, and ability

In addition to the name of the course, the form required a rating of the student's interest, conduct, and learning ability in the class in which the accident occurred. The object was to get the general opinion of lecturers about these qualities in students who had accidents. Lecturers in FE are frequently called upon to report upon students' progress and many are accustomed to using five-point scales similar to those provided on the form. For the more advanced students it is likely that such a procedure would be considered inappropriate in so far as conduct was concerned, and naive in so far as other items were concerned. Therefore, the form was worded so as to exclude degree-level students from this part.

Interest in the classwork could have an effect on a student's liability to have an accident. The keen student might push forward beyond his capabilities. On the other hand, there can be little learning without interest. In a review of the literature on vocational interests Berdie (1944) said that abilities and interests were the co-determiners of achievement, whether it be vocational, educational, or athletic. Lack of interest may lead to a 'couldn't care less' attitude.

Discipline in the laboratory or workshop is necessary to ensure that instructions are followed and to prevent horseplay etc. Hence, questions arise about the demeanour of students and its effect upon accidents. The inclusion of a rating scale for conduct was an attempt to see whether lecturers believed that accidents were 'visited upon sinners'.

A strong link between level of intelligence and liability to have accidents has not been established in people above the educationally subnormal. Brown and Ghiselli (1947) found that the correlation between scores on an intelligence test and accident rate was virtually zero for motor coach drivers. I obtained lecturers' assessment of speed of learning by a rating scale on the form. Learning speed would depend upon interest and other factors as well as intelligence but intelligence would play a large part. This alone made it worthy of consideration; additionally we can postulate that the fast learner does not stop to think about safety.

Macomber (1961) obtained achievement ratings from teachers of students who had had accidents in chemistry laboratories. From the results he concluded that accidents were most likely to occur with the capable inquisitive student allowed to use his initiative while the teacher supervised others. However, as Macomber failed to obtain ratings of students who had not had accidents, and failed to obtain details of the amount of supervision exercised, his conclusions were unsubstantiated.

Severity and disabling effect of injuries

An attempt was made to obtain information about the severity of the injury, in non-medical terms, by asking for details of the length of time before the injured person could resume normal activities. Either the estimated or the actual time was called for. The reasons for asking for an estimated time were not only that the form might be filled in before the person had returned to work, but that in FE establishments the majority of students attend classes one day a week. A student who is injured in an accident will not return until at least a week later. In the meantime, he may have been away from work because of the injury but the lecturer making the report would not normally know about this at the time of filling in the form. Further indication of the severity of the injury was obtained by asking who gave treatment.

Agent

The cause of injury, the agent, is not always clearly stated when a classification system which fails to discriminate rigorously between the agent and the injury is used. In some classification systems burns and scalds are cited as types of accident when they are, in fact, injury descriptions. Injuries that are called burns may be caused by hot objects or substances, electric currents, or acids, alkalis and other corrosive poisons. Cold objects or substances can also denature tissue proteins and hence inflict 'burns'. The American National Standards Institute 'Method of Recording Basic Facts Relating to the Nature and Occurrence of work Injuries' (ANSI, 1962) avoids confusion by the use of categories described as follows :

(i) Contact with temperature extremes (with four sub-divisions covering general heat and cold, and hot and cold objects or substances).

(ii) Contact with electric current.

(iii) Contact with radiations, caustics, toxic and noxious substances (with sub-divisions covering inhalation, ingestion, and absorption).

Unless the type of accident and the nature of injury are mutually exclusive, cross-tabulations of data cannot be made. This applies also to categories under other headings; precise delineation is necessary for analysis to proceed beyond the elementary stage. The annual reports of the Chief Inspector of Factories exhibit the limitations of an unscientific system. Accidents are classified under a system which was revised in 1959 (Parl. Papers, 1959-1960), prior to that date the classifications used were broadly the same as those in the 'simple' system adopted in 1923 by the First International Conference of Labour Statisticians (International Labour Office, 1970). Categories now used (Parl. Papers, 1974a)include 'Machinery in motion under power' (which could be defined as a source of injury), 'Fall on or from ladder' (a type of accident), and 'Handling goods' (an activity). The categories used to be described as 'causes of accidents', now they are described simply as 'accidents'.

My report form was designed to elicit the information necessary to identify the agent from the question 'What directly inflicted the injury?', and the instruction 'Describe how the accident occurred'.

Environment

The environment in which the person and the agent are found was the third and last item to be considered. The environment embraces all the ambient factors surrounding the accident. These may be classified as physical, biological, social or economic. Only a limited amount of information about the environment could be expected to be obtained from the report form. What could be obtained was covered by the question about location of the accident and by the question 'What conditions of machines, apparatus, buildings etc. contributed to, or had a part in, the occurrence of the accident?' It was appreciated that respondents would not always have the specialised knowledge necessary to answer this.

The question 'What did the injured person, or someone else, do or fail to do that contributed to the accident?' could produce information about the person, the agent, or the environment.

Signed forms

Whether the form required a signature was given a great deal of consideration. People are usually more careful about filling in forms of this sort if they have to sign them because they know that they may be asked to give further information if they skimp the task in the first instance. On the other hand, the signature was not really necessary - it would not contribute to the analysis in any way. There was also the possibility that any hazardous condition for which blame might be attributed might be less likely to be revealed if the form was signed. In the matter of attitude to questionnaires, Corey (1937) found that students were about as forthright in their expression on cheating in examinations when questionnaires were signed as when they were not signed. I decided on a compromise: I wished to ask the reporters to put their names to the forms in order to encourage them to give a full account of the accidents but as a full signature was not essential, I asked only for initials.

The Survey

The accident report forms were used in an accident survey which took place over the full session of 1972-73. Establishments approached to take part were further education colleges, polytechnics, colleges of education, and universities, all of them in England and Wales. The FE colleges and polytechnics were selected by taking a 20 per cent sample from the Education Authorities Directory (1972) as described on p. 28. Colleges of education were selected in the same way after those establishments which were not independent from polytechnics and universities had been deleted. Although polytechnics were selected separately it was intended that the results obtained from these establishments should be included with those from FE colleges because it was felt that in view of the recent development of polytechnics from the general FE system their safety problems would be similar to those of FE colleges. As the eventual returns from polytechnics were very small it would not in any case have been worthwhile to consider them separately. The universities that were approached were those that constituted the 50 per cent sample described on p. 32.

Method of approach

When the approach was made, the same letter was sent to FE colleges, polytechnics, and colleges of education. It was addressed by name to the principals of the FE colleges and colleges of education and to the chief administrative officers (bursar, registrar or secretary) of the polytechnics. A reminder was sent to those who did not reply to the initial letter.

A different approach was adopted in the case of universities to ensure that the request for cooperation in the survey reached the right quarter. Firstly, a letter was addressed to the registrar asking him for the name of someone who would be prepared to provide information about

TABLE 10

Establishments involved in the accident survey

	Type			
	FE colleges	Poly-technics	Coll. of Educ.	Univer-sities
Approached	127	6	32	24
Agreed to participate	71	4	14	12
Actually participated	39	3	7	11

safety in the university. All provided a name. The named person was written to and asked if his establishment would be willing to take part in the survey.

Factors affecting the response

In establishments of all types the request was sometimes taken to the safety committee for their consideration before a reply was made. Four universities regretted that they could not complete the form I had prepared but offered to send copies of their own forms. In view of the poor overall response, the offer was accepted. The number of establishments that agreed to take part and the number that actually participated are shown in Table 10.

Of the 56 FE colleges and two polytechnics who did not agree to participate, replies were received from 21 FE colleges and one polytechnic. Three of the replies were from small establishments who said that they did not think that the survey was applicable to them. It was, of course: the intention had been to obtain a representative sample comprising both large and small establishments. Eleven, including the polytechnic, said that they did not have the staff to make the returns, or that pressure of work would prevent participation, or that they were reluctant to impose a further burden on staff. If they had considered what was involved and arranged for my form to be completed at the same time that their own report was made, the additional work would have been spread thinly throughout the staff and throughout the year. Seven said they were not willing to take part without giving a reason. One principal of a large college refused and said 'We get inundated with requests such as yours' - a surprising comment from an educationalist who must himself have students who are able to undertake project work only with the assistance of outside bodies.

Replies were received from 11 of the 18 colleges of education who found themselves unable to contribute to the survey. Three felt that they had little to offer either because of their small size or because most of their accidents happened on the games field. One reply from the senior administrative officer of a college was of special interest. He said '... it is regretted that at the present time we are precluded from entering into any extraneous activities involving time consumption'. Another college mentioned staffing difficulties. Two said they could not help because they had no safety officer. The other four declined without explanation.

Eleven universities explained why they could not take part. Four replies came from university safety officers. One of these wanted a 'more circumspect questionnaire', the others said that they could not cope with the additional work which would be entailed. Two of the other replies were from secretaries of safety committees. One secretary said that his committee had not reached a stage where such a detailed matter could be contemplated, the other said no because he did not think it a feasible proposition to fill in the attitude portion of the form - an answer which showed that he had not examined the form thoroughly. A professor who was chairman of his university's safety committee said 'There is no person who could fill in the kind of form you have submitted except a doctor'. A finance officer said it would involve an additional routine which he was unable to undertake. An assistant buildings officer said that he did not think his university college was in a position to usefully collect information on accidents on a college basis. A radiation protection officer said that radiation protection was his concern. Lastly, a deputy bursar said that he was reluctant to burden his colleagues.

It would be wrong to draw too many conclusions from answers such as were received. They may not have been carefully considered, and the university refusals may not have come from the persons best fitted to speak for the establishments in this matter. However it is clear that in many establishments in both FE and HE sectors, safety is not regarded as a pressing problem. Also, there is evidence of a wide variation in approach to safety.

Contact with participants

With establishments that agreed to participate, efforts were made to keep in touch with the people who sent in reports and to establish a personal relationship with them. On establishments signifying their willingness to send reports, the name of the safety officer or other member of staff to whom correspondence was to be addressed was obtained. A letter of acknowledgment was addressed to this person, another letter was sent later with a supply of report forms and this was followed by a letter of thanks (where appropriate) and encouragement at the end of the first term. A similar letter was sent at the beginning of June, 1973, and correspondents were urged to continue to send reports so that a complete year would be covered.

Consistency of response

By no means all of those who started maintained their participation over the whole of the session. It is difficult to say conclusively how many did because the completeness of cover could not be checked. Some small establishments would only have a few accidents to report, and perhaps none of them would occur in the last month or so. Some idea of the persistence shown is given by the fact that 60 per cent of the FE colleges who started sent in reports for accidents that occurred in March or later. Only one polytechnic made more than a token contribution. There were so few reports from colleges of education that the completeness of cover is extremely conjectural. I think most of them had forgotten about the survey by the time they had an accident to report. Five universities did not send sufficient reports for them to be numbered in double figures. The others, which included two which used their own forms, continued to send reports until a late date in the session, but the number of reports from three of them was considerably below what might have been expected on the basis of returns from comparable establishments.

Establishment A

When the pilot survey was made one FE college (referred to as Establishment A) attempted to report all accidents, no matter how slight, that received treatment. The method that was used involved a duplicate book by each first-aid box. Reports were made in the book, following a pro forma, whenever first-aid was administered, by a lecturer or other member of staff. Another book was used for treatment other than on-the-spot first-aid. The college safety officer* collected copies of the reports each week and obtained what additional information was necessary in order to complete my forms. In the term in which the pilot survey was made 86 reports were completed in this way. The method proved satisfactory except in respect of the part of the form concerned with what was done that contributed to the accident, and what conditions contributed. These were seldom used. This proved to be the case with other reports received in the pilot survey and was not unexpected because, as I have mentioned previously, expert knowledge is necessary for answering such questions.

When the full survey was conducted, I was pleased to accept the safety officer's offer to continue to make reports on all accidents throughout the session under review. This she did in a most conscientious manner: only at the end of the session, when under much pressure due to a shortage of lecturing staff in her department, was she unable to get some parts of the form completed. Only a few forms were affected. I tried to make a similar arrangement to obtain reports on all accidents from another establishment but was unable to do so.

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* I am especially grateful for the assistance given by this lady. Without her help this research would have been a lot less complete. Unfortunately she must remain anonymous to preserve the guarantee of confidentiality given to all establishments that contributed to the survey.

TABLE 11

Accident reports received

	FE colleges and polytechnics		Colleges of Education	Univer-sities
	Est. A	Others		
Total received	197	505	20	411
Used	194	346	13	404
Physical Ed.	3	65	5	7
Incomplete or outside scope	-	94	2	-

Scope of reporting

Some establishments reported accidents occurring in physical education and recreational activities, others apparently did not. Originally it was intended that accidents occurring during such activities should be included but in view of the uncertain response and the comparatively small number of reports received, I decided to confine the analysis of results to domestic and industrial-type accidents. Details of the number of reports received and those used in the analysis are given in Table 11.

Reports described as incomplete or outside scope in Table 11 were those which did not contain sufficient information to warrant their inclusion in an analysis of results, and those which either reported accidents where only first-aid treatment was given or reported incidents which were not accidents. Examples of the latter were: an attempted suicide, a heart attack, and fainting spells.

Final response

The response was not good. Only 30 per cent of FE colleges in the original sample actually participated in the survey and only about 60 per cent of those did so throughout the session. Hence, out of the number asked to take part, only about 20 per cent did so satisfactorily. These were colleges where the safety officer, or some other responsible person, was keen to help. They either instituted a procedure whereby my form was automatically completed along with the internal report, or else they made it part of their job to investigate accidents in the college and then answered my questions as part of their investigation. A procedure which worked well at one college was for the principal's secretary to get my form completed when people brought the draft internal report to her for typing. (The draft report had to be given to her so that she could obtain the principal's signature on the typed copy before it was sent to the education office.)

Colleges of education did not appear to be convinced of the relevance of the survey as it applied to them. This matter needs more consideration and could form the basis for further research.

Universities faced difficulties in persuading people who reported accidents to fill in my forms. The safety officer, or the person fulfilling some of his functions whom I contacted, did not have the authority to insist on this being done. The establishments are so large and diverse that even with cooperation from departments it would not be easy to ensure that the necessary instructions got to all who might be concerned. To convince them that the matter was worthy of their attention would be another problem. In one university, the chairman of the safety committee - a professor - expressed willingness to assist the project. When I sent him a supply of forms, he distributed them to safety liaison officers in each department of the university together with a memorandum explaining the purpose of the forms. The professor asked for the forms to be kept with the university's own forms so that whenever an accident was reported, one of my forms could be filled in and sent to me. I received one!

The poor response generally was a further indication of the low priority given to safety in the establishments.

CHAPTER 8

THE ANALYSIS OF ACCIDENTS AND THE RATING OF ATTRIBUTES

My purpose in obtaining information about accidents was described at the start of Chapter 7. In this chapter the methods used to analyse the accident reports received from establishments are described, together with the extraction of results relating to the attitude and ability of students who were involved in accidents.

Coding classifications

When completed report forms were received they were coded in the boxes provided for the purpose on the right-hand side of the form. The coding was then transferred to punched cards. The pilot survey had provided a means of trying out and modifying the coding and its subsequent analysis. A computer program, to provide cross-tabulations of the data was prepared* and trial runs were made with the data from the pilot survey. On completion of the coding, which had been made as specific as practicable in the first instance, the number of categories was reduced in order to make the tabulations comprehensible. This resulted in some loss of precision but such loss must be accepted in attempts to detect a general pattern in an area containing many diverse factors.

The tables produced by the computer were used principally to identify common factors and patterns of accidents; they represented only one stage in the analysis of reports, which was afterwards carried out by examination of the reports directly. The tables are not reproduced in this work.

Coding was straight-forward for items such as sex, age, and location of accident. For other items either a classification system had to be

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* I am much indebted to my son, Mr. M. R. Sinnott, B.Sc., M.Tech., for his preparation of the initial program and for his help in diagnosing the errors I made in the subsequent development of the program for use in the full survey.

developed or an existing system had to be adapted. Items of special interest, in this connection, are described below.

Course

The first item which required special consideration was the course followed by the student. So many different courses are provided that grouping of courses into areas of study was essential. The classification system used as a basis was the subject code of the Department of Education and Science (1972). Only the main divisions of this code were used, e.g. Health and Welfare subjects, Electrical Engineering, Building, Chemistry, Economics, etc. There are 93 of these; they were reduced to ten for tabulating FE results. No tabulation was made of HE results because of the low number of student accidents reported, nevertheless the classification of subjects appeared to be satisfactory when applied to HE courses.

ANSI method

The ANSI Method of Recording Basic Facts Relating to the Nature and Occurrence of Work Injuries represents what has been described by the International Labour Office (1961) as 'probably the boldest attempt at evolving a statistical scheme providing information adequate for accident prevention purposes'. Ramsey (1973) described how data was accumulated and reported in accordance with the method by numerous groups in the USA. These included the National Safety Council, the Bureau of Labour Statistics, most states, industrial trade associations and many companies. Much of the method stems from Heinrich (1959). It provided the basis of the classification I used for items in the following categories :

Person:	(i)	Nature of injury
	(ii)	Part of body affected
	(iii)	Unsafe Act
Agent:	(iv)	Source of injury
	(v)	Type of accident
Environment:	(vi)	Hazardous condition
	(vii)	Agency of accident (the object, substance, or premises in or about which the hazardous condition existed).

Many of the hundreds of classifications in the ANSI codes were not applicable to the accidents that were reported, and of the remainder, a number of combinations were required in order that comprehensible tables of a reasonable size could be produced. Certain items such as lathes, swarf, and work bench and vice, which the pilot survey had indicated were common sources of injury in FE establishments, I coded separately instead of including them under a more general heading.

Unsafe acts and hazardous conditions

This category may require special explanation. One of Heinrich's theories has led to the inclusion of this in the ANSI method. His theory was that 88 per cent of all accidents result primarily from unsafe acts, 10 per cent from unsafe conditions, and 2 per cent from acts of God. This has often been quoted, usually with slightly amended percentages. As Atherley (1975) has pointed out, the best-documented empirical study so far published is that by the H.M. Factory Inspectorate of a 0.5 per cent random sample of accidents notified to them during the period 1 July to 31 December, 1968 (Department of Employment, 1973). Of 621 accidents that were analysed, in 43 per cent reasonably practical precautions wholly or mainly under the control of workpeople were available but not taken. These were broadly what Heinrich, and the ANSI method, classify as unsafe acts; they include refraining from wearing protective clothing when it is available, not conforming to a safe method of work, and so on.

De Reamer (1958) has pointed out that the percentage of accidents triggered by either an unsafe act, or an unsafe condition will vary considerably according to the type of work and the conditions under which it is performed. He has described how unsafe conditions have trapped persons into performing the so-called unsafe acts.

Whereas the unsafe act classification in the ANSI method represents the personal cause of the accident, the hazardous condition classification represents the physical or environmental cause. It is made clear by ANSI that their classification procedures are not designed to establish primary causes of accidents in terms of unsafe acts or hazardous conditions and that for recording purposes, these classifications are to be assigned without reference to their relative importance in the accident sequence. The object is to obtain factual statistics, not personal opinions, so that interpretation of summaries can be made on compatible data compiled by different persons. One difficulty in attaining this object is the reluctance of persons to report facts which implicate themselves unfavourably. Shaver and Carroll (1970) conducted experiments in which they found that avoidance of blame for an accident appeared to be more important to observers than avoidance of the occurrence.

Another difficulty is that a hazardous condition may be created by an unsafe act; however, strict adherence to the ANSI definitions should remove difficulties of interpretation of the classification. In general, decisions or supervisory actions of management representatives are not regarded as unsafe acts: the hazards created by such actions are hazardous conditions. The selected unsafe act is intended to be closely associated in terms of time with the occurrence of the accident, if the management have had time to recognise and correct a hazard then the act which created the hazard is not regarded as the unsafe act of the accident.

Activities classification

To code the activities on which persons had been engaged when the accidents happened, a classification system had to be devised. Seven main divisions were used: these were (i) machine work, (ii) benchwork and other hand-work, (iii) laboratory work, (iv) catering, (v) handling, (vi) cleaning, (vii) perambulation. In addition, a category for activities which did not fall into any of these divisions was found to be necessary. Machine work was sub-divided into: machining workpiece or otherwise operating machine; and other operations on machine, e.g. adjusting, cleaning. In the next stage of classification, the machine itself was named, e.g. lathe, drill. Benchwork and general hand-work was sub-divided into operations such as filing, using wood chisel, sawing, cutting with knife. Laboratory work had sub-divisions, e.g. heating substances, inserting glass tubing into bung (or removing bung). Catering was divided into, frying, cutting up ingredients, and other activities. Sub-divisions of handling were, lifting or moving objects, loading or unloading. Cleaning meant cleaning the rooms and other parts of the building, and was not sub-divided. Perambulation had three sub-divisions: moving around room, moving around building, moving around outside building. In the final tabulation of results, certain classifications which had not been much used were combined so that the general pattern could be seen. The number of classifications used in the table was 24. This included the all-embracing 'activity not elsewhere classified', but it was only necessary to use this for 6 per cent of the total. These operations of classifying, coding, and tabulating were successful in that they showed that it was possible to categorise the multifarious activities in a manner which (as will be shown) is of use for safety purposes.

Tabulation and analysis

My next step here is to describe in more detail certain of the more critical areas of my study. I describe the results of the tabulation and cross-tabulation of data which followed the process of coding, and I assess the value of the procedures as a method of analysing the accident reports.

The areas first examined were those where the ANSI categories were used with the exception of unsafe act, hazardous condition, and agency of accident. Additionally, the 'activity' (what the person was doing at the time of the accident) was considered. The three ANSI categories were omitted because they were not sufficiently well reported to be of value in a general way. Only 23 per cent of reports contained an answer to one or both of the questions about what someone did and what were the conditions that played a part in the accident; the questions were, however, useful in revealing something about individual accidents, and also about the reporter of the accident: they will be considered later.

Activities

In isolating reliable statistical information to be of value in accident prevention and in safety training, I feel that the identification of the activity is the most useful. It was because the persons had been performing a particular activity that the accident happened; the form the accident took and its consequence are secondary matters. As I mentioned previously, it is particularly important that those who teach 'activities' should know whether accidents are occurring as a result of what they teach. Consideration can then be given to the question whether or not they are teaching correctly. In this connection the FE reports were of prime importance for two reasons: firstly, because unlike the HE reports they mostly concern accidents to students, and secondly, because there is more teaching of practical activities in FE than in HE.

The report form asked '*Exactly* what activity was the injured person engaged in at the time of the accident?' Some reports gave far from exact descriptions, one said simply 'Working on a job'. Often further details could be culled from the remainder of the form, but much of the exactness had to be forsaken anyway when the data were tabulated. However, even the identification of main areas of activity is valuable. For example, tabulation of the reports revealed that in machine work nearly as many accidents occurred in operations other than machining as occurred in machining. The analysis also showed that 17 per cent of the reported accidents occurred in an activity where the quality of teaching was not directly involved, that was, in the movement of people in and around the rooms and buildings of the establishments.

An *exactly* described activity which reflected directly on what had been taught was 'Inserting glass tubing into bung'. In activities classified as laboratory work, nearly 18 per cent of the FE accidents reported occurred when this operation was being carried out. Another example, less exactly described, but valuable perhaps in indicating a need for the teaching of an improved technique was 'filing'. This was found to be responsible for about 13 per cent of the accidents reported by Establishment A (this establishment reported all accidents).

Activity - type of accident

The cross-tabulation of the activity classification with the type of accident classification enabled the circumstances of the accidents to be discerned relatively clearly. For instance, with the FE data cross-tabulation showed that although almost all persons who had accidents while using wood chisels injured themselves with the tool, almost all those who were injured while filing struck themselves against stationary objects (usually the workpiece or the vice). With both FE and HE data the cross-tabulation showed that nearly half of the persons injured while they were moving around the building were injured by falling on stairs. While lifting or moving objects, more persons were injured by falling objects than by over-exertion (32 per cent and 20 per cent respectively of the total). The highest single cause of laboratory work injuries was contact with caustics, toxic, and noxious substances. These examples show how cross-tabulation of accident data can point out areas where further investigation might be undertaken to see whether safety can be improved.

Activity - nature of injury

A cross-tabulation of activity with nature of injury proved less illuminating. Knowledge of the injury inflicted did not add anything of value in accident prevention to what the previously described cross-tabulation had shown, and by itself the activity/injury cross-tabulation would not have revealed as much. The reason why was that nature of injury was almost inevitably determined by the type of accident which, in turn, was closely determined by the particular activity. For example, cuts resulted from 'cutting with knife' and from 'sawing'; burns resulted from 'soldering and welding', and from 'cooking'. It is true that the type of accident is also almost predictable from the activity, for example, 'cutting with knife' results in the person being 'struck by hand tool'.

But there were cases where knowing what type of accident actually resulted provided useful information. For example, knowledge that persons fell on stairs when moving about the buildings was more useful than knowing whether the injury they suffered was a bruise or a fracture. This is not to say that the activity/injury analysis may not in some circumstances reveal a need for remedial measures. One might instance, as example, 'welding' resulting in a high proportion of cuts. This would perhaps suggest that the nature of the material being welded required the wearing of gloves. On balance, however, knowledge of activity/injury seems relatively unimportant for my study.

Nature of injury - source of injury

It proved fruitful to consider the nature of the injury with the source of injury. This cross-classification revealed specific objects and materials which caused injuries. It provided information of value for secondary safety precautions, information, that is, which is helpful in ameliorating injury, rather than in preventing accidents.

We have seen that a large proportion of the reported accidents occurred when people were moving about buildings so, naturally, parts of buildings figured high as sources of injury. Floors, and steps and stairs caused many injuries and indicated a need for ensuring that they do not exacerbate injuries through faulty design.

Knives and metal sheet figured prominently among sources of injury in the nature/source-of-injury analysis. Knives inflicted more injuries than any other hand tool, but unlike other tools, they are used casually for purposes such as sharpening pencils, and cutting string. This casual use added to the number of injuries that were reported. Even so, in FE the great majority occurred when students were under instruction. The activity/accident-type analysis had split accidents involving knives into more than one category. For example, carving came under catering; and cutting with knife came under benchwork and general hand-work. Focussing attention on the injury, in this case, highlighted an area where safety could be bettered. It is probable that many lecturers do not appreciate that this is, in fact, necessary. During the pilot survey I received reports on three girl students, all of whom had cut themselves in the same class while lino-cutting. In each case the lecturer who made the reports attributed the accident to carelessness on the part of the student. Further attention will be given to knife accidents, and carelessness, when accidents in the different types of establishments are considered (see p. 117).

Cuts from metal sheets showed the need, for instance, for the wearing of gloves when students handle sharp-edged metal.

Nature of injury - part of body affected

Fuller details of the injuries were obtained by cross-tabulating the nature of injury classification and the part of body classification. That this showed 40 per cent of cut fingers in the FE data caused no surprise. The fact that 9 per cent of injuries were to the eye was more startling and immediately drew attention to the value of this form of analysis. It gives an indication of the seriousness of the injuries and indicates areas in which personal protective equipment could be more used. Eye injuries are not only potentially very serious but are often preventable by protective equipment. This also will be further examined when accidents in different types of establishment are considered.

Nature or source of injury - type of accident

Other cross-tabulations that I carried out were nature of injury with type of accident and source of injury with type of accident. The first of these at its best cannot yield more than a broad pattern of how injuries are inflicted; with the data I had, it added nothing of value to the analyses already made. The second, the source-of-injury/accident-type analysis, indicated the way in which the injured persons came into contact with the injury-producing objects or substances. It can show the kind of event which must be prevented when certain objects or substances are being used. This would appear to be useful in certain industrial situations; the ANSI describe it as a very significant and informative cross-tabulation but I did not find this to be so when applied to my data. The data were diverse and the analysis yielded nothing of value beyond that which I had already uncovered. The source-of-injury/accident-type analysis would only be useful, I think, when a considerable quantity of data was available and when the activities which resulted in accidents had not been closely examined.

The Causes of Accidents

In the analyses described in this chapter the emphasis has been on the circumstances of the accidents and little consideration has been given to causal factors. The reason for this is that I did not attempt the identification of causal factors, except for asking what was done that contributed to the accident and what conditions contributed to the accident. I have mentioned that relatively few answers were given to these questions. The pilot survey had shown that this was likely to be the case. It would not have been practicable to have attempted to obtain answers to additional questions - assuming that previous research had indicated what I should ask for.

Cause is a very difficult concept in relation to accidents, it has different meanings in different contexts and is seen differently from different viewpoints. It is, however, now generally accepted that an accident is not caused by a single factor but by a number of interrelated factors. Attempts to link together in a conceptual framework factors that contribute to an accident reflect the different orientations of the constructors of the various framework; Jones, 1929; Hale and Hale, 1970; Lawrence, 1974; Surry, 1971; Wigglesworth, 1972, have all developed their own theoretical models. Lawrence applied his to an analysis of human error in gold mining accidents and concluded that it gave fresh insight into the accidents with implications for training in the perception of dangers. The expert knowledge he required in accident reports and the amount of work required to fit the reports to the model showed up some of the practical difficulties that have to be faced when attempting to apply such models to the study of data gathered after an accident. If in the future they are shown to be of direct application to accident prevention it will probably be in their predictive use.

The British Steel Corporation (Anon, 1972), has attempted to classify the causes of accidents under 35 headings - seven of them relating to individual behaviour, the remaining 28 to management controls. When they used this analysis, 33 per cent of accident causes were found to come under the heading of 'Personal errors of judgment'. Such a classification would be unsuitable for application to a student who is learning a skill or process. This would be especially so if other British Steel Corporation classifications of personal qualities such as 'Lack of skill', 'Lack of experience in present occupation', 'Refusal to obey instructions or rules', were used. Even in industry the exactness with which a distinction can be made between these classifications and an error of judgment is questionable.

An industrial system which was used in an educational establishment has been described by Steere (1973). It was called Basic Cause Analysis and was used originally by the Consumers Power Company in Michigan, USA. There were ten classifications of 'basic causes' in the system. Multiple causes could be reported. When more than one cause was felt to apply, the contributing causes were listed in order of importance.

When the system was used at Michigan State University it was found that the supervisors who were responsible for making reports very frequently cited as a basic cause of the accidents a classification which came under the heading, in the system, of Knowledge or Mental Attitude. Causes under this heading implied a lack of knowledge or failure to apply it properly, or the wrong mental attitude. On the other hand, the supervisors very seldom cited statements that came under the headings of Failure of Person in Charge to Give Adequate Instructions or Inspection, or Failure of Person in Charge to Properly Plan or Conduct the Activity. One would hardly have expected it to be otherwise because it is a normal tendency to blame others. This highlights an inherent weakness in any system where reports are not based on an independent investigation.

The ANSI method does not include classifications such as 'lack of skill' or 'error in judgment', which were often given as the cause of accident in the reports I received; it concentrates on more objective descriptions such as 'taking wrong hold of objects' and 'feeding or supplying too rapidly'. 'Cleaning, oiling, adjusting, etc. of moving machinery' was quite often recognised as the cause of the accidents reported in the survey; as indeed it has been since machinery has been used. Carelessness was often mentioned but this is too vague to mean anything; in any future survey it would probably be necessary to instruct reporters to define the way in which the person was careless. One lecturer who returned a report to me was apparently under the impression that all accidents were acts of God: she gave no cause but wrote "It was an accident!'

Attitude and Ability of Students

Rating scales

The grading of students' attitude and ability in the class in which the accident occurred was a process rather different from the completion of the remainder of the report; it was therefore given special consideration in analysis.

Rating scales of the type used suffer from the following well-known faults.

(i) The error of central tendency. Raters hesitate to give extreme judgments. This is said to be perhaps more common in rating individuals whom the rater does not know well (Guilford, 1954). If this is so, it would not be pronounced in our reports. Generally the lecturers could be expected to know their students very well. If they did not, most would not attempt a rating - several uncompleted forms bore a note to the effect that the accident had occurred close to the beginning of the session, or something similar, and therefore a report could not be given.

(ii) The error of leniency. When the rater is ego-involved, he is especially likely to rate higher than he should. This certainly applies when a lecturer reports on his students.

(iii) The halo effect. This was named by Thorndike (1920); it is the tendency to rate an individual in the same way whether the characteristics in question tend to go together or not. We might assume that although it had some influence on the lecturers the effect would not be very great for the reason that the lecturers would be experienced in observing traits in students.

In addition to these errors, the descriptive labels placed on the scales as reference points could be expected to have influenced the raters and have biased the results. Moreover, although the report form asked for a rating of the particular student's attitude and ability 'in this class' the lecturers could be expected to have based their judgment on a standard they considered to be desirable rather than in comparison with the standard of other students in the class, as the scale implied.

To determine the extent of the 'built-in' bias of the scales, a test was made at one FE college. Lecturers were asked to report on the first three students on the register present in their next class. The pro forma for the reports was the same as that used on the accident reports (see Appendix 4). One hundred and three lecturers reported on different students. I found that there was a distinct shift of the distribution of results towards the 'good' end of the scales in the rating of students on courses requiring a higher academic standard of entry as compared with the rating of students on craft courses.

This demonstrated the need for reports on students who had suffered accidents to be matched with reports on other students taking comparable courses. In a control sample obtained in this way, the errors and biases of the grading scales could be assumed to act in the same way as in the accident sample and a direct comparison between the two samples could be made. Accordingly, a control sample was obtained. It was arbitrarily decided that reports from 100 lecturers would be sufficient. As, using the system previously described, this gave 300 reports, and because virtually 400 reports on students suffering accidents had been obtained, every four reports from the accident sample were matched by three reports from the control sample.

The criteria for matching the reports were as follows :

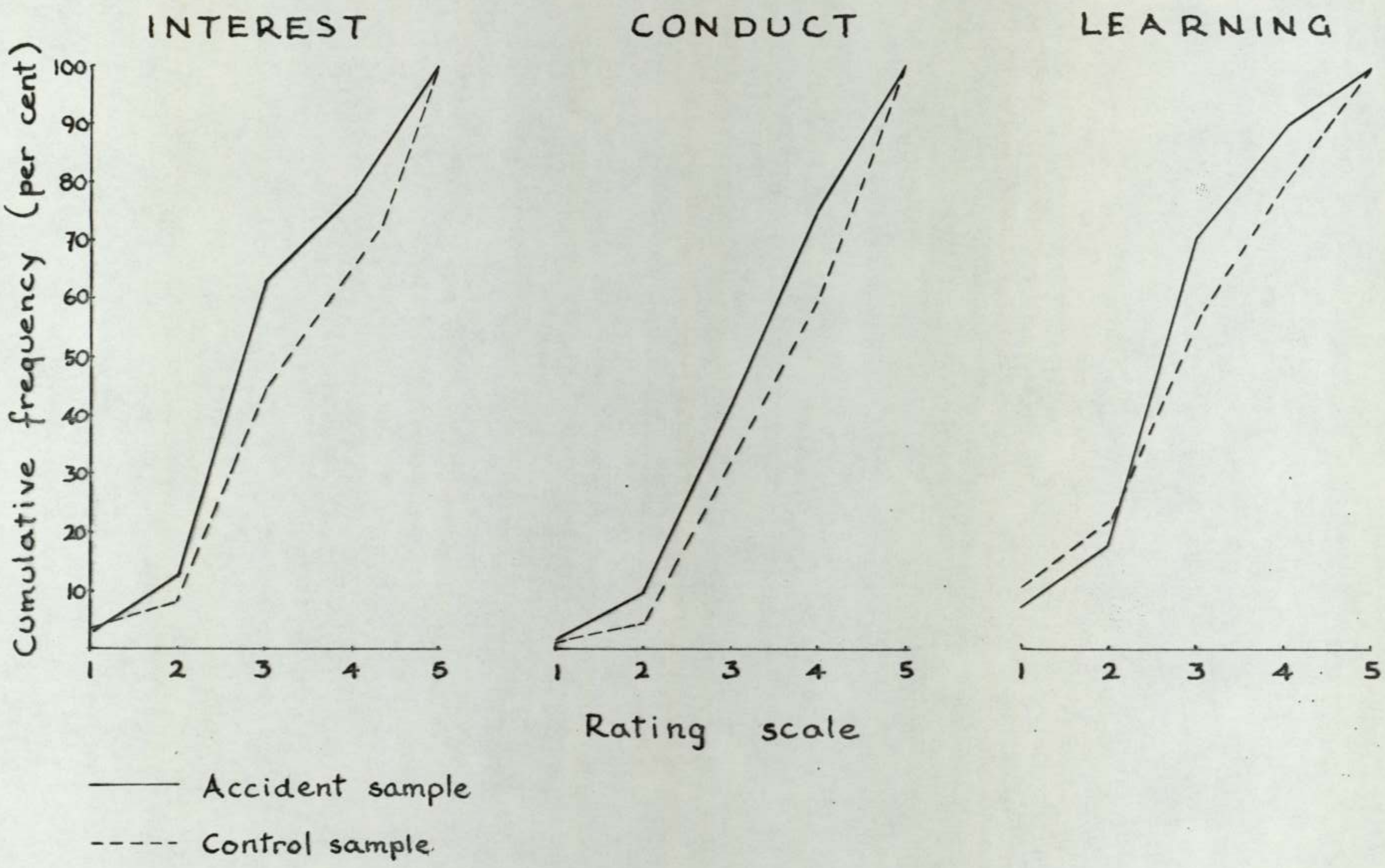
(i) Broad area of study, e.g. technology, science, catering, business studies.

(ii) Type of course, e.g. school-linked, craft, technician, national certificate.

(iii) Stage of course, e.g. 1st year, 2nd year.

Of the reports obtained from the 103 lecturers at one college as described above, 70 sets of three reports each were matched with the accident sample. The additional 30 sets required to make 100 in all were obtained from six other colleges. These colleges were asked to supply

FIGURE 1


INTEREST
CONDUCT
LEARNING
Cumulative frequency (per cent)
100
90
80
70
60
50
40
30
20
10
1
2
3
4
5
Rating scale
Accident sample
Control sample

reports on students in specific courses as necessary to complete the control sample. The same system was used as on the previous occasion to ensure that the lecturers' choice of student was unbiased.

Results

The percentaged results of the two samples are compared by means of cumulative frequency polygons in Figure 1. These show that the overall distribution of results from the accident sample is nearer the lower end of the scale than the distribution of the control sample. For Interest there are 19.5 per cent more students with scores of 3 or less in the accident sample compared with the control sample. For Conduct the corresponding difference between accident sample and control sample is just under 9 per cent. When values for scores of 4 or less for Conduct are compared the difference is seen to be 16 per cent. For Learning the greatest difference is with scores of 3 or less, where it is 15 per cent.

Testing the null hypothesis that there was no significant difference between the two samples by means of the chi-square test gave the results shown in Table 12. As the value of χ^2 was significant beyond the 0.001 level in all three cases the null hypothesis can be rejected at $\alpha = 0.001$.

Thus I found that students who suffer accidents are more likely than students as a whole to be rated by their lecturers as having less learning ability, to be less interested, and less well behaved. The question that then arose was whether the lecturers had shown a tendency to downrate students just because of the accident. Apart from the fact that the lecturers would not be pleased about having to make out a report, they would be unhappy about the accident and might think it reflected on their ability as teachers.

Whether this speculation had any basis in fact might have been tested had it been possible to obtain reports from lecturers who did not know whether or not the students concerned had had accidents. Unfortunately, the only lecturer who could report on the student's attitude and ability

TABLE 12

Significance of differences between accident sample and control sample in the rating of attributes

Attribute	χ^2	df	p
Interest	33.71	4	0.001
Conduct	21.12	4	0.001
Learning	28.82	4	0.001

in the class where the accident occurred was the one that had done so - the class lecturer.

Alternatively, whether bias had been shown in the ratings could have been determined if it had been known how attribution of responsibility for an accident is affected by the teacher and pupil relationship. In a review of the research on the attribution of responsibility for an accident by people in general, Vidmar and Crinklaw, 1974, point out that judgments of responsibility are the result of a rather complex process. People may have rules for judging responsibility based on a complex formula weighting such factors as the outcome of the behaviour, the foreseeability of the outcome, the contribution of environmental factors, and the extent to which the victim has already been compensated or deserved to suffer. All these factors, as well as the responsibility of the lecturer for what goes on in his class, no doubt influenced the ratings awarded by the lecturers.

In any event, the results gave no support to Macomber's supposition (see p. 59) that accidents were most likely to occur with the capable inquisitive student.

CHAPTER 9

ACCIDENTS IN AN ESTABLISHMENT FOR FURTHER EDUCATION

Establishment A - the FE college that reported accidents without restriction on their severity - was a local college in an industrial area. The full-time lecturing staff numbered 142 in the year of the accident survey; approximately 20 per cent of the lecturers were in the construction department and 20 per cent were in the engineering department. Most of the practical classes in the college were provided by these two departments. Each department had part-time day release courses for school-linked students, for craft students (four year courses), and for Part I technicians and ONC students. In addition, the engineering department provided an O-level course and a basic training craft course on a full-time basis. Both departments also had full-time pre-apprenticeship courses. In other departments a number of practical classes were held in chemistry, physics, biology, cookery, needlecraft, and hairdressing. A few classes were held in drawing and painting, pottery, soft furnishing, art metalwork and other non-vocational subjects.

Accidents reported by Establishment A numbered 194. Of these 177 were to students and 17 to staff. The pattern of accidents to students is shown in Table 13. As 90 per cent of these accidents occurred in engineering and building areas of study, it followed that nearly all the accidents involved male rather than female students.

Age of students

The survey took place in the last year that the statutory school-leaving age allowed the enrolment of students for further education at the age of 15+. Younger students attended on school-linked courses only. Whether the liability of a student to have an accident varied with his age could not be determined. This would have required consideration of such factors as the period of exposure to risk, the type of work undertaken, and the quality of teaching. Relevant information about these factors

TABLE 13

Analysis of 177 student-accidents occurring in one session in one establishment

PERSON

Sex

Male	Female
168	9

Age

14	15	16	17	18	19+	Not Spec
18	34	44	38	19	18	6

Area of study

Mech/Prod Engineering	Building	Other	
111	48	13	5

Activity

Lathe wk	Other m/c	Filing	Bench & Gen. hand wk	Cook	Hdlg	Peramb	Other	
31	13	25	73	5	11	10	6	3

Nature of injury

Burn (heat)	Cut	Irritation (Eye)	Bruise	Other	
17	128	12	8	9	4

Part of body affected

Finger	Hand	Eye	Other	
127	13	16	18	3

Treatment given

Hospital	Staff	First-aider	
10	152	7	8

Time (Hours) before activities resumed

up to 0·5	0·5–3	Over 24	
157	7	3	10

AGENT

Source of injury

Machines	Hand tools	Metal items	Building	Other	
33	42	63	8	34	7

Type of accident

Sk again stationary obj	Sk. by	Sk by hd tool	Obj hd	Hot obj	Other	
69	19	35	19	15	20	4

ENVIRONMENT

Location

Workshop/room, kitchen	Other	
169	6	2

Staff/Stu. ratio

6 or less	7	8	9	10	11	12	13	14	15	16	17	18+	
20	6	9	12	6	22	5		28	4	8	3		41

Abbreviations Cook = Cooking, Hdlg = Handling, Peramb = Perambulation
Sk = Struck, Sk by = Struck by falling or flying object
Obj Hd = Injured by object handled, Hot obj = Contact with ~

was not available to me. However, the information I did obtain about the age of students was useful in building up the picture of accidents in the establishment.

Activity

Most accidents occurred when students were engaged on benchwork of some kind or on hand-work generally such as cutting with a knife, sawing, or soldering or welding. As a high proportion occurred when the person was filing, the number of accidents of this sort is shown separately. Filing led to injury when the file slipped and the person struck his hand on the workpiece, or the vice, or the bench. Such accidents show a need for special precautions to be employed while skill is being acquired. A possible solution in the case of filing is a guard fitted to the handle of the file. Other tools might be modified in different ways.

More precise descriptions of the activities in which persons were engaged when accidents involving lathes occurred are given in Table 14. This shows that 13 out of 30 accidents happened when operations other than machining were being carried out. With other machines as shown in Table 15 only two out of 12 accidents occurred while machining was in progress. Thus, taking machine work as a whole, close to 65 per cent of accidents occurred while the person was setting up, adjusting, or cleaning the machine rather than engaged actually in operating the machine.

Injuries

When the nature of the injury and the part of body affected are considered, Table 13 shows that the most common injury, by far, was a cut finger. Mostly this was of slight severity and was treated on the spot by the member of staff present. Potentially the most serious common injuries were those to eyes. They ranked next to finger injuries in the number reported. An analysis of eye injuries is shown in Table 16. An indication of the degree of severity with which they were regarded is given

TABLE 14

Analysis of 31 lathe accidents to students in one establishment

<table>
<tr><th colspan="2">Activity</th><th colspan="2">Agent of injury</th></tr>
<tr><td rowspan="4">Machining</td><td rowspan="4">17</td><td>Struck by flying swarf</td><td>7</td></tr>
<tr><td>Contact with hot tool</td><td>1</td></tr>
<tr><td>Struck by falling workpiece</td><td>1</td></tr>
<tr><td rowspan="2">Struck against machine, tool bit, or workpiece</td><td rowspan="2">18</td></tr>
<tr><td rowspan="2">Setting up or adjusting</td><td rowspan="2">11</td></tr>
<tr><td>Struck by falling chuck</td><td>1</td></tr>
<tr><td rowspan="2">Cleaning machines</td><td rowspan="2">2</td><td>Struck against swarf</td><td>1</td></tr>
<tr><td rowspan="2">Struck against machine, tool bit, or workpiece</td><td rowspan="2">2</td></tr>
<tr><td>Unspecified</td><td>1</td></tr>
</table>

TABLE 15

Analysis of 13 machine accidents to students
in one establishment

<table>
<tr><th colspan="2">Machine</th><th colspan="2">Activity</th><th colspan="2">Agent of injury</th></tr>
<tr><td rowspan="4">Drill</td><td rowspan="4">5</td><td>Machining</td><td>1</td><td rowspan="2">Struck against machine, tool bit, or workpiece</td><td rowspan="2">2</td></tr>
<tr><td rowspan="2">Setting up or adjusting</td><td rowspan="2">3</td></tr>
<tr><td>Caught between machine parts</td><td>2</td></tr>
<tr><td>Cleaning</td><td>1</td><td rowspan="2">Struck against swarf</td><td rowspan="2">2</td></tr>
<tr><td rowspan="2">Unspecified</td><td rowspan="2">2</td><td>Unspecified</td><td>1</td></tr>
<tr><td rowspan="5">Setting up or adjusting</td><td rowspan="5">6</td><td rowspan="6">Struck against machine, cutter or workpiece</td><td rowspan="6">7</td></tr>
<tr><td>Miller</td><td>2</td></tr>
<tr><td>Spindle (wood)</td><td>1</td></tr>
<tr><td>Saw (metal)</td><td>1</td></tr>
<tr><td>Tenoner</td><td>1</td></tr>
<tr><td>Shaper</td><td>1</td><td>Machining</td><td>1</td></tr>
</table>

in the column showing who gave treatment. This is related in the figure to the activity and source of injury shown in the other columns. From these the lack of effective precautions when an activity carrying an obvious risk of eye injury was being carried out is apparent. Machining, welding, soldering, and demolition are such activities.

One of the eye injuries happened when a student was turning brass in a lathe. If the accident had occurred in an establishment covered by the Factories Act it would have revealed a breach of the then current, as well as the present, Protection of Eyes Regulations (Statutory Instruments, 1974). The Regulations in force at the time when the accident occurred specifically required eye protection to be provided when brass was turned dry on a lathe. No mention of eye protection was made in the report of this accident. In another report where the accident described was similar, but where the kind of metal was unspecified, a remark was made that the student had discarded goggles of poor quality. No other mention of personal eye protection was made in any other of the reports on lathe accidents involving injuries to the eyes.

The welding accident named in Table 16 occurred when a student was welding lead sheet (lead-burning). In this case the report stated that he had removed his goggles. Two of the soldering accidents happened in engineering workshops, and the third occurred in a plumbing workshop when a student was wiping a soldered joint. The splashes that caused the eye injuries were brought about by inexperience and this emphasises the particular need for protection when new processes and skills are being learnt.

An activity that needs another form of personal protective equipment - gloves - is the handling of sheet metal. There were eleven injuries caused by sheet metal, eight occurred when the student was working with the metal and gloves would have been a hindrance, the other three occurred when the student was carrying a sheet and should have had gloves to protect his hands.

TABLE 16

Analysis of 16 eye injuries to students at one establishment

<table>
<tr><th>Activity of injured person</th><th>Source of injury</th><th>Treatment by -</th></tr>
<tr><td rowspan="2">Machining on Lathe 7</td><td rowspan="6">Metal particle 11</td><td>Staff 6</td></tr>
<tr><td>Unspecified 1</td></tr>
<tr><td>Filing 1</td><td>Staff 1</td></tr>
<tr><td>Welding 1</td><td rowspan="2">Hospital 2</td></tr>
<tr><td rowspan="3">Soldering 3</td></tr>
<tr><td>Staff 1</td></tr>
<tr><td>Flux 1</td><td rowspan="2">First-aider 2</td></tr>
<tr><td>Perambulation 1</td><td>Door 1</td></tr>
<tr><td>Demolition 1</td><td>Brick particle 1</td><td>Staff 1</td></tr>
<tr><td>Cutting brick 1</td><td>Brick particle 1</td><td>Hospital 1</td></tr>
<tr><td>Hairdressing 1</td><td>Hair lotion 1</td><td>Hospital 1</td></tr>
</table>

In addition to the four eye injuries shown in Table 16 as having been treated in hospital, there were six other cases that received hospital treatment. Two of the injuries were fractures, one of them a broken finger, the other a severe complicated fracture of an elbow. Both happened during a break-time and both to 16-year old students. One of the students was walking on the top of a wall, for the want of something better to do, and fell off causing the injury to his elbow. The other fell when running out of a workshop - probably in an attempt to be first in the queue at the refectory.

Of the remaining four treated in hospital, one cut his hand while setting up a machine (unspecified), without knowing how he did it. Another cut his finger when his workpiece came out of a lathe chuck and fell on his hand. The report on this accident stated that the student did not follow instructions. This point was not made, however, in connection with a hospital-treated accident which occurred as the result of an unsafe procedure in the use of the centre lathe. A student offered up a loose part to the workpiece fixed in the chuck, while he did this with one hand he kept his other hand on the clutch lever; the clutch engaged and he cut the hand holding the part on the tool bit. The last of the ten students treated in hospital cut his finger when the knife slipped as he was stripping a wire: whether wire-strippers were available was not reported.

The three students who were not able to resume normal activities within 24 hours, see Table 13, were all amongst those treated in hospital. They were the two who suffered fractures and the one who inadvertently engaged the chuck on the lathe.

Agent

Examination in detail of the items given under the heading of Agent in Table 13 revealed no information likely to be of value in accident prevention, beyond what has already been extracted and described.

A cross-tabulation of source of injury and type of accident is used when compiling accident statistics to indicate how injured persons came into contact with injury-producing objects or substances. Under certain circumstances events which should be prevented are revealed and objects or substances which need control are identified. A detailed cross-tabulation of the data relating to accidents at Establishment A was made but this gave no new knowledge of any consequence.

Environment

Particulars of the environment given in Table 13 show that in this establishment very few accidents occurred outside workshops, workrooms, or kitchens.

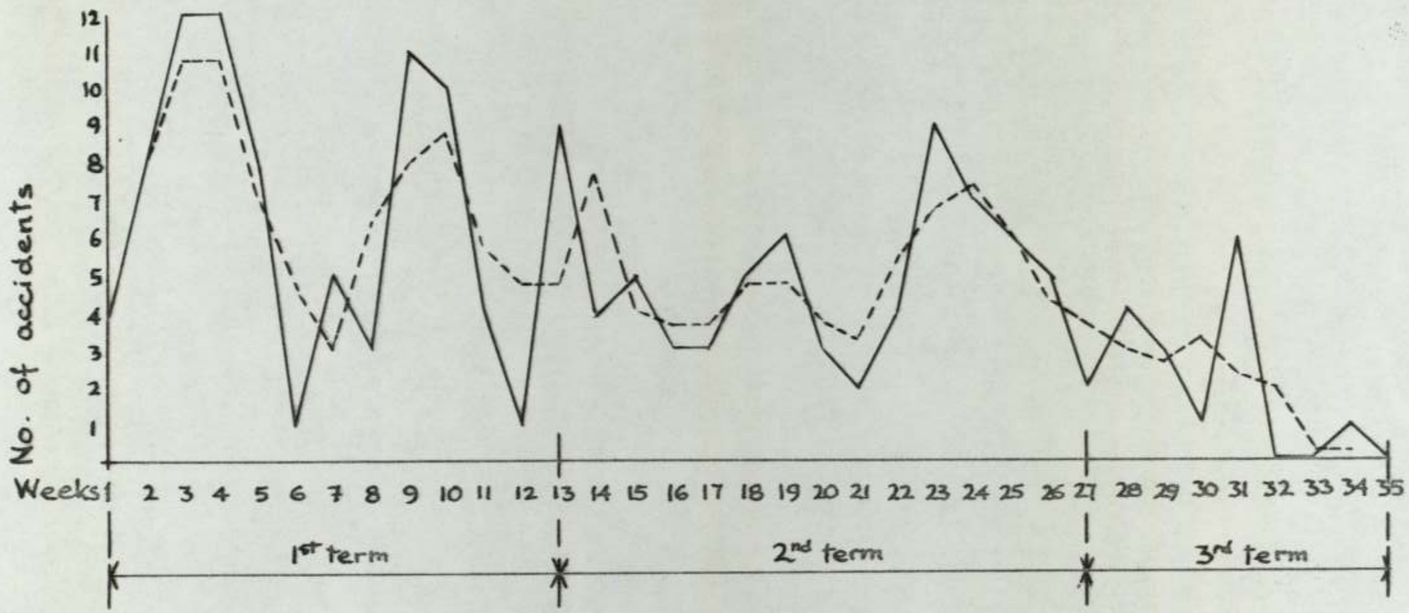
Staff/student ratio

The staff/student ratios which were obtained were of limited value because the ratio for all groups at risk was not known. However, there is no indication from the breakdown in Table 13 that a low staff/student ratio made an appreciable difference to the accident rate.

There were two examples of repetitive accidents where a high ratio of students to staff may have had an influence. In one, a student was injured while reaching over a lathe; 25 minutes later another student was injured in the same way. In the other example, three students each cut a thumb or finger when using a handsaw, within a few minutes of each other. The lathe accident happened in a second-year class with a staff/student ratio of 1:14, the handsaw accidents happened in a first-year class with a staff/student ratio of 1:17. In each of these classes the number of students was about the most one lecturer could be expected to handle. Nevertheless, the repetition of the accidents makes suspect the emphasis on safe working procedures that was especially necessary under the circumstances.

FIGURE 2

Incidence of 168 accidents to students in one session
(only full working weeks included)



Key: Reported accidents ——— 3-week moving average - - - - - -

Causal factors

Very little other information about conditions or about unsafe acts was given beyond what has already been mentioned. There were, however, two remarks made about wrong-sized spanners being used. Also three reports contained statements that students were 'fooling about' when the accident happened. Two remarks concerning physical conditions were made, one that the conditions were crowded, and the other that there was oil on the floor. Aside from these points there was little to indicate the cause of the accidents, and the relevant part of the report form was usually left blank.

Time distribution

The time series of 168 student-accidents that occurred during the normal college session is illustrated in Figure 2. So that a valid week-by-week comparison could be made, weeks split by holidays were omitted from the series.

A three-week moving average was used to smooth out fluctuations in the incidence of the reported accidents. This showed that a peak was reached about one month after the start of the session. In the first week or so practical work would have been getting under way; by the third or fourth week it would have been well in hand. The weekly number of accidents reported thereafter showed a general decline and tapered off sharply as practical work was brought to a close towards the end of the session.

In the Pennsylvania study (Ade, 1938) which was described in Chapter 7, it was found that the accident rate increased as the year progressed and this was attributed to the placing of greater stress on safety at the beginning of the year than at other times. The time series provides no evidence that this was so in Establishment A.

TABLE 17

Number of accidents in first term and subsequent terms, in one establishment, to first-year and post-first-year students

Activity	Students: 1st-year, 1st term	Students: 1st-year, Later terms	Students: Post-1st-year, 1st term	Students: Post-1st-year, Later terms	χ^2	Level of significance for one-tail test (df = 1)
Machine work	12	11	6	13	1.06	$\alpha = 0.15$
Hand-work	42	28	9	16	3.36	$0.025 \leq \alpha \leq 0.0$
Other work	11	3	7	3	-	-
Total	65	42	22	32	5.01	$0.01 \leq \alpha \leq 0.025$
Perambulation	5	1	1	1		

Experience

To see whether new students were more, or less, likely to have accidents than more advanced students, a comparison was made between accidents to first-year students and accidents to post first-year students that occurred in (i) the first term of the session and (ii) the subsequent (later) terms of the session. This way of investigating the effect of students' advancement in studies allowed for any slackening off of reporting that might have taken place as the session progressed. It assumed that if this had occurred, reports on both first-year and other students would have been proportionally affected. A significant reduction during the session in the accident rate of first-year students, compared with other students, was revealed. This was broken down as shown in Table 17.

In considering the figures shown in Table 17, it must be remembered that the term-periods are not equal, hence although post-first-year students had more accidents in the second period than in the first term, this does not mean that the accident rate was greater. The second and third term figures were combined because of the unequal length of the terms. It would have been possible to have ignored the third term but this would not have made full use of the available data. Alternatively, it would have been possible to have divided the session into two parts of equal length but this would not have taken account of the Christmas break and the effect of the fresh start made in the new year.

The category of Hand-work in the Table included the activities which were described as Filing, and Bench and General Hand-work in Table 13; other work covered the activities that had been described as Cookery, Handling, and Other, together with unspecified items. Eight of the 177 student accidents had to be disregarded because the reports on them did not contain the necessary information about the date or the student's course.

The category called Perambulation was considered separately because the activity it covered was different to the other activities in that it was not taught. There was, of course, an element of learning in it. New students would have to get used to negotiating strange staircases and other parts of the building. In this connection, the drop in the number of accidents to first-year students that occurred after their first term is of interest. Even though the numbers are too small to reliably indicate a trend they seem to indicate that the accident rate might drop as students get used to the building.

The figures of Table 17 showed that, barring Perambulation, in the first term there had been nearly three accidents to first-year students for every one to a post-first-year student. In later terms this comparative rate of accidents had fallen to 1.30. A chi-square test was made to determine whether the null hypothesis that there was no significant difference in the number of accidents that occurred in the first term, compared with later terms, in the two groups, could be rejected with reasonable confidence, say $\alpha = 0.05$.

The result of a one-tailed test (see Table 17) showed that this was so and the null hypothesis was, therefore, rejected in favour of the alternative hypothesis that, compared with other students, first-year students had proportionally fewer accidents in later terms of the session than in the first term.

The categories of activity shown in Table 17 were examined in turn to see whether the difference in the comparative accident rate of first-year students was peculiar to one or more categories, or whether it indicated a general trend. The examination showed that the reduction in the comparative rate was common to all categories and was roughly of the same order in the two largest: i.e. Machine Work and Hand-work. The first-year/post-first-year ratio of Machine Work accidents fell by 58 per cent in the later terms compared with the first term. For Hand-work accidents there was a 63 per cent fall. The similarity of these figures was of particular interest considering that there had been some change in the type of work done as the session progressed. For instance, first-year engineering students did more filing in the first term and more machine work in the later terms. However, chi-square tests showed that although the alternative hypothesis could be accepted for Hand-work accidents, when Machine Work accidents were considered separately, the difference in the proportions of accidents in the first and later terms for the two groups was not such that the null hypothesis could be confidently rejected.

The numbers of accidents in the Other Work and Perambulation categories were too small for chi-square tests. The Fisher exact probability test (Siegel, 1956) can be used for such samples; it requires rather tedious computation except when a significance level rather than an exact value of probability of the observed occurrence is acceptable; in these cases a table of critical values can be used. For Other Work and Perambulation accidents, the significance level observed in the table was in excess of 0.05 for a one-tailed test for both samples.

Although the null hypothesis could not be rejected for three of the categories when the results were broken down as described, the numbers in the last two categories considered were really too small for a conclusive result to have been expected. The inference that I drew, therefore, was that the trend I had found was common to all activities but probably more marked in Hand-work than in Machine Work and Other Work.

One must, of course, consider that instead of a drop in the accident rate for first-year students, compared with the accident rate for post-first-year students, the trend had been the other way and that the post-first-year students had increased their rate. I could see no reason why this should have been the case in view of my knowledge of the courses provided by the college.

It was natural that the accident rate should decline as skills developed in the breaking-in period (Van Zelst, 1954), but to reduce the accident rate it is necessary to improve on the natural order. From this analysis it appears that the necessary improvement was not accomplished - more attention should have been paid to safety measures and safety training directed at new students.

Accident rate

An overall view of the accidents to students in Establishment A showed a number of slight accidents, cut fingers predominating: injuries which many educators would consider of little consequence, or indeed, would regard as part of the learning process. Jones (1969), Executive Director of the Labour Safety Council of Ontario, would go further; he argues that the removal of dangers that are unlikely to result in major accidents may be detrimental to overall safety because it will reduce awareness of hazards. Serious accidents in the establishment were few and some of them (such as falling off a wall) had nothing to do with the teaching of practical work. But a closer look revealed a less satisfactory picture; eye protection was neglected to the extent that a practice that is illegal in industry was tolerated. Also it could be seen that despite the trivial nature of most of the injuries, the accident rate was quite high.

To compare the accident rate with that which obtains in comparable areas of practical activity in industry, I used the data that concerned the students who took the basic engineering, integrated training course. In the course sufficient time was spent on practical work to make valid measurements possible. The number of students enrolled was 23 but one or two left during the year, and towards the end of the course there were only 18 present. We might reasonably assume the average number of students on the course to have numbered 20. They spent almost exactly 200 days ($6\frac{3}{4}$ hours per day) on practical work. There were 40 accidents to these students: the accident rate was, therefore, one per 100 man days.

In the study of industrial accidents by Powell et al (1971), which included an investigation of every injury in a machine shop even if, in Powell's words, '... this was only a small cut to a finger, or a bruise to a shin', over a period of 21 months, the accident rate for those men who had worked in the shop for the whole of the period was 0.98 per 100 man days. Foremen, charge-hands and setters were excluded when this rate was calculated (a separate calculation showed that the rate for setters was 0.90). The sections of work that were studied were listed by Powell as lathes (apparently mostly turret lathes), power presses, grinders, drills, milling machines, gear-cutters, and inspection. The work was individual on the production of small pressings and a variety of small turned parts.

An earlier study, in 1944 (Williams and Capel, 1945), of all injuries, however slight, to production workers in a light engineering works, showed that the accident rate was about seven per 100 man days. The disparity between the figures obtained by Powell and those obtained by Williams and Capel, I believe, reflected not the improvement in safety in the years between the two studies, but the difficulty of making comparisons between accidents that occurred in different situations. As Chapanis (1959) said 'It is virtually impossible to get any meaningful comparisons of the absolute or relative frequencies of occurrence of various kinds of accidents because of the difficulty of estimating exposure to the risk of accidents' - to this he might have added, 'and the difficulty of getting them reliably reported in a meaningful way'.

Getting slight accidents recorded in an industrial situation is extremely difficult and aside from the examples mentioned here this does not seem to have been attempted. Powell said that the accidents he studied were recorded as and when they occurred, or were discovered by observers. Capel and Williams got charge-hands to ascertain from workers at the end of the day the injuries they had received. In this case the injury was defined as any lesion that drew blood from the skin; this definition may well have led to the recording of injuries too slight to have been discovered by Powell's method, or indeed, by my method, although presumably some bruises may have been excluded. Neither Powell nor Williams and Capel recorded the length of the working day.

Powell said that the top management of the firms concerned in his research were keen about the promotion of safety, and that his report was about workshops with 'good' safety records. All in all, it seemed that Powell's findings were the best guide to the accident rate found in the sort of industrial situation that the students were preparing to enter. This meant that the rate of accidents among the engineering students at Establishment A was the same as that in a comparable area of industry with a good safety record.

In comparing an FE establishment with industry, it must be remembered that the student intake is inexperienced and initially lacking in skill. For all that, the conditions in a college workshop are essentially superior to those found in industry; there is not the pressure of production, no race to earn a bonus, and no excessive noise. Supervision will be closer and I believe that safety precautions can be more easily enforced. Therefore, the relevant rate should be much less than in industry.

Accidents to staff

Of the 17 accidents to staff, eight were to lecturers, eight to technicians, and one to a cleaner. Two of the injured persons, both technicians, suffered fractures and were treated in hospital: one had a broken toe, the other a broken leg. Four cases received treatment from a first-aider, the remaining 11 were treated on-the-spot.

Two lecturers suffered eye injuries. One of them had been demonstrating to a chemistry class when he placed a small piece of sodium in water, it exploded on contact and some of the metal entered his eye. He said that it had not happened before although he had done the same experiment many times, so presumably he learnt something from this particular experiment. The other lecturer was inspecting a student's work which was lying on a bench adjacent to a drilling machine. The student was drilling a piece of metal at the time; the drill broke and a piece of it grazed the corner of the lecturer's eye. In the first of these cases the lecturer concerned should have used eye protection, not just to protect himself but also to set an example to his students. In the second the lecturer should have ensured that the drill was properly guarded.

Another failure to set a good example to students occurred when a lecturer was using a file and he cut his hand on the sharp edge of a jaw protector in the vice. The fault here was not that he was clumsy but that he used a jaw protector (probably worn by constant use) with a sharp edge.

Three lecturers tripped over obstacles, another was hit by a door, and another was cut by flying glass when a window was broken by a ball. One lecturer and two technicians were cut by glassware or glass tubing. Three technicians were injured by falling objects. These were, respectively, a stack of timber, a metal bar, and a lathe which toppled as it was being positioned. The other accidents were of a miscellaneous nature and the injuries were slight.

Technicians often work alone and take risks by tackling jobs single-handed when they should get help. This was the primary cause of the accident where a metal bar fell on a technician's foot and broke his toe; it is also the reason why the technician who was moving some timber suffered a badly bruised toe. These accidents revealed that the technicians did not wear safety shoes. Whether the technician who broke a leg when the lathe toppled on to him was receiving adequate assistance at the time is not known. H.M. Factory Inspectorate (Department of Employment and Productivity, 1968) have pointed out that careful supervision and training should be given to all men involved in the difficult task of moving machine tools and that they should be provided with adequate equipment.

The accident rates for staff members were low. They were 0.03 per 100 man days for lecturers, and 0.17 per 100 man days for technicians (based on 20 technicians). These figures are unreliable because of the small number of accidents to these persons, also because there is reason to believe that staff members did not report many slight accidents which they treated themselves. The ratio of injuries treated on-the-spot to injuries treated elsewhere was only 1:2 (6:11) for staff whereas for students it was 1:10 (16:161).

Comparison with other establishments

Before any conclusions about safety in FE establishments generally could be drawn from the accidents reported by Establishment A, it was necessary to judge how typical Establishment A was of other FE establishments in respect of safety. Evidence was obtained which showed that in so far as safety in engineering workshops was concerned Establishment A was in fact fairly typical. I investigated safe working procedures in engineering workshop classes in ten FE establishments (described in Chapter 13), and I found that the score which I awarded to Establishment A was exactly equal to the average of scores for the ten establishments.

In respect of safety in the establishment as a whole, Establishment A had made more provision for safety in a formal way, e.g. by implementing measures recommended by official bodies, than had any of the other establishments in the previously mentioned sample of ten. My assessment of safety provisions in these establishments is described in Chapter 5. The interest shown in safety at Establishment A together with a willingness to do something about it was demonstrated by the valuable assistance given to me in my research. The survey described in Chapter 5 showed that such a level of interest was far from typical of establishments in general.

Summary

In brief, the examination of accidents described in this chapter showed that adoption by the establishment of the conventional official position in respect of safety did not bring about its acceptance in the workshop or laboratory. Lecturers and technicians failed to set a high standard of safe working. Students were exposed to needless risks and it was likely that the accident rate for them was as high as that in comparable areas of industry.

Reduction in accidents to students would have resulted from the following actions :

(i) Insistance on the wearing of eye protection whenever there is a risk of eye injury.

(ii) More attention to the safety of new students with special consideration given to errors which are prevalent when new skills were being acquired.

(iii) More attention to the less obvious dangers (e.g. in setting up a machine).

Further improvement in accident prevention coupled with an improvement in safety training would probably have been brought about if all staff who come into contact with the students had a better understanding of their role in promoting safety in the college.

CHAPTER 10

ACCIDENTS IN SEVERAL FURTHER EDUCATION ESTABLISHMENTS

In addition to the returns of all accidents made by Establishment A, 38 other FE colleges and three polytechnics contributed to the survey by reporting accidents that required other than simple on-the-spot first-aid. The selection of establishments and the amount of cooperation obtained from them has been described in Chapter 5 and Chapter 7. The 38 FE colleges had a total of just short of 4,000 full-time lecturers. Excluding polytechnics, in 1971 there were 42,190 lecturers in major establishments for FE in England and Wales (Statistics of Education, 1973). Therefore, in terms of full-time lecturers, the size of the sample from which the accident reports were drawn was approaching 10 per cent of the whole. This sample reported 270 accidents to students and 59 accidents to staff. The three polytechnics reported ten accidents to students and nine to staff.

Accident pattern

The pattern of the accidents to students is shown in Table 18. There was no way of checking what proportion of accidents that actually occurred were reported, so it cannot be assumed that the pattern shown is representative of accidents in FE as a whole.

In comparison with the similar chart which depicts accidents that occurred in Establishment A, Table 18 shows a striking difference in the proportion of female students injured. Of these, 19 were taking courses which came under the heading of catering and institutional management, nine were on business studies, commerce and secretarial courses, eight were on health and welfare courses, five were taking home economics, the other 24 were scattered in ones and twos over a range of different courses.

The higher proportion of female students and the greater diversity shown in other factors relating to the person, compared with the factors in the data obtained from Establishment A, was seemingly due to the greater range of work in the reporting establishments. Because of this wider range

TABLE 18

Analysis of 280 student-accidents requiring other than on-the-spot first aid in FE establishments

PERSON

Sex

Male	Female
215	65

Age

14	15	16	17	18	19	20	21→	Not spec
8	32	64	68	42	19	11	22	14

Area of study

Auto	Mech/Prod	Building	Other tech	Catering	Other	
21	33	66	38	35	64	23

Activity

Mach'g	Bench & Gen hand wk	Lab	Cater'g	Hdlg	Peramb	Other	
32	89	22	29	20	60	27	1

Nature of injury

Burn (heat)	(chem)	Cut	Irritation (Eye)	Bruise	Spr	Fract	Other	
35	7	183	14	28	19	9	18	9

Part of body affected

Eye	Head	Finger	Hand	Arm	Low Extrem	Trunk	Multi	
27	30	91	44	24	37	13	12	2

Treatment given

Hospital	Doctor	Nurse	1st-aider	Staff	
215	20	12	17	12	4

Time (Hours) before activities resumed

up to ½	1	2	3	24	over 24	
27	32	41	12	33	95	40

AGENT

Source of injury

Mach	Hand tools	Metal items	Building	Chem	Other	
26	66	44	54	13	76	1

Type of accident

Sk against	Sk by	Sk by hd tool	Fall	Hot obj	Caught	Other	
44	42	54	47	28	20	43	2

ENVIRONMENT

Location

Lec rm	Lab	Workshop/room kitchen	Corridor	Stairs	Other	
11	24	189	21	17	15	3

Staff/Stu ratio

≤6	7-8	9	10	11	12	13	14	15	16-18	19→	
12	25	10	34	12	33	11	10	16	14	9	93

Abbreviations Auto = Automobile engineering; Mech/Prod = Mechanical and Production engineering; Other tech = Other technology; Lab = Laboratory work; Hdlg = Handling; Spr = Sprain; Low extrem = Lower extremities; Mach = Machinery; Chem = Chemical; Sk = Struck; Obj = Object.

of work one cannot generally see from the chart the overall effect of restricting reports to cases requiring treatment other than on-the-spot first-aid, compared with reports on all accidents, however slight, although it is still possible to make some comparisons in limited areas.

Factors in categories coming under the headings of Agent and Environment in Table 18 were also found to have a greater diversity than was the case in Establishment A.

Age of students

The average age of students who had accidents was greater in the 41 establishments as a whole than in Establishment A. There were more accidents to mature students in the several establishments - 6 per cent were over 21 years of age compared with 1 per cent in Establishment A. Even when the effect of this was circumvented by disregarding mature students, the average age of those under 21 was 17 years in the several establishments and 16.4 years in Establishment A.

Activity

In the fields of activity, filing ceased to figure in the analysis: accidents resulting from filing operations usually produce only slight injuries. Only one filing injury that required other than on-the-spot first-aid was reported - this was a lacerated right thumb inflicted, by a vice clamp, when the student's hand slipped.

The analysis of machine-accidents presented in Table 19 shows that three-quarters of the accidents happened while the students were actually operating the machines and one-quarter occurred when the machines were being set up, adjusted, or cleaned. This was almost the reverse of the situation of Establishment A. It was no doubt due to the omission of slight accidents from the returns.

In very many of the 32 machine-accidents a lack of safe working procedure was apparent. Leaving aside, for the moment, six cases where

TABLE 19

Analysis of 32 machine-accidents to students requiring other than on-the-spot first-aid, reported by FE establishments

Machine	Activity	Agent of injury
Lathe 10	Machining 6	Struck by swarf 4
		Struck by m/c 1
		Struck by hd. tool 1
	Cleaning 1	Struck against swarf 1
	Setting up or adjusting 3	Caught between parts 1
		Struck by chuck 1
		Struck against machine or cutter 2
Miller 3	Cleaning 1	
	Machining 14	Caught between parts 1
		Struck against machine or cutter 2
Shaper 3		Caught between parts 1
		Struck by swarf 1
Bandsaw 4		Struck against machine or cutter 4
Drill 2		Struck by workpiece 1
		Caught in (hair) 1
Grinder 2		Struck against machine or cutter 2
Sewing 2		Struck by needle 2
Miscellaneous 6	Setting up or adjusting 3	Struck by machine 5
	Machining 4	
		Struck against machine 1

eye protection was neglected, there were cases in engineering workshops of cleaning off swarf, reaching over the machine, and adjusting the coolant pipe, all done while the machine was in motion. Machines were started unintentionally - a girl's foot slipped on the starter pedal of her sewing machine while she was manipulating the fabric into position, another student started a loom while he was examining it, a printing press was started as a student was removing cylinder packing. Material was drilled without being clamped down. A guard was removed from a guillotine.

Two of the students injured when using a woodcutting bandsaw were only 15 years of age, another one was 16 years old; no age was given for the fourth student involved in an accident of this type. Although the bandsaw is less dangerous than many other woodcutting machines, if students as young as this are to be allowed to use it, thorough training must be followed by close supervision. The staff/student ratio was 1:15 for one of the cases where a 15 year old was injured, 1:10 in the other and 1:13 in the case of the 16 year old. The type of work done in these classes was mostly benchwork and a wise teacher would not allow more than one machine to be used at a time. Nevertheless, I consider a staff/student ratio of 1:15 too high to permit proper supervision when machines are used. For advanced carpentry and joinery classes where the work is predominantly hand-work but there is a large machining content, some establishments work to a staff/student ratio of 1:8. This is the ratio recommended by the Foundry Industry Training Committee for patternmaking training courses where conditions are similar. The ratio is not fixed with safety in mind, but the quality of training; however, one objective may be difficult to attain without the other.

Injuries

Personal protection was lacking when a student with long hair was allowed to use a drilling machine without wearing a head covering and some

TABLE 20

Analysis of 27 eye injuries to students

<table>
<tr><th colspan="2">Activity of injured person</th><th>Source of injury</th><th>Treatment by -</th></tr>
<tr><td rowspan="3">Machining</td><td>Lathe 3</td><td rowspan="3">Metal particle 5</td><td rowspan="5">Hospital 10</td></tr>
<tr><td>Shaper 1</td></tr>
<tr><td>Miller 1</td></tr>
<tr><td colspan="2" rowspan="3">Welding 6</td><td>Slag 4</td></tr>
<tr><td rowspan="4">Molten metal 4</td></tr>
<tr><td>First-aider 1</td></tr>
<tr><td colspan="2">Melting lead 1</td><td>Hospital 1</td></tr>
<tr><td colspan="2">Soldering 1</td><td>Nurse 1</td></tr>
<tr><td colspan="2">Forging 1</td><td rowspan="2">Particle 2</td><td rowspan="2">First-aider 2</td></tr>
<tr><td colspan="2">Grinding 1</td></tr>
<tr><td colspan="2" rowspan="2">Cehmistry exp't. 2</td><td>Sodium 1</td><td rowspan="7">Hospital 10</td></tr>
<tr><td rowspan="2">Acid 3</td></tr>
<tr><td colspan="2">Etching 2</td></tr>
<tr><td colspan="2">Handling length of material 3</td><td>Wood or metal item 3</td></tr>
<tr><td colspan="2" rowspan="5">Miscellaneous 5</td><td>Brick particle 1</td></tr>
<tr><td>Battery acid 1</td></tr>
<tr><td>Metal probe 1</td></tr>
<tr><td rowspan="2">Dust 2</td><td>Nurse 1</td></tr>
<tr><td>First-aider 1</td></tr>
</table>

of his hair was torn out. No details were given of how his hair happened to get caught in the machine but it was reported that the machine was guarded. Ordinary chuck guards can leave the drift-way uncovered and hair can get caught up in the rapidly rotating hole: when I was investigating how this type of accident could occur, a lecturer showed me how this had once happened to one of his students.

Six of the machine-accidents resulted in eye injuries. These, together with the other eye injuries that were reported, have been included in Table 20. In at least 19 of the 27 cases analysed, better eye protection should have been provided. These were the cases that are shown in Table 20 down to and including Etching. They are similar to many of those that occurred in Establishment A, e.g. turning on lathes without eye protectors, lead welding and soldering without goggles, experimenting with sodium without protection.

There were two mentions in the reports of unsuitable goggles. In one case a particle from a grinding stone entered the eye, but how this happened when goggles were being worn was not specified. In the other case an oxide flake, chipped off a weld, flew through a gap in the goggles between the eye and nose of the wearer and into his eye.

Most eye injuries were described in the reports as 'foreign body in eye' or something similar, without actually describing the injury this caused - probably this was not known. One or two of the reports gave descriptions such as 'graze' or 'cut on cornea'. Cuts and burns generally affected the eye lid rather than the eye itself. Burns were caused by splashes of solder or lead or by hot swarf lodging on the eye lid.

There were four cases where acid splashed into the eyes of students. In one of these a test tube containing acetic acid was dropped and splashes entered the eye of a student. In another case a student taking a course in etching was applying acid to a plate with a feather - this is apparently a standard procedure in etching, but this student flicked the feather and a droplet of acid went into his eye. Another student, etching a plate for print making, had acid splash into his eye when the plate slipped. The other case involving acid was unusual and is distinguished from the others in that it was not one where the student might have been expected to wear eye protection. He dropped his cap into some battery acid which had been spilt on the floor, when he shook his cap to remove the acid some splashed into his eye.

Some deficiency in the other form of personal protective equipment - gloves - was found. Two students had to be treated in hospital for cuts received when they were carrying sheet metal. Injuries received in this way are usually slight: the three incidents that were reported by Establishment A were all minor injuries treated on-the-spot. The lack of protection may, therefore, be more prevalent in FE establishments than is apparent from just two reports of hospital cases.

There were four reports of chemical or heat burns received when students spilt substances onto their hands when engaged in laboratory work. Only one of these stated that the student should have been wearing gloves.

<u>Knife accidents</u>

In 31 of the 280 accidents a knife was the source of injury, 21 of these were kitchen knives, three were penknives, two were plumber's draw-knives. Two accidents were caused by students playing with knives. Seven reports attributed the accident to the use of the wrong technique, six stated that the knife slipped, one contained the previously (p. 82) quoted remark 'It was an accident!', 12 attributed the accident to carelessness, indicating that the lecturers probably did not appreciate the need for instruction in the safe use of knives.

On the whole, the reports confirmed an impression of lack of appreciation of the need for knife drill which I had gained from the pilot survey. This impression was due, in part, to three reports of accidents with knives which happened one after the other in a class where students were lino-cutting as previously mentioned (p. 79). In each case the lecturer had attributed the accident to carelessness.

In accidents where the injury was caused by a wood chisel, there was a lesser tendency to blame carelessness. Of the 14 chisel accidents reported, there were three ascribed to carelessness but all the others (except one where no explanation was offered) were said to be due to the student's failure to follow a safe working procedure: free hand kept behind chisel, and whenever possible the work held in a vice. Awareness here of a method of safe working, which students should be trained to use, which was lacking in the knife accidents,was, I believe, due to the training and experience of the lecturers. Keeping the hand behind the chisel is a rule every craftsman in wood learns to respect. The lecturers taking carpentry and joinery, and other craft classes working in wood, would in the normal course of events have served an apprenticeship and have worked in industry as craftsmen. Although their realisation of the need for safe working procedures was not adequate in all cases, it was better on the whole than that of lecturers whose students had accidents when using knives.

So far as carelessness is concerned, R. E. Graves, H.M. Inspector of Factories and Workshops said in 1919 (Parl. Papers, 1920) of cases where accidents had happened to young people who had been in employment for only a few weeks, and were naturally ignorant and inexperienced :

> 'The excuse in such cases that the worker was careless is irrelevant, as indiscretion at this age must be assumed as natural, and, moreover, it is seldom proved that there has been wilful carelessness...'

When lecturers impute carelessness on the part of their students it raises the question whether the dangers in the activities have been pointed out, and the appropriate safeguards taught.

Laboratory accidents

Unsafe procedures in laboratory work apart from those previously mentioned included pipetting caustic soda by mouth. This was apparently condoned, if not taught, by the lecturer concerned even though the class was not one for persons trained in laboratory techniques but a science class in a general science and engineering course. There were three reports of students injured when inserting glass tubing into bungs but in each of these cases the report indicated that the student had failed to use the correct technique.

There were two reports of ether catching fire, in one case the student brought a beaker containing diethyl ether solvent close to a lighted bunsen burner. In the other case the student was evaporating off ether in a beaker, the ether inflamed, he knocked it over and flaming ether went onto the pullover he was wearing. It appears that in this case the student was not only using incorrect apparatus but was also incorrectly attired.

Clothing

The worst case of failure to wear proper clothing revealed in the survey was that where a girl art student was holding the end of a metal rod which was being welded for her by a technician. Her tutor was also present. The girl had averted her eyes from the welding, as the technician had suggested, and so she did not see the spark from the arc welder which ignited her skirt. The flames melted her nylon slip and tights and she suffered second degree burns to one of her thighs, her buttocks, back and abdomen. These necessitated three weeks treatment in a hospital burns unit, followed by a further week in a convalescent unit. The technician also suffered second degree burns to his hands, in extinguishing the flames.* The student's skirt was of floor length, home-made out of flimsy Indian cotton. This accident revealed the failure of all concerned to consider

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* The injury to the technician was not reported to me. I learned of it from the report 'Accidents in Further Education Establishments 1972/73' compiled by the London and Home Counties Regional Advisory Council for Technological Education.

safety as a factor in the work that they were doing. The only danger that had been seen was the risk to the girl's eyes and even then they had not been properly protected.

Another quite serious accident occurred when a student was wearing a long skirt. This time she was perhaps less inappropriately dressed for the job in hand - a life drawing class. An electric fire was in use for warming the nude model. The student stood too close to the electric fire and her voluminous skirt caught fire. The electric fire should have been mounted above head level.

Perambulation accidents

Over 20 per cent of the 280 accidents to students were included under the heading of Perambulation in Table 18. Of the 60 accidents, 23 happened while the injured persons were moving about the room for some reason, 32 occurred while they were moving around the building and 5 occurred while they were moving about outside the buildings but within the grounds of the establishment.

The proportion of injuries caused by Perambulation accidents was much higher than at Establishment A where it was six per cent. It may be that Perambulation accidents cause more serious injuries than most other types of accident. Certainly there were more fractures: out of nine reported, four occurred in Perambulation accidents.

There is a large movement of people in FE colleges, particularly at break-times. At these times, many students are hurrying to get to the refectory, also, when classes finish at the end of the day, an eagerness to get out of the building is often apparent. Under these conditions there are many opportunities for accidents to occur. Because of this there is a need for careful design in areas where people circulate. This is regrettably lacking in many instances.

My investigation of domestic buildings (Sinnott, 1969) showed that official recommendations in respect of design for safety are commonly ignored. Inspection, limited to the buildings of this University and to other buildings visited in the course of this work, indicates that this is also the case in educational buildings, indeed, even requirements that are legally demanded in certain other buildings under the Building Regulations, 1965 and 1972 (Statutory Instruments 1965 and 1972), in respect of the design of staircases, are not observed. There are several examples of this in new buildings of this University; there are other examples in new buildings of FE colleges only a few miles away.

Falls on steps or stairs accounted for 22 of the 60 perambulation accidents. How many of these were due to faulty design cannot be assessed. It would have been unreasonable to have expected reports to have provided this information. Assessment of the design would have necessitated specialised knowledge. However, one report mentioned that steps were slightly uneven and another that there had been a number of accidents on a particular staircase without speculating on possible reasons. Two reports on accidents that had occurred at different times on the same staircase were received from one FE establishment, the reports included a note to the effect that the stairs were at a corner in a corridor indicating a design fault.

As it is almost inevitable that there will be some accidents on stairs, secondary safety is important and care should be taken to see that faulty design will not exacerbate injuries. Sharp-edged members of balustrades and sharp edges of steps will cause cuts that rounded edges will prevent. Modern functional designs, where traditional mouldings are eschewed, are potentially the most dangerous in this respect; however, cuts and grazes were not outstanding among the injuries caused by stairs in the FE establishments: only three cases were reported.

Screens and windows glazed to floor level have been responsible for injuries and at least one death in recent years. One of the injuries, reported as having occurred when students were moving about in a building, was caused when the companion of the injured person walked through a plate glass screen without himself suffering injury. If it is necessary to use large panes of glass down to floor level, then fixed guards should be provided. These are required not only to protect users of the building who mistake the glazed area for an opening, but also to protect those who may be the victims of unforeseen consequences when students are bustling about the building.

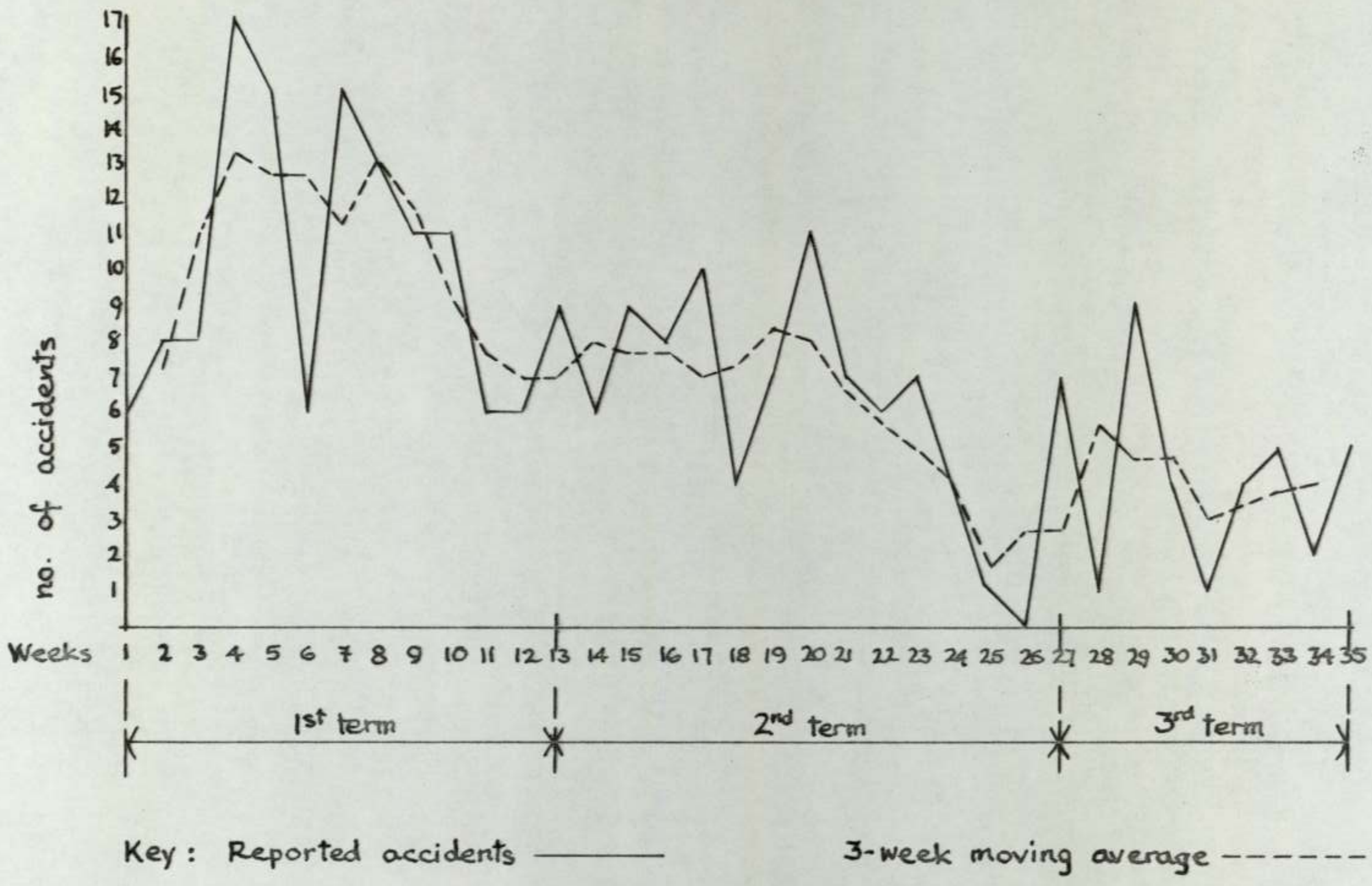
The danger constituted by glazed swing doors when they are unexpectedly found to be bolted was emphasised by a report which described an accident which occurred when a student was hurrying along a corridor. He attempted to open a glazed fire door but the door was bolted and his hand went through the glass. Only toughened glass should be used in glazed doors (British Standard Institution, 1972). Wired glass is used in fire doors because it will not fall out if cracked by heat, but wired glass is not safety glass, it can be broken as described above and cause serious injury. A fire door that is also a swing door must contain glass so that a person approaching the door can see that his way is clear on the other side, but such doors should be designed so that they do not contain glass in the position where a person attempts to push them open.

Slippery floors were responsible for a number of accidents, sometimes the floor was slippery because it was wet or had been highly polished; at other times it was slippery because grease or oil had been spilt on it. It is unfortunate that the hard-wearing and easy-to-clean properties that are desirable in materials used for floor and stair tread surfaces are not conducive to safety. However, notwithstanding the need for limited wear and hygiene, the accidents that occurred showed that non-slip properties must also be taken into consideration.

In one accident in a workshop, an uneven floor was the cause; in another accident a student stumbled over a 100 mm high step between two levels of a workshop.

FIGURE 3

Incidence of 249 accidents to students in one session
(only full working weeks included)



Time distribution

The time series of reported accidents in the 41 establishments that contributed to the survey is shown in Figure 3. It was broadly similar to the time series of accidents that occurred in Establishment A. The initial peak occurred on approximately the same date and thereafter the number of accidents reported each week fell away in much the same way. No conclusions can be drawn from the similarity because of the absence of checks on the reliability of reporting.

Experience

In the preceding chapter a comparison was made between accidents to first-year students and accidents to post-first-year students that occurred in (i) the first term of the session, and (ii) the later terms of the session. It was assumed that any slackening of reporting that took place as the session progressed had affected both categories of student in equal proportion. The comparison revealed that there had been a marked reduction in the accident rate of first-year students during the session, compared with other students.

When the same comparison was made for the several FE establishments considered in this chapter, I found that in contrast to the result obtained from Establishment A, the overall comparative rate was virtually the same in the later terms as in the first term. The figures for all accidents were, in the first term, 83 to first-year students, 45 to post-first-year students, in the second term 85 and 47 respectively.

Information about either the stage of the course attended by the student, or the date of the accident, was lacking on 24 of the reports. The remaining 256 reports were used to compile Table 21. Following the procedure laid down in the last chapter, the category Other Work in the table included all activities except those already defined. The activities that were combined in this way were given in Table 18 under the headings

TABLE 21

Number of accidents in first term and subsequent terms to first-year and post-first-year students

Activity	Students: 1st-year: 1st term	Students: 1st-year: Later terms	Students: Post-1st-year: 1st term	Students: Post-1st-year: Later terms	χ^2	Level of significance for two-tailed test (df = 1)
Machine work	10	9	5	8	0.187	$0.50 \leq \alpha \leq 0.70$
Hand-work	24	29	16	14	0.227	$0.50 \leq \alpha \leq 0.70$
Other work	24	29	19	15	0.555	$0.30 \leq \alpha \leq 0.50$
Total	58	67	40	37	0.386	$0.50 \leq \alpha \leq 0.70$
Perambulation	25	14	5	10	3.001	$0.05 \leq \alpha \leq 0.10$

of Laboratory Work, Catering, Handling, and Other. As before Perambulation accidents were kept separate.

When the first-year/post-first-year ratios for the first term and later terms were compared, Machine Work showed a reduction of 44 per cent in the later terms. At Establishment A there had been a 58 per cent reduction. Both of the other areas of activity showed an increase, this was 38 per cent for Hand-work and 53 per cent for Other Work. When the three categories were considered together, the overall change was an increase of 25 per cent. This compared with an overall reduction of 56 per cent at Establishment A.

Chi-square tests were made on the data. These were two-tailed tests because the direction of change varied in the several categories. For one-tailed tests the significance levels shown in Table 21 would have been halved. Excepting Perambulation accidents, this would still not have allowed the rejection of the null hypothesis with the necessary confidence in any category of activity. Hence I had found that the trend identified in Establishment A was not repeated in the results from the 41 establishments.

The implications of the two sets of results require several possible explanations to be considered. These are as follows :

(i) The accident rate for first-year students fell compared with the accident rate for post-first-year students in Establishment A, where nearly all the injuries reported were slight, but rose in the other establishments, where only the more serious injuries were reported. This means that as students progress in the first year of their studies they learn to avoid slight injuries better than they learn to avoid the more serious injuries.

(ii) The trend in each set of results was the reverse to that described in (i) above. That is to say that it was the rate for post-first-year students which rose not the rate for first-year students that fell in Establishment A, etc. The outcome in terms of injuries would also be reversed. This did not seem to be an acceptable explanation so far as Establishment A was concerned (see p. 102).

(iii) The results from Establishment A were not typical. This would mean that the trend for slight accidents to fall had not also occurred in the other establishments and, therefore, that the rates for slight injuries and the rates for more serious injuries, in first-year students, did not move in opposite directions. But we have seen (p. 108) that there is evidence that Establishment A is typical in respect of safety in engineering workshops.

(iv) First-year students were exposed to greater risk of the more serious type of injury in the second and third term, than they were in the first term. If this was so, it was probably either counteracted better in machine work than in other activities, or it occurred to a lesser extent in this type of activity. Although not statistically conclusive, the findings in both Establishment A and in the 41 establishments support this qualification.

(v) The reverse to (iv) above, that is, that post-first-year students were exposed to less risk in the second and third terms. This seems to be most unlikely.

Explanations (i) and (iv) are compatible and together offer the best explanation of the findings. A need for better safety training is revealed. Students may themselves learn how to avoid small cuts and bruises on simple tasks but fail to counter fresh hazards as they progress to more involved work.

Support for the view of the way that self-learning affects the accident rate was obtained from the Perambulation accidents. When a one-tailed chi-square test was made on data of these accidents, the decision was made to reject the null hypothesis at the observed significance level which lay between 0.025 and 0.05 (half the level of significance shown in Table 21), in favour of the alternative hypothesis. This was that, compared with other students, first-year students had proportionally fewer accidents in later terms of the session, than in the first term.

In the last chapter, I suggested that although the numbers for Perambulation accidents were too small to be really reliable, they seemed to show that the accident rate declined as students got used to the building. I came to the same conclusion in respect of the accidents in the 41 establishments, but with greater confidence. This finding is in accordance with everyday experience. We have only to consider how used we are to the idiosyncrasies of design in our own homes and places of work to appreciate that safe building design is of especial value to the unacquainted.

Staff accidents

Accidents to staff that were reported numbered 66, 21 were to lecturers, 18 to technicians, 9 to kitchen and refectory assistants, 6 to caretakers and porters, 4 to cleaners, 4 to clerical and administrative workers, 2 to maintenance workers, and 2 others. Of these, 24 were female members of staff.

Perambulation accidents figured high among staff accidents. There were 16 accidents of this type. Seven persons slipped and fell on floors, but only one fell on a staircase. Three tripped over projections from floors, such as loose blocks, two fell over obstacles in car parks. Twelve of the 16 accidents resulted in injuries that prevented the resumption of normal activities for more than 24 hours.

There was another case of a drill breaking and a piece of the drill inflicting an eye injury, this time it was a technician who was hurt; at Establishment A it was a lecturer.

Other blatant examples of unsafe procedures were as follows :

(i) A technician, ripping a board on a circular saw, failed to use a push stick when he got close to the end of the cut. The board closed up in the cut portion, gripped the saw, and recoiled. The technician's hand slipped along the timber and came into contact with the saw. The Woodworking Regulations 1974 (Statutory Instrument, 1974) require a push stick to be used for the last 300 mm of the cut.

(ii) Another technician who used a circular saw apparently failed to put the guard over the top of the saw. He cut his hand on the teeth of the saw, which were protruding slightly through the timber, while changing his grip on the timber. This is another example of what an industry would constitute a breach of the Woodworking Regulations.

(iii) A lecturer was tapering a piece of hardwood on a surface planer, the timber kicked back and he caught his fingers on the rotating knives of the planer. Tapering timber in this way is extremely dangerous and if proper precautions are not taken, it often leads to an accident. An almost exact replication of the accident to the lecturer was reported to me during the pilot survey, the only difference was that it was a technician who was injured on that occasion.

(iv) A lecturer removed swarf from a lathe with his bare hands and with the machine running at the time.

(v) A technician dropped a lathe chuck on his foot. He had been provided with safety shoes but was not wearing them.

(vi) A technician was making a solution of bromine. He did not wear gloves and did not have a neutralising bath near at hand for the emergency which developed.

(vii) A technician handled a bottle of potassium cyanide which was believed to have had cyanide dust around the neck of the bottle. He then stroked his beard and in doing so rubbed his mouth.

In order to display to students proper concern for safety and what to do about it, technicians as well as lecturers should set an example to students. Caretakers, refectory assistants and similar staff are engaged in activities different from those of the students and are not likely to influence students, but the technicians' work will usually be similar to the practical activities of the students and it will probably be done in the laboratory or workshop used by the students. An establishment that aims to reach a standard of excellence in safety may find it necessary to accept an occasional lapse by some staff, but it cannot tolerate any of the nature described on the part of lecturers and technicians. It must insist that safety teaching is by example rather than precept.

Summary

The seven examples were not many from which to generalise about the attitude to safety of staff, but these seven represented 18 per cent of the 39 accidents to lecturers and technicians that were reported. Moreover, the nature of some of the other accidents to these persons led me to suspect that safe procedures were not being followed when the accidents occurred. There was additional evidence from accidents to students that the lecturing staff condoned many unsafe practices. All this built up a picture similar to that which I found in the single establishment and which I described in the previous chapter. Lecturers and technicians had failed to set a high standard of safe working and students had been allowed to take needless risks. Eye protection had been neglected, students had not been sufficiently drilled in the safe use of machinery or in safe laboratory techniques, non-craftsmen lecturers, in particular, had failed to appreciate the need for safety training in the use of hand tools. Additionally, I found that some accidents might have been prevented if attention had been given to the correction of faults in the design of the buildings.

CHAPTER 11

ACCIDENTS IN UNIVERSITIES

Whereas the reports from FE establishments had mostly been concerned with student-accidents, the reports from universities were mostly about staff-accidents. Taking as an example the figures from three universities that reported to me all the accidents that were reported to them internally, I found that there were only 26 student-accidents compared with 273 staff-accidents.

The three universities respectively sent in 99, 94, and 80 reports on staff-accidents. The first establishment was a technological university with a complement of teaching and research staff that numbered over 900 in 1971 (Statistics of Education, 1974). The second, a 19th century-tradition type university, had nearly 600 on its academic staff; the third, another technological university, had nearly 450. In round numbers, full-time students at each, including post-graduates, (post-graduate student numbers in brackets) were, respectively, 3,900 (1,400), 4,700 (1,100), 3,600 (600).

The two largest universities reported accidents to me on their own forms, the other used my specially-designed form. All three had an extensive safety organisation, with departmental safety officers from each department and student representatives on the university safety committees. The smallest university had a full-time safety officer for the university as a whole, the largest incorporated the post of safety officer within that of chief maintenance officer, the other university did not have a safety officer. In respect of the overall provision of safety officers, at least, the three were fairly typical of universities as a whole.

Eight other universities reported a total of 90 staff-accidents, and 15 student-accidents. Although these reports provided useful information about the type of accident that occurred in universities, I felt that a better picture of accidents to university staff as a whole would be obtained from the data provided by the three establishments that had made the most complete returns, therefore, only the figures from these three were used

TABLE 22

Analysis of 273 staff-accidents in three universities

PERSON

Sex

Male	Female	Not spec
145	128	

Occupation

Lect	Tech	Porter	Cleaner	Kit/Refec	Maint	Other	Not spec
9	89	15	57	56	28	17	2

Activity

M/c'g	Ben wk	Lab	Cat	Handling	Cleaning	Peramb	Other	Not spec
25	34	24	24	52	39	46	11	18

Nature of injury

Burn (heat)	Burn (chem)	Cut	Irritation (Eye)	Bruise	Sprain	Fract	Other	Not spec
21	9	101	7	75	38	10	11	1

Part of body affected

Eye	Head	Finger	Hand	Up Extr	Low Extr	Trunk	Multiple	Not spec
11	25	65	20	30	65	41	12	3

Treatment given

Hospital	Doctor	Health centre	1st-aider	No treat	Other	Not spec
56	42	95	15	27	7	31

Time before activities resumed

About ½ hour	24 hours or more	Not spec
195	74	4

AGENT

Source of injury

M/c	Hd tool	Building	Metal	Chem	Furn	Cont	Other	Not spec
18	15	88	22	12	26	17	65	10

Type of accident

Sk against	Sk by	Sk by hd tool	Fall	Obj hd	Hot obj	O'ex	Other	Not spec
49	56	17	79	19	15	12	24	2

ENVIRONMENT

Location

Lab	W'shop, Kit	Corr	Stairs	Refec, As rm	Other	Not spec
42	72	25	20	38	54	22

Abbreviations Ben wk = Benchwork & general handwork; Lab = Laboratory
Cat = Catering : Peramb = Perambulation : Fract = Fracture
Up extr = Upper extremities : Low extr = Lower ~ :
M/c = Machine : Hd tool = Hand ~ : Chem = Chemical
Furn = Furniture : Cont = Container : Sk = Struck : Obj hd = Injured by object handled : O'ex = Overexertion
Refec, As rm = Refectory, Assembly rooms

in Table 22. There was, of course, a bias towards the technological university and this may have emphasised industrial-type accidents more than warranted for universities in toto.

Accident pattern

The picture that evolved showed roughly half male and half female persons injured, nearly all of them service staff. Technicians figured prominently; they were involved in most of the machinery, benchwork and laboratory work accidents. Cleaners were next in number to technicians, like the porters, they were generally injured when moving about the building or when lifting or handling articles. Cleaning activities such as dusting and polishing also led to accidents. Handling was the largest category of activity in which persons were engaged when they were injured. Cuts were again the most common form of injury but to a lesser extent than had been the case with student-accidents in FE establishments shown in the comparable tables in other chapters. Bruises, sprains and fractures were more numerous because of the larger proportion of handling and perambulation accidents. Rather more than one-third of the persons were treated in hospital or by a doctor, over a quarter were away from work for 24 hours or more.

More persons were injured by the buildings in which they worked than any other source; this was the result of falling onto stairs, or floors, or striking against parts of the building. Furniture and fitments also caused several injuries: they were either struck against by persons, or persons were struck by falling items.

Workshops, kitchens and laboratories were, not unexpectedly, common locations of accidents; circulating and assembly areas also figured prominently.

Research

When all of the 404 reports received from universities are considered it is doubtful whether any of the accidents that occurred in research laboratories were primarily the result of exploratory techniques or the use of unique apparatus. Most accidents in the research situation occurred in the course of mundane procedures such as inserting a glass tube into a bung or sawing a piece of wood. Where injuries were caused by dangerous chemicals, they were the result of failure to take ordinary safety precautions such as the wearing of gloves or face shields. Safety officers who investigated these accidents often reported that they found an apathetic attitude towards safety procedures.

There was one injury, to a research student, that fitted the popular conception of a research-accident - it was caused by a minor explosion in a chemistry department; unfortunately, how it occurred was not explained. Another accident happened when a piece of apparatus of the kind which the Committee of Vice-Chancellors and Principals, in its evidence to the Robens Committee (Robens, 1972b), described as being 'an experimental prototype of strictly limited life' and hence inappropriate for safety legislation, was being used. A post-graduate chemistry student had an experimental glass vacuum system supported in a metal framework, he mounted a stool carrying a high-frequency discharge tester (Tesla coil) in his right hand and holding the metal framework in his left. One of the leads from the tester made contact with the framework and the student received an electric shock which caused him to fall to the floor. No injury resulted from the fall but the current caused a burn to the palm of the student's hand. The accident might have been prevented by securing the leads of the tester against accidental contact but the basic precautions which had been neglected were (i) the provision of a switch on the tester so that it need not be alive until ready for taking readings, (ii) earthing the metal framework, (iii) using suitable steps or a ladder to reach the apparatus. All in all, this is an example of failure to take elementary safety precautions in the design of apparatus which illustrates the need for researchers to have safety training in areas outside their own subject.

Teaching

The pattern of accidents in commonplace activities found in research was repeated in the teaching situation. Pipettes were involved in four of the reported accidents, in one the student had sucked up a solution, in another the student had taken precautions to avoid this type of accident by using a safety pump but he broke the pipette as he attempted to fix the pump onto it, in the other two accidents the pipette broke when it was incorrectly handled. A common type of accident that occurred in teaching laboratories, as in research laboratories, was that where chemicals were spilt or splashed and students were not wearing protective devices.

In advancing reasons why the Factories Act or other legislation should not apply to educational establishments, it has often been said that it must be possible for working parts to be exposed so that their behaviour can be observed (for example the Committee of Vice-Chancellors and Principals in its evidence to Robens, 1972b). The Gowers Committee (1949) recommended legislation but said that guards and safety devices might be removed from machines when in the opinion of the competent instructor it was necessary to do so for the purposes of tuition. In this connection it is interesting to note that an accident which occurred in a situation where students were observing the operation of a machine and where the proviso of Gowers might have been applied, resulted not from the exposure of dangerous parts but failure to observe simple safe working procedures. Students had grouped around a planing machine to watch the planing of a casting. Apparently the nut of the bolt which secured the table traverse stop had not been fully tightened, the casting struck part of the machine and the bolt broke under stress, it flew through the air and struck one of the students on the nose.

TABLE 23

Analysis of 39 machine-accidents to
staff reported by university establishments

Machine		Activity		Agent of injury	
Lathe	10	Machining	6	Struck against swarf	1
				Struck by swarf	2
				Struck by hd. tool	1
				Rubbed by workpiece	1
				Struck by workpiece	3
		Setting up or adjusting	5	Caught between parts	1
				Struck against machine or cutter	2
Drill	6	Machining	15	Struck by machine or workpiece	3
				Struck by swarf	1
				Struck by particles	1
Circular saw	5			Struck against cutter	1
				Overexertion	1
				Struck by workpiece or particles	5
Planer (wood)	5			Struck against cutter	5
Slicer (food)	3	Cleaning	6	Struck by machine	3
Miscellaneous	10			Struck against m/c	2
		Machining	5	Struck by machine	1
				Struck against machine or cutter	4
		Setting up or adjusting	2	Struck by machine	1

Machinery

There were 39 machine-accidents to staff: the personnel comprised 25 technicians, one experimental officer, five maintenance staff, four kitchen or refectory assistants, one clerical staff, one cleaner, and two lecturers. The pattern of accidents they suffered is shown in Table 23. Only one accident report concerned a student - he was the unfortunate observer who was struck on the nose by a bolt.

There is inevitably a similarity about the accidents categorised in Table 23 and those which I found in machine shops elsewhere, but some of the working procedures with machines adopted by the university staff were more unsafe than any I have previously described. They revealed a fool-hardiness which I am sure must have been due to ignorance of how accidents could happen with machines.

Failure of technicians to anticipate danger was shown by several accidents, for instance, one of them used a file without a handle to finish a workpiece in a lathe. Not only was he wrong to employ a file in this way but he compounded the danger by not having a handle on the file and the tang was driven into his hand. Another technician somehow touched a milling machine cutter while it was moving. Other technicians used lathes without eye protection, one put his thumb into a chuck and found himself trapped, others removed swarf with their bare hands, another felt the finish of the workpiece while it was turning and caught his hand between the workpiece and the tool. Technicians failed to clamp metal when it was being drilled and were injured as a result. One adjusted the depth of cut on a circular saw bench when he was grooving a piece of timber, he kept the timber over the rotating saw while he made the adjustment and the piece of timber was propelled into the air striking him in the face. A technician who was injured when planing a piece of perspex was partially to blame because he did not hold it in a push block; the establishment bore some responsibility, however, because the machine used was not fitted with a bridge guard to cover the cutters. The machine was unsuitable also in that it was driven by unguarded vee-belts from an electric motor.

Accidents to staff

Many technicians are called upon to carry out a variety of tasks and in doing so may employ dangerous machines which they have not been trained to use. Because they are unaware of dangers they may put themselves at risk by using unsafe procedures.

Three kitchen staff were injured while cleaning foodslicing machines. The implementation of the Offices, Shops and Railway Premises Act, 1963, drew attention to the large number of accidents that occurred at food-slicing machines (Parl. Papers, 1966-67). They have been prescribed as dangerous machines under the Prescribed Dangerous Machines Order, 1964; persons who work them must have been trained in their use and have been fully instructed as to the dangers arising in connection with them. At the University of Bristol in the years from 1939 to 1961 injuries from bacon slicers exceeded those from burns in the chemical laboratories (Couper, 1961). This draws attention to the need for safety to be seen throughout the whole of an establishment.

Of the five maintenance workers injured, four were hurt when using woodworking machines, three of them when using surface planers. These staff are in a similar situation to that of technicians; men employed on maintenance extend their range of work, and joiners might undertake machining that machine woodworkers would do for them in industry, hence, training may again be deficient.

Eye Injuries

In total, reports were received of 22 eye injuries. Ten of these were to technicians, seven were to students, three to maintenance staff, one to a research fellow, and one to a porter. The types of accident causing the injuries and the agents of injury were too varied to enable a chart to be used to depict the accidents as in Chapters 9 and 10. However, some important categories can be established; one is that where eye protection should have been worn or precautions taken to render it unnecessary, another is that where the risk was either not likely to have been foreseen or it was extremely small. In 13 of the accidents, precautions of some sort should have been taken; in four it appears unreasonable to have expected precautions; in the remaining five the reports are insufficiently detailed to determine whether eye protection should have been provided. These included sawing with a circular saw, two cases of dropping items into formalin solution, and two cases where dust was blown into the eyes of persons.

Some of the accidents previously noted, such as those involving dangerous chemicals, fell into the first category of eye accidents, i.e. where protection was necessary. There were also the two injuries inflicted when technicians were turning items on lathes. Another technician blew out an electric motor with compressed air and a piece of steel entered his eye. A maintenance worker drilled a concrete ceiling without wearing goggles. Among the other injured persons was a geology student who chipped a rock with a hammer and got a particle of rock in his eye.

Handling

Only staff were concerned in the 54 accidents reported that occurred when persons were lifting or moving objects. Of these accidents, 16 resulted in sprains or strains, 17 in crushing or bruising, one fracture (a broken toe), and 16 cuts or abrasions. There were 19 other accidents that occurred when objects were being handled; typical of this type were a technician hit by a van door and two technicians hit by swinging loads; they included the case of the technician who so overloaded a cabinet that it warped the frame and the glass doors fell on to him. Injuries caused by these accidents included four fractures.

Among the persons injured in handling accidents involving swinging loads was one student. He was a research student who was knocked unconscious by a 300 mm diameter pipe which he was assisting two technicians to remove from a large water tank. The accident was caused by incorrect rigging of lifting tackle by the technicians. In all there were five cases of persons hit by swinging loads. They occurred in circumstances which called into question the training of the personnel involved.

A number of technicians and maintenance workers suffered bruised or crushed toes in accidents that occurred when handling equipment or materials. Only one report contained a reference to safety shoes - it noted that the injured person was not wearing them.

Apart from other considerations, these handling accidents were responsible for a great deal of lost time; strained backs and crushed toes were often responsible for long absences. For example, a technician who strained his back by carrying a heavy battery from one laboratory to another was away from work for three weeks. Of course the bad back syndrome is often suspected as a cause of unnecessary absence from work. Hill and Trist (1953 and 1955) concluded that there may be a general absence behaviour which functions as a kind of group standard or norm. Nevertheless, the introduction, or intensification, of training in handling procedures might usefully contribute to the reduction of accidents in universities.

Cleaners

The existence of a group standard of absence may have been responsible for what appeared to be a disproportionate number of accidents to cleaners in universities compared with FE establishments. In universities there were 68 accidents to cleaners reported out of a total of 358 staff-accidents, that is, 19 per cent. In the three universities which sent in the most complete returns, accidents to cleaners numbered 57 out of 272 (21 per cent) so the returns were reasonably consistent, but in the FE establishments there were only four accidents to cleaners out of a total of 83 staff-accidents (6 per cent). The number of cleaners at any one establishment would be much greater in the university sector. Possibly, therefore, cleaners in universities achieve a corporate identity that is lacking in smaller FE establishments.

Perambulation accidents

Of 77 perambulation accidents, 18 occurred while persons were moving around a room, 48 while they were moving around the building and 11 while they were moving about outside the building. A high proportion, 11 in number (14 per cent) of the accidents resulted in fractures. Falls on stairs accounted for 23 accidents, falls to the walkway for 29. Unfortunately, as in the FE establishments, it was not possible to determine how many of the accidents were due to faulty design. The 1973 report on the working of the Offices, Shops and Railway Premises Act, 1963 (Parl. Papers, 1974b) criticised some new staircases as being of poor design with gaps between the edges of stairs and the walls of buildings, excessive space between the rails on the open side, and occasionally inadequate or non-existent guarding. All these faults can be found in the buildings of this University alone. Macklin (1973) described a recently completed university building crossed and inter-connected by superb open-riser wooden staircases. Within weeks of opening, he said, these beautiful staircases had become the number one hazard: any wet weather was immediately accompanied by an alarming number of accidents.

An establishment which does not vet an architect's design for safety cannot be aware of its obligations to users of its buildings. Moreover, errors, such as described above, can necessitate expensive modifications and are wasteful of resources.

As we have seen, in its evidence to the Robens Committee (1972b) the Committee of Vice-Chancellors and Principals expressed its concern in promoting safety consciousness among staff and students. This was further emphasised by the now familiar statement about universities' responsibility for instilling safety consciousness into undergraduates which they can carry forward into subsequent careers. This somewhat elusive objective will not be aided by the provision of buildings obviously lacking in design for safety.

Summary

Essential though laboratory safety is, it should not be overlooked that the greatest contribution that could be made to university safety in so far as making a safe place to work is concerned would be a reduction in handling and perambulation accidents. This does not appear to have been realised by the establishments.

CHAPTER 12

SAFETY NEEDS IN ENGINEERING WORKSHOPS

The study of accidents in the establishments had covered the whole spectrum of activities in FE and HE. It revealed much about the situation in respect of safety in the establishments and enabled the broad picture to be seen. While the study was in progress a closer look was taken at a limited area. The area had to be limited because increasing the magnification, as it were, of necessity involved a reduction in the field of view.

My objective in the closer investigation was to obtain further evidence relevant to three of the key questions which I identified in Chapter 3. The three questions were as follows :

(i) Is the practical significance of classroom teaching demonstrated to students at a personal level?

(ii) Are the necessary steps being taken to ensure that precautions known to be essential to safety in work activities are being observed?

(iii) Is safety taught in a positive way, particularly in connection with skills which students will use in industry?

It was desirable to choose an area of study in FE rather than in HE because there is more practical instruction in FE and as a result students are more likely to be involved in accidents; also, they will in the main continue to be at risk when in employment. HE students, on the other hand, do not prepare for careers which put them to face occupational danger in the front line. If educators had become aware of the need for safety education then it should, at least, have been apparent in an area where both the immediate and future safety of their students was involved, and where the educators themselves could be held accountable for accidents arising out of their teaching.

The field of FE was narrowed to engineering workshop practice because the nature of this work lent itself to the identification of safe working procedures in a large number of steps in various processes. It had the additional advantage that there were a large number of students in many different colleges following courses which included this area of study.

I sought evidence by investigating the way in which students followed recognised safe working procedures in their practical work. As in all my research, the intention was to find out what was actually happening about safety, rather than what was thought to be happening by those in authority.

First, it was necessary to examine the safety needs in the chosen area of work to see what procedures the students should be following. This required a look at how recommended safe working procedures had evolved and consideration of their relevance to the student of today. For instance, now that men wear their hair long it was necessary to consider whether safe working procedures which take account of this should be followed.

Long hair

From the earliest days H.M. Factory Inspectorate have expressed concern about scalping accidents which have occurred when the hair of the victim has been caught up in revolving machinery. One of the first reports on accidents by the inspectorate (Parl. Papers, 1843) included the case of a young woman who had 'lost part of the scalp of her head from being caught by her hair, with a very narrow escape of her life'. Today, over 130 years later, such accidents are still happening. In the most recent report of B. H. Harvey, H.M. Chief Inspector of Factories (Parl. Paper, 1974a) the danger of long hair becoming entangled with rotating parts was pointed out in a special section dealing with accidents on lathes.

Unfenced shafting was the most common agent of injury in the earlier accidents. Such horrifying accidents were inflicted in a most casual way ('...she threw back her long hair...'), that accidents caused by drills and lathes were obscured until such time as guarding of shafting was more satisfactory and later when its use declined with the advent of motorised machines. Projecting set screws on rotating parts of drills and lathes were seen as a particular cause of entanglement of hair and clothing and manufacturers were urged to set these flush (Parl. Papers, 1901 and 1913). Today it is a requirement of the Factories Act, 1961* that they should be sunk or guarded so as to prevent danger.

Rules and recommendations about the wearing of head covering or keeping hair short have a long history. In 1859 a manager in a cotton mill enforced a regulation that in a certain part of the mill all the women should wear a hat and a jacket (Parl. Papers, 1860).

During the last war, with the employment of additional women in factories, accidents due to loose hair and clothing increased and a campaign was launched for the wearing of caps and overalls (Parl. Papers, 1941). There was a similar campaign in the U.S.A. In America and in this country, the danger was increased by women following a style created by the film actress Veronica Lake. At a time when most women wore their hair fairly short, Miss Lake had long, fine, blonde hair hanging loose over one eye. Early in 1942, it was publicized here that the American War Manpower Commission, through the War Production Board, had requested Miss Lake to refrain from wearing her hair long for the duration of the war. The reason for this could not have been made clear: Miss Lake, for one, seemed to think that the concern was for production, rather than people; in her autobiography she said '... I must admit I was flattered to think I had become that crucial to our war effort. The last thing I wanted was to have caused a work force of one-eyed women fouling up the defence machinery.' (Lake, 1969).

The campaign lapsed after the War and its message faded to such an extent that by the time that men began to wear their hair long, the editor of the British Journal of Industrial Safety (Anon, 1964), felt it necessary to publicly criticise safety officers who had drawn attention to dangers

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* Factories Act, 1961 9 & 10 Eliz 2 C 34.

associated with the practice. He asked why there should be an outcry over a few men with long hair '... when there was no evidence of a campaign to get women to wear hair nets or to have a "short back and sides"...'

British Railways were presumably talking to men rather than women when in 1954 they told their 'Shopmen' to either see that their hair was maintained at a 'sensible length' or to wear a suitable cap. G. Barnett, H.M. Chief Inspector of Factories (Parl. Papers, 1950-51) thought it would be good practice if one of the conditions of employment of apprentices was that hair must be kept short: this thought was prompted by an accident where an apprentice had removed the guard from a sensitive drilling machine and was using the table of the machine as a writing desk when his long forelock was caught by the running drill and pulled out.

Perhaps strict observance of the law relating to the fencing of machinery would make the wearing of caps unnecessary. A metropolitan magistrate, hearing a case where the defendant had relied on women and girls wearing caps, once remarked 'The law requires you to fence the machine, not the girl' (Parl. Papers, 1945-46). Also a cap does not give complete protection. When reporting on 71 hair entanglement accidents analysed in the Birmingham division in 1942, Arthur Garrett, H.M. Chief Inspector of Factories said that one of the severest occurred to a girl wearing a cap. Nevertheless the Chief Inspector felt that a well designed cap, properly worn, was a great protection (Parl. Papers, 1942-43).

There are difficulties in guarding machines - a lathe, for instance, so that long hair cannot somehow get caught up in a rotating part. It would be foolish to expect to find complete guarding at times in all places of work, therefore the correct training of a student in a college should include the restraint of long hair. The syllabus of the Council of Technical Examining Bodies for basic engineering craft studies Part I contains under the heading of Dress and Behaviour, a section about the avoidance of dangerous items of clothing and long hair in proximity to moving parts.

To restrain long hair is felt to be a desirable procedure in industry; in the booklet Machine Shop Safety published by the Royal Society for the Prevention of Accidents (1974), keeping long hair well inside a cap when at work is advised. Railway shopmen are still told to keep their hair short or under a hat (British Railways Board, 1968). Bulletin E2 of the North Western Regional Advisory Council for Further Education (1965) said that long hair should be avoided or kept under control by students using lathes. The Code of Safety Practice published by the Engineering Industry Training Board (1972) stresses the danger of loose hair.

Apparel

Whereas hair is perhaps most likely to get entangled at drilling machines, clothing is most likely to get entangled at lathes. But it has been amply demonstrated over the years that all rotating shafts or workpieces, be they smooth or threaded, fast or slow running, are highly dangerous, and it has been said that the danger is accentuated a hundred-fold if those working at the machines are wearing any loose, frayed or torn clothing, dangling ties or scarves, or long hair (Department of Employment, 1971). An investigation of lathe accidents which were notified to H.M. Factory Inspectorate during the first six months of 1973 revealed that wearing gloves, loose sleeves, other unsuitable clothing and long hair, accounted for nearly two-thirds of the accidents due to entanglement with rotating parts (Parl. Papers, 1974a).

The difficulty of ensuring that even well-known hazards are fenced and hence the need to impress upon a student that he should not take risks by being unsuitably attired is exemplified by the way in which lathe carriers have caused entanglement from the time they were first used to the present day. In his report for 1898, Arthur Whitelegge, H.M. Chief Inspector of Factories and Workshops (Parl. Papers, 1900) drew attention to the very many accidents on smaller lathes due to clothing caught by the projecting set-screws and leg-ends of carriers holding workpieces. Similar accidents were reported time after time in subsequent reports and they were still occurring 70 years later, although by this time a glass-fibre cover which could give the operator full protection from the rotating projections of a carrier had been developed (Anon, 1968).

Warning of danger of entanglement in milling machines was given by the Committee on the Safeguarding of Milling Machines (Ministry of Labour, 1967); they said :

> 'Continuing experience emphasises the need for the prevention of all loose clothing near parts which are in motion... It is essential to prevent any loose clothing in the region of the wrist and forearm because in some cases, absolute safety cannot be ensured by guarding which may be practicable for a particular operation; loose garments may be picked up and tracked into very small openings.'

An interesting point made by the factory inspector for the Birmingham district in 1901 (Parl. Papers, 1902) does not seem to have been given the attention it obviously deserved. He stated that the seriousness of some accidents which occurred when a projecting set pin on a drill caught the sleeve of the operator was greater than would otherwise have been the case due to the habit of turning up the sleeves to the elbows effected by some men. Had the sleeve been fastened at the wrist then the set pin might have torn through the single thickness of cloth, but when it encountered the rolled-up sleeve, the danger was increased because not only did the rolled-up sleeve offer a better chance for the set pin to grip the cloth but the pin got firmly caught in the four or five thicknesses of cloth which would not give way so easily. Nowadays, drills no longer have projecting set pins but there are still dangers, perhaps some as yet unseen, therefore, the warning is still relevant. Throughout the years advice to roll-up sleeves has continually been stressed, for instance, a notice in a works' training school in 1938, referring to lathes read, 'Do not wear loose sleeves, always have these rolled-up above the elbows and close fitting when operating a machine' (Parl. Papers, 1938-39). A local FE college in its current prospectus advises students taking practical instruction in its workshops to take off their jackets and ties and roll-up their sleeves. Another college, in its safety rules for engineering students, says 'Sleeves must be rolled back or buttoned at the wrist'. However, more enlightened advice comes from senior safety organisations. The Royal Society for the Prevention of Accidents (1974) advises close fitting overalls without cuffs. The ILO Model Code of Safety for Industrial establishments says that shirts with short sleeves should be worn in preference to shirts with rolled-up sleeves. Rings and wrist watches are generally prohibited in safety rules for engineering workshops but in his report for 1942, H.M. Chief Inspector of Factories (Parl. Papers, 1942-43) remarked that although the removal of rings during work on machines was desirable, he had little evidence that rings were a direct cause of accidents. However, the risk did exist, as was shown by a report in 'Accidents' (Department of Employment, 1971) of an accident where the wedding ring of a woman drilling machine operator was caught by the drill point as she was sweeping her hand across the drill table to clear accumulated work to one side. The injuries were such that the finger had to be amputated. It was said that there had been a history of accidents involving the entanglement of women's finger rings in drilling machines in the factory.

The Committee on the Safeguarding of Milling Machines, in their Interim Report first published in 1947 (Department of Employment and Productivity, 1969b) said that accidents in conjunction with only partially fenced cutters in motion had occurred through the wearing of jewellery, such as rings.

There is a parallel between entanglement accidents and eye injuries in that both can be prevented by the wearing of items of apparel as an alternative to effective guarding and screening. It is better to guard the machine but there are some acknowledged difficulties, as with a radial drilling machine, for example, when it is necessary to drill a hole close to a vertical face (Ministry of Labour, 1967). In other machining operations the work may be managed better if the operator wears eye protection rather than makes use of guards on the machine. Difficulties should be overcome if at all possible because of the reluctance of people to wear goggles or safety spectacles. Rather surprisingly, the Department of Education and Science (1973) considers the wearing of safety spectacles to be preferable to transparent screens attached to lathes. It is possible for a metal particle to get past a screen, perhaps by rebounding from the bed of the lathe, but this seems to constitute a lesser risk than the likelihood of safety spectacles being pushed onto the top of the head, or left off entirely.

Goggles are usually hot and uncomfortable, spectacles can be easier to wear if properly fitted. Good fitting and a fashionable design are generally thought to make safety spectacles more acceptable but Powell (1971) found that even when these conditions were met, there was still an unwillingness to wear them. This stems, I believe, from the fact that unless they correct defective eyesight, spectacles are an impediment to vision and irritating to wear. Under these conditions they are left off because, as Bremner Davis, a factory inspector, said about this problem in 1911 :

> '... many men escape without injury for years and knowing this, they regard the risk as not greater than the many of all kinds to which all in different ways are subject.' (Parl. Papers, 1912-13)

At that time the accepted level of risk must have been high, or the goggles extremely uncomfortable because in the same year, another inspector reported that a surgeon at a very large opthalmic hospital had said that even men who had lost the sight of one eye would refuse to protect the remaining one (Parl. Papers, 1912-13). Nevertheless, in the worksof one of the railway companies at that time, a reduction in eye injuries was obtained by rigidly enforcing a rule that all persons employed on wheel lathes must wear goggles (Parl. Papers, 1912). In Prussia, many years before, in the period 1869-1889, the State Railways had taken the more desirable step of using guards on their lathes to protect the workmen from pieces of metal thrown off from the tools (Collection, 1895).

Reliance was generally placed entirely upon goggles until suitable transparent guards became available. In 1927, Gerald Bellhouse, H.M. Chief Inspector of Factories and Workshops (Parl. Papers, 1928) reported that in a particular firm, eye injuries caused by brass finishers' lathes were high until the firm were induced to fit transparent shields and that since that was done, not a single eye injury had been reported. The growing concern over eye injuries such as evidenced in this case, led eventually to the Protection of Eyes Regulations 1938. This required eye protection to be provided for specified operations which included the turning of non-ferrous metals and cast iron. The dry grinding of metals or articles applied by hand to a revolving wheel or disc driven by mechanical power, was also covered by the Regulations.

The effect of the Regulations was obscured by the outbreak of the second world war. Under wartime conditions, all accidents increased; after the war, there were still difficulties in getting the Regulations observed. One conscientious foreman was reported as saying that his effort to induce his men to wear goggles caused him more unpleasantness and friction than any other of his duties (Parl. Papers, 1951-52). By 1951 the total of eye injuries reported to H.M. Factory Inspectorate was only slightly below the 1939 figure, but only a small proportion of these occurred in processes covered by the Regulations. In his report for 1953, G. Barnett, H.M. Chief Inspector of Factories (Parl. Papers, 1954-55) said that whether the Regulations could profitably be extended was debatable. The debate continued for twenty years until the Protection of Eyes Regulations were made in 1974. These extended the Regulations to cover, among many other items, the machining of metals where there was a reasonably foreseeable risk of injury to the eyes of any person engaged in any such work from particles or fragments thrown off.

My investigation of accidents had shown that students were at risk in the work that they did on lathes, shaping machines, milling machines and drilling machines. Except for drilling machines, these machines were rarely provided with protective shields, therefore, until this is done, students should wear safety spectacles or goggles when they are put at risk by operating these machines. That the same argument applies to off-hand grinding operations needs little further support. In a special study of accidents that occurred at abrasive wheels during the year 1955, the results of which were used as the basis of a draft code which was subsequently developed into the Abrasive Wheels Regulations, 1970, 235 cases of eye injury were found. It was said that there was little doubt that all these would have been prevented by the use of suitable goggles (Parl. Papers, 1956-57).

Dangerous acts

Under this heading I have grouped actions which appeared to me to be obviously dangerous. They were leaving a machine running unattended, directing compressed air at people, throwing something at or to another person, using a file without a handle, stopping a lathe or drill by placing a hand on the rotating chuck or spindle. It is not difficult to perceive that any of these actions would be likely to lead to an accident if practiced, certainly the risk should be well known to lecturers and prohibition of the acts strictly enforced by them. In rules printed in 1871 by a firm who made and repaired agricultural implements, one item read 'Any person throwing at another ... shall be fined threepence' (Hudson, 1970). In respect of a file without a handle, the North West Regional Advisory Council (1965) in one of their bulletins remark '... many a file tang has pierced the hand and even a stomach'. The dangers of the misuse of compressed air have been well publicised: the Royal Society for the Prevention of Accidents (1973) have a special booklet on it.

Some of the dangers were at first not obvious. In 1920 a factory inspector described how milling machine accidents in one factory, which occurred when operators were removing swarf, had been almost stamped out by the use of a blast of compressed air to remove cuttings and swarf from the point of danger on the machines. He suggested it might be applied for this purpose generally (Parl. Papers, 1921). By 1950, G. Barnett, H.M. Chief Inspector of Factories was complaining that the increasing use of air lines for the removal of swarf was giving rise to a number of accidents (Parl. Papers, 1951). He suggested that a reducing valve be fitted to lessen the chances of injury from high pressure, but this was not likely to have been effective because, as is now recognised, the pressure necessary to remove particles of metal from a machine is also strong enough to blow them into the eyes, ears, or skin of people nearby. This danger and others is described in the booklet published by the Royal Society for the Prevention of Accidents.

Swarf - risk to hands

Among the types of accidents which have been found to occur time and time again on milling machines are those involving the removal of swarf near cutters in motion (Ministry of Labour, 1967). There are obvious dangers of minor cuts from cleaning up swarf with bare hands or with a hand rag, also a rag may become entangled in machinery.

I described on p. 137 how a university technician felt the finish of a workpiece in a lathe and caught his hand between the workpiece and the tool. Accidents such as this have been happening for a long time but attention was not drawn to them until accidents on lathes due to unfenced gearing were reduced. This led to consideration of other types of accidents. In 1900 it was found that a great many of the lathe accidents reported to H.M. Factory Inspectorate concerned workers' hands being caught between the tool and the job (Parl. Papers, 1901). A superintendent inspector remarked on them again in the following year (Parl. Papers, 1902). Additionally, there is a risk of entanglement of clothing if the hands are placed on rotating work.

In order to keep the minor accident rate down, attention has to be given to reducing cuts to fingers and hands. These injuries have been found to occur in ways such as when milling cutters are being lifted without the protection of a rag around the cutters, and when workpieces are lifted by placing the fingers in holes or slots which have sharp edges.

Switching off machines

There are several reasons why students should be taught the correct use of isolating switches. Not least among these is that it requires a deliberate act to start a machine. Their use thereby removes the danger of a workmate of the operator pressing the start button aimlessly when talking to him, a danger which led to recommendations for special arrangements for starting milling machines (Ministry of Labour, 1967).

When belting and shafting were used with machinery, some degree of intentional physical effort was necessary to operate the belt-shifting mechanism to start a machine. When individual drives replaced the belting and shafting, machines could be started by light-finger pressure on a start button. G. Barnett remarked on the possible dangers of this in his report for 1956 (Parl. Papers, 1957-58). This was nearly 60 years after an inspector had noted that the increase in the use of electricity as a motor power was doing away with much 'gearing and shafting'. The inspector had taken the opposite point of view to Mr. Barnett and seen the great advantage of being able to stop machinery quickly in the event of an accident (Parl. Papers, 1900).

Another way that an accident can happen because the isolating switch has not been used was reported by the London and Home Counties Regional

Advisory Council (1970). A student was re-positioning the belt of a vertical drilling machine when another student, not realising that the machine was being adjusted, started it. The first student's fingers were caught between the belt and the pulley wheel and he had to receive hospital treatment.

Failure to isolate a machine while making adjustments to it can also lead to the people working on the machine starting it unintentionally themselves, an example from industry is described in a Department of Employment (1973) publication. A skilled maintenance engineer was working on a lathe, he caught the start lever with his elbow, the chuck turned and caught his thumb.

The need to isolate a machine at the end of the day, and after the operator has ceased to use it at other times, impressed itself upon me when I visited the woodwork shop of a light engineering company recently. I was shown a cross-cut saw which had been found running when the shop was opened up one morning, it was then switched off at the motor but it started up again soon afterwards when no-one was near it. Obviously it was an electrical fault; one that might have occurred when the saw was being changed.

A mechanical failure which caused an accident was the subject of a report by the London and Home Counties Regional Advisory Council (1970). The retaining pin on the clutch of a lathe broke due to metal fatigue and the clutch automatically engaged with the drive. A student was changing a workpiece in the chuck at the time and his hand was dragged between the rotating chuck and the lathe bed by the chuck key. He had kept the motor running while changing the workpiece. The practice of keeping the motor on while measuring the work or making adjustments has often led to an accident, I described one that was reported to me on p. 96.

Advice to isolate machines before adjustments are made has come from many quarters, one of the most authoritative, H.M. Factory Inspectorate, have said that it should be simply stated that

> '... as a general principle of safe operation of all machinery, ... during adjustments and measurements there should be no power capable of causing movement in any dangerous part. The machine should always be switched off from its source of power.'

<u>Checks before starting machines</u>

The advice on checking that all is well before starting a machine used to be something similar to that given by Pull (1941) in the 9th edition of his standard work, which was described as being 'For students, apprentices, fitters, turners, and general machinists'.

> 'Try the lathe by giving a few turns on the belt by hand, and make quite sure that everything is clear and safe.'

This advice was given to make sure that the job would be done right, not to ensure the personal safety of the operator. The author was thinking of the machine-age which Rolt (1965) described when he said that as late as 1930 the average British production machine shop was still a dense jungle of leather belts and line-shafting. The hand-book issued by the well-established American manufacturers of machine tools, Brown and Sharp (1942), about the same time as Pull's 9th edition was published, gave the more up-to-date advice :

> 'After fastening the work in the chuck, give the chuck a complete turn to make sure the work clears the machine.'

This is the sort of check now advocated by most authorities, an example taken from a text book by Houghton (1963) reads :

> 'Prior to putting the lathe under power, take the machine over by hand to ensure that nothing fouls the slides or lathe bed; check every bolt and packing piece, thus making sure that each is securely fastened.'

When a machine is not checked like this there is a possibility of an accident such as that I described on p. 135 where a student was struck by a broken bolt from a planing machine.

The importance of checking that the workrest of an off-hand grinder is properly adjusted has often been stressed. If the user is not trained to check the rest before using the machine, an accident such as described in the London and Home Counties Regional Advisory Council (1971) report is likely. In this case a special course for welders had led to heavy use of a grinding wheel for removing metal from welds. A student in the class that followed that of the welders used the grinder and the metal he was holding was caught in the gap which had opened up between the wheel and the rest. Fortunately he suffered only slight injury to his finger tips and nails.

In the Department of Employment (1973) publication on accidents in factories, it was pointed out that, in connection with an identical accident in industry, there was a breach of the law in force at the time relating to the fencing of machinery. This was prior to the introduction of the Abrasive Wheels Regulations, 1970, which now apply.

In the book written by Harrison (1872), in 1868, he advised the 'young mechanic' to cultivate order in the arrangement of tools upon the bench, for if a man was untidy he said '... we soon feel distrust of any great ability of the workman'. The National Institute of Industrial Psychology (1944) said that tidiness was the foundation of safety and that learners should be shown the importance of keeping tools and materials in their proper place.

Keeping tools and equipment tidy on the bench should help keep down minor accidents. Keeping spanners, hammers, and other loose tools in trays provided on machines may prevent some major accidents.

Drilling sheet material, or thicker material with other than small diameter drills, without clamping it to the table often causes accidents. Inexperienced persons are not aware of the dangers of the practice. Some serious accidents caused by it were brought to the notice of G. Barnett, H.M. Chief Inspector of Factories in 1949; he said that in one of his districts there were three cases of severe arm and finger injuries to boys, all due to the workpieces on drill machines being seized by the tool and carried round (Parl. Papers, 1950-51). The way that even experienced men over-estimate their ability to master a machine on this work was described long ago by Watson (1880): he wrote, in 1866, that he had seen mechanics attempt to drill small castings on a lathe by holding them in their hands against the dead spindle, a practice which he said was 'often attended with bruised or lacerated fingers, the result of the work "getting away" from their grasp'.

Leaning on a machine was described as a dangerous habit by the National Institute of Industrial Psychology (1944) and one that could become a habit very easily. The British Standard (1968) on school workshops says that sitting on or lying across a machine even though it is inoperative leads to careless habits and should be discouraged. Leaning on a machine when it is running is obviously dangerous.

In his 1973 report, B. H. Harvey, H.M. Chief Inspector of Factories, showed how his analysis of lathe accidents had highlighted the risk of injury when polishing or dressing operations were performed with the aid of hand-held emery cloth, wire wool or a file. The dangers of these practices has been realised for some time and in a bulletin of the North Western Regional Advisory Council (1972) the use of emery cloth to improve the surface finish of a turned component was cited as a 'classic case of a bad example' found daily in college workshops. There was a time when no danger was seen: Rose (1905) described in his book how to polish work in the lathe using the file and emery paper, he said :

> '(To produce) a really fine finish revolve the work very fast... and keep the emergy paper moving rapidly... continually reversing its position in the hand so that all parts become worn.'

In this we have yet another example of how although safety knowledge has improved over the years, it has (as I shall show in the next chapter) failed to get through to education establishments.

Safety survey

When, in 1969, H.M. Factory Inspectorate made an investigation of the safety content of instruction in the working of lathes and horizontal milling machines given in training courses approved by the Engineering Industry Training Board, they visited two training centres, three training schools attached to factories, and three FE establishments (Department of Employment and Productivity, 1969b). It would seem that the standard of safety that they found in the FE establishments was no more acceptable than that found in the other centres. There was a lack of appreciation of safety requirements by many instructors, and little grasp of the safety content of the work by trainees. In almost all of the places visited it was found that trainees were allowed to use strips of emery cloth on lathes, and that the guarding of milling machines could have been improved.

Arising out of the investigation, the following conclusions and recommendations were made to the Sub-Committee on Safety Training of the Industrial Safety Advisory Council, who had initiated the investigation :

(i) There was considerable variation in the extent to which the instructors appreciated what is involved in the concept of safety training, in the context of different machines. It is, therefore, recommended that arrangements should be madefor instructors to receive appropriate guidance.

(ii) It is recommended that data sheets dealing with the dangers of the particular machine and the precautions to be observed should be prepared and issued to instructors.

(iii) It is recommended that there should be systematic arrangements for verifying that the trainee has understood the safety content of his training.

(iv) It is recommended that steps should be taken to improve the standard of guarding of cutters of horizontal milling machines, and to encourage suitable holders for emery cloth.

The circular letter FECL 1/70 issued by the Department of Education and Science (1970) which followed the report, emphasised the responsibility of teachers for ensuring that safe procedures in the use of machines, equipment, and materials were thoroughly understood and practised but did not repeat the recommendation that they should receive appropriate guidance. So far as the suggested data sheets were concerned, the Department said these should be given to the trainees, not the instructors (lecturers) as recommended by H.M. Factory Inspectorate. No suggestions were made about the other two recommendations.

Only the apprentice training school and one of the ten FE establishments, for which I evaluated safety activities, as described in Chapter 5, had produced printed safety instructions applicable to a particular workshop, machine, or job. One establishment, outside the evaluation exercise, which I visited, Henley College of Further Education, Coventry (1972), had a booklet for issue to engineering students which I found useful in developing the checklist described in the next chapter.

CHAPTER 13

THE APPLICATION OF SAFETY NEEDS IN ENGINEERING WORKSHOP CLASSES

The use of safe working procedures by students in engineering workshop practice classes provided in FE establishments was investigated by means of a questionnaire/checklist. There were over 70 items requiring responses from students in this: most of the items concerned machine work but a few related to benchwork. The need for these procedures was examined in the previous chapter.

The questionnaire/checklist was administered to 360 students taking a full-time 48-week course of basic engineering training integrated with an FE course. Rather more than half the students were taking mechanical engineering craft studies Part I as their FE course; the others were taking general, technician, or ordinary national certificate (ONC) courses according to their academic ability, and some were, in addition, preparing for the examinations of the mechanical engineering craft studies course. All were following the same detailed scheme of practical work and only in exceptional cases had they had experience in industry.

Students such as those in my sample may be categorised as craft, general, technician, or ONC according to the type of FE course they are following. They are placed in a particular category according to their examination results at school, the job they are training for, and possibly a selection test at the start of their training. For a non-craft student the general course provides preparation for either the technician course or the ONC course, and at the same time determines which of the two courses he should follow in further studies. When the diagnostic general course is not required the non-craft student makes a direct entry into either the technician course or the ONC course, provided he has the necessary entry qualifications.

Van der Eyken (1972) has described how the Further Education Group at Brunel University tested classes of craft, technician, and ONC students with a series of cognitive tests in English and mathematics together with a standard intelligence test (AH 4)*. In the Brunel sample of 570 students a well-established bias towards the non-verbal level of ability was found in the intelligence test results. When different classes were examined it was found that their overall mean scores in the tests indicated a general increase in ability from craft classes to technician classes to ONC classes. But within the craft sub-group of the sample some craft students who had been specially selected by the aero industry had scores on the tests that were more comparable to the scores of non-aero technicians than they were to those of other craft students. Without the aero students there was still a wide range of cognitive ability among craft students. An analysis showed that on the basis of the test results something like 14 per cent of all students could have had their categories altered.

For the work covered by my study it seemed reasonable to assume that students in the sample I used had all been drawn from the same population.

Strictly, the practical work carried out by students on an integrated course is regarded as training rather than education but with this type of work especially, fine distinctions cannot be drawn between the two. Moreover, courses of this type have become an important part of the work of a large number of FE establishments, and there are relatively few establishments of this type that do not provide courses which include an element of engineering workshop activity.

The research took place in ten colleges and one apprentice training school attached to a large works. This was the same sample that was used in my investigation of safety activities described in Chapter 5. The apprentice school was included to provide a comparison with the colleges; students attended the school for the training element of the course and a nearby college for the FE element.

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* Heim, A. W. (1967) Manual of the AH 4 group test of general intelligence, Slough, National Foundation for Educational Research.

Pilot work

The whole of the pilot work and initial testing was carried out in one college with 82 students who were in the first year of Part II of the mechanical engineering craft studies course, the second year that is of their attendance at the college, but on a day release or block release basis. All of them had attended the college in the previous session, 72 of them had taken the integrated course, the other 10 had received their basic training in the apprentice school referred to above. Their second year course included more advanced work in engineering workshops.

An indication that a questionnaire could be used to reveal safe and unsafe methods of working by students came from Tarrants' (1963) study of the feasibility of using the critical incident technique developed by Flanagan (1954) to identify accident causes. Tarrants' work indicated that the technique could dependably reveal errors and unsafe conditions which had led to industrial accidents. The normal critical incident technique is, however, lengthy and too time-consuming to use on a large number of respondents.

Tarrants' interviewers, in their preliminary interviews to explain the project, presented orally to the respondents a list of accident causal factors; the respondents were given an opportunity to ask questions, and then given the list to take away with them so that they would have its assistance in recalling incidents where accidents had occurred. Later, in the actual data collection interviews, the interviewers probed for answers by asking questions from the list. This procedure indicated that the technique might be simplified by presenting as many as possible accident causal factors to a respondent and asking him to state whether he had seen them and if so, how often. This would be in accord with the technique explored and defined by Flanagan for he makes the point that the critical incident technique does not consist of a rigid set of rules governing data collection. Rather it is a flexible set of principles which must be modified and adapted to meet a specified situation. He also says that one procedure is to record incidents on forms which describe most of the possible types of incidents by placing a check or tally in the appropriate place. Of postal questionnaires he says :

'In situations where the observers are motivated to read the instructions carefully and answer conscientiously, this technique seems to give results which are not essentially different from those obtained by the interview method.'

The questionnaire eventually developed (Appendix 5) was designed to be used in a classroom and to be introduced to the student-respondents by the researcher. In this situation it was believed that the students would answer conscientiously because they would be motivated to help a researcher who showed a personal interest in them. Individuals were asked only about their own actions rather than those of other people as had been the case in Tarrants' study because it was the individual's own version of his experience which was required.

The record of incidents which was developed for completion by the students is a checklist rather than a questionnaire, and the more appropriate name of checklist was eventually adopted. Originally the format was more that of a questionnaire and remained as such until the final stages of testing.

The questions used were based on the recommendations and safety hints from various sources, which were discussed in Chapter 11. Each question was in two parts. The first part of the question was concerned with the frequency of the procedure. The second part was concerned with whether or not the procedure, or lack of it, had ever led to either damage or injury, or both. The supplementary questions were included with the object of finding out which of the procedures had been found to be most unsafe by the students.

FIGURE 4

Second format of questionnaire

(Students were required to ring the appropriate number)

GENERAL ITEMS	Never	Once or twice	Several times	Often	Always	No opportunity or not applicable
Have you opened or removed a guard before a machine has stopped? ...(1)	0	1	2	3	4	5
Has this contributed to damage or injury?	6	7	8	9	10	11
Have you leaned on a machine when it has been running? ...(2)	0	1	2	3	4	5
Has this contributed to damage or injury?	6	7	8	9	10	11
Have you left a machine running when you have moved away from it? ...(3)	0	1	2	3	4	5
Has this contributed to damage or injury?	6	7	8	9	10	11
Have you switched off the machine you have been using at the isolating switch at the end of the class period? ...(4)	0	1	2	3	4	5
So far as you know, has not switching off contributed to damage or injury?	6	7	8	9	10	11

Two technical college lecturers well experienced in teaching machine shop practice went through the questionnaire and suggested some small amendments. They agreed that its contents covered the unsafe methods adopted by students. 'It reads as though you have been watching over their shoulders' was one of the comments made. They could not think of any additional items that ought to have been included.

Next, the questionnaire was put orally to two students, one at a time. They had little difficulty in answering the questions but the format of the questionnaire was found to be unsatisfactory. This was because of the two parts of the questions. Not only was this complicated but there was a tendency to miss the second part.

A new format, as illustrated in Figure 4, was devised and the questionnaire administered separately to three students, again orally. The new format appeared to be satisfactory, the separate question about damage and injury was no longer missed and the questioning appeared less complicated. A few questions which still caused some difficulty were re-worded.

For the next stage of compiling the questionnaire, two groups each of three students were used. Each student was given a copy of the questionnaire and he completed it himself, one question at a time as I read it out. This procedure allowed discussion to take place when any ambiguity or lack of clarity was revealed. Two questions which had previously given difficulty were felt to be inapplicable and were, therefore, dropped. Minor alterations were made to a few other questions. After it was found that the second group, which had been specially picked to represent the less cooperative and less literate body of students, were able to complete the questionnaire satisfactorily, it was felt that the questionnaire was now ready for testing.

Initial testing of responses to questionnaire

The questionnaire was completed by 44 students. Seven had assisted in clarifying the questions three weeks previously so their papers were not used in further testing. The students were in groups from 7 to 10 in size. In administering the questionnaire, I first explained that the purpose was to find out how students went about their work; I asked for their cooperation in a research project and assured them that their answers would be treated in confidence. I invited them to ask questions and walked round the room while they answered the questionnaire so that a student who wished to ask a question could do so without attracting the attention of other students. No lecturer or other person, apart from myself and the students, was present.

One of the 44 students gave answers which were obviously unreliable, for example, after stating that some actions had never been performed, he went on to say that they had caused damage or injury. His lecturer had said that he had a language difficulty and would not be capable of fully understanding the questions. This was confirmed when I attempted to get the student to understand what he was required to do. His paper was, therefore, disregarded. Little difficulty was experienced by the remainder of the students. They took from 15 minutes to 40 minutes to complete the questionnaire - the average time was 25 minutes. One other questionnaire could not be fully completed by the student concerned as he had not taken the first year course - his paper was also disregarded.

With the object of comparing the constancy of response of the students, the questionnaire was re-administered to 20 students four weeks after they had completed the first copy, with Christmas intervening. Conditions were the same as on the first occasion. The responses were then analysed.

The responses obtained to the questions about workshop procedures were first considered. Each response was scored on a five-point scale - 0 for the safest procedure to 4 for the most unsafe. Table 24 shows how responses

TABLE 24

Change of response to trial questionnaire
on retesting 20 students

Ident. no. of student		No. of resp. to both q'naires	Change by points shown 1	2	3	4
1		73	18	11	3	4
2		73	26	5	2	1
3		73	19	13	1	4
4		73	21	6	2	3
5		71	23	4	3	0
6		73	27	4	2	1
7		72	25	6	2	1
8		73	12	8	5	1
9		71	28	6	2	1
10		71	18	4	2	5
11		73	29	8	3	1
12		72	25	3	1	0
13		71	17	6	2	0
14		70	21	5	5	2
15		72	16	4	3	7
16		69	14	4	0	3
17		73	30	10	3	0
18		73	27	4	3	5
19		72	25	7	1	4
20		72	18	1	2	1
Totals	:	1440	439	119	47	44
% Totals	:	100	30.5	8.3	3.3	3.1

varied. Changes of one point are not very significant. Kendall (1954) has described how, when distinctions between answers to be selected are minor ones, two alternatives are selected with more or less equal frequency, and with repeated testing there is considerable vacillation from one alternative to the other. Changes of two points could be caused by the same sort of vacillation. An excessive number of such vacillations would have caused the category statements from which the respondent had to make his choice to be called into question. However, a change of two points could also be caused by the respondent misreading the question on one occasion and placing his response on the wrong side of the central point. There were times during the oral testing when students made a complete reversal of response and said 'Always' when they meant 'Never'. The reverse change also occurred. For example, when answering the question 'Have you switched off a machine at the isolating switch before removing or re-fitting a chuck, faceplate, cutter, drill, etc.?' - the latter part of the question was coupled with 'switching off' and the student said 'Never' meaning that he had never changed a chuck etc. without switching off. A complete reversal of response such as this would cause a four-point change. A three-point change could occur in the same way if it was coupled with a swing of one point.

Two-point changes which were caused by a movement of the response from one side of the central point to the other numbered 69 out of 1440 pairs of responses (4.8 per cent). When such changes were included with three-point and four-point changes, a reversal of response was shown in 11.2 per cent of paired responses.

Not all changes, of course, would occur in this way. Kendall found that interviewees who lack interest in a topic are likely to give perfunctory responses, and (in terms of his analysis) such responses are unstable. There was no evidence of a lack of interest on the part of the student-respondents. Completing the questionnaire made a welcome break from their

TABLE 25

Scores for pairs of trial questionnaire completed by 20 students

Ident. no. of student		Test score	Retest score	Diff- erence
1	:	1.10	0.96	0.14
2	:	1.79	1.79	0.00
3	:	1.94	2.15	-0.21
4	:	1.12	1.39	-0.27
5	:	1.63	1.75	-0.12
6	:	1.49	1.46	0.03
7	:	1.54	1.79	-0.25
8	:	0.97	0.76	0.21
9	:	1.00	1.18	-0.18
10	:	1.51	1.37	0.14
11	:	1.52	2.03	-0.51
12	:	1.56	1.29	0.27
13	:	1.05	1.12	-0.07
14	:	1.40	0.99	0.41
15	:	1.51	1.04	0.47
16	:	0.88	0.67	0.21
17	:	1.87	2.29	-0.42
18	:	1.42	1.75	-0.33
19	:	1.47	1.33	0.14
20	:	1.27	1.29	-0.02

normal classroom routine and they showed the usual willingness to help someone who considered their answers to be of value. Some perfunctory responses were no doubt made but these were felt to be comparatively few in number. If this was so, clearly a reduction in the accidental reversal of response would improve the accuracy of the questionnaire.

At a later stage in the development of the questionnaire, the accuracy of response was improved but first, parametric aspects of the responses were considered.

A mean score was computed for each completed questionnaire by summating the scores awarded for item-responses and dividing by the number of responses. It was necessary to use mean scores rather than total scores because there were instances - a few only - where some items were not applicable to the respondent. The mean scores are shown in Table 25.

When summated scores from a questionnaire such as this are used for comparison between one score and another, the following assumptions are made :

(i) that the item-scores are on an equal interval scale;

(ii) that the items are of equal weight.

It was felt that the five-point scale approached an equal interval scale sufficiently well to justify the first assumption. In the development of his well-known scaling technique Likert (1932) found that the integral values 1 to 5 for five-choice responses gave scores just as reliable as the more involved 'category-scale' method. This method weights the category responses in an attempt to produce a scale which has equal psychological intervals. The safe-unsafe rating used in the questionnaire resembled a Likert five-point rating, (strongly approve, approve, undecided, disapprove, strongly disapprove) closely enough to support the belief that it would have the same reliability in respect of the intervals between the choices.

The second assumption is justified by strong evidence that in tests and measures composed of a large number of items, weighting items differentially does not make much difference in final outcome. For instance, Guilford (1954) says that differential weighting of items usually pays little dividends when there are more than 10 to 20 items.

Using the mean scores for test and a re-test, an estimation was made of the reliability of the questionnaire. Reliability in respect of a test is formally defined as the ratio of true score variance to observed score variance. It is an index of the amount of variable error in a test. This varies from zero when the measurement involves nothing but error to one when there is no variable error at all in the measurement. Since with the test - re-test procedure any flunctuation in score from one testing to the other is called error, the index is sometimes referred to as the 'coefficient of stability' (Cronbach, 1951).

Helmstader (1966) shows that the product-moment correlation coefficient (Pearson r) between scores obtained on a first and second testing provides an estimate of reliability as defined above.

It is a requirement when computing a product-moment correlation coefficient that the two sets of data are relatively homoscedastic. Guilford (1954) states that this condition will prevail generally when the two distributions are fairly symmetrical within themselves: thus, he says, we need not go so far as to compute standard deviations in order to find out.

The correlation coefficient between the test and re-test was 0.82.

In order to obtain some comparison with accepted tests, note was taken of test - re-test reliability coefficients in tests assembled by Shaw and Wright (1967). The average value of 58 reliability coefficients quoted by Shaw and Wright was 0.82. These were for tests recommended for experimental use only. For this use 0.75 was considered to be moderately reliable. Accordingly, at this stage of the development of the questionnaire, 0.82 was considered to be quite high, although as described above, an attempt to reduce the accidental reversal of responses was desirable.

Leaving aside, for reasons which will be explained later, the questions about damage and injury, a new format of questionnaire was devised. It took the form of a list of statements requiring completion by students instead of questions requiring an answer as had been required previously. It was felt that this would make the accidental reversal of response described above less likely. Additionally, the answer 'Often' was changed to 'Nearly Always' to give a more balanced scale and because some students had queried the difference between 'Several times' and 'Often'.

Twenty-one questions which had shown the greatest reversal of response were made up into a checklist together with one other originally ambiguous question which it was felt desirable to re-test.

The checklist was put twice to 18 students, who had not previously been involved in the tests, with a three-week interval between test and re-test.

In explaining how the checklist was to be completed, the statement given below was used as an example :

I have	never once or twice several times nearly always always	been late for a General Studies class.

The students were shown how to select the most appropriate of the alternatives to complete the statement as it applied to them and how to indicate their selection by putting a ring round it. It was pointed out to them that if they had never attended a General Studies class, perhaps because it was not included in their course, then to ring 'never' would be misleading. If such a case occurred when they completed the checklist, then they should strike out the whole statement to indicate that it was not applicable to them.

The results from the checklist were then compared with the responses

TABLE 26

Percentage of responses changing on re-testing
by number of points shown in two different formats
of checklist (21 items)

		Points change					
Format	:	1	2	3	4		Total
1	:	19.5	12.7	8.4	8.9	:	49.5
2	:	29.8	7.9	6.6	2.1	:	45.8

which had been made to the same 21 difficult items* in the former questionnaire, as shown in Table 26. The complete reversal of responses was reduced from 8.9 per cent to 2.1 per cent and changes of 3 or 4 points combined from 17.3 per cent to 8.7 per cent.

Inspection showed that two-point changes from one side of the central point to the other were 4.5 per cent of total responses compared with 6.3 per cent in the first questionnaire. The indications were that the new format was less likely to lead to error in response. Obviously, wrong responses made on one occasion showing up as four-point changes in the other, had been significantly reduced. Other changes of more than one point which contained an element of vacillation due to uncertaincy as well as an element of error due to misunderstanding has also been reduced. The fact that the total percentage of changes was little altered showed up the effect of vacillation and reinforced the view that changes of one point were not significant. It also suggested that the limit of precision had been approached.

At an early stage, the pilot work had revealed the need to make clear some terms used in the checklist. Therefore the following definitions were given when the checklist was administered. The same definitions were also given later when the checklist was in its final form.

(i) Isolating switch - the switch that disconnects a machine from the mains. This was illustrated by means of a sketch on the blackboard making clear the distinction between the isolating switch and the motor switch. The students were told that if they switched off the isolating switch they did in effect switch off the motor, therefore, they could say 'Yes' when asked if they had switched off the motor.

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* Items in final checklist numbered as follows : 4, 6, 8, 20, 21, 26, 27, 29, 41, 45, 47, 50, 51, 53, 55, 56, 57, 59, 67, 69, 73.

(ii) Off-hand grinding - grinding done while holding the article to be ground in the hand.

(iii) Workrest - that part of a grinding machine on which the article being ground is steadied. Again, a sketch was used to make sure that the term was understood.

(iv) Safety hat - any hat worn to protect the hair or to keep hair in place. No necessarily one of approved design.

(v) Hair length - the length of hair at the side of the head*.

At the completion of the pilot testing, the checklist was made up in its final form as shown in Appendix 5.

Validity of items relating to workshop procedure

The validity of the content of the questionnaire was assured in respect of workshop procedures by the way in which the items had been selected, see Chapter 12. Confirmation that the procedures described were consistent with the work of mechanical engineering courses had been obtained by submitting the items to lecturers and students at the initial testing stage.

What had not so far been ascertained was whether the answers obtained were true answers. This could be checked either by continuous observation over a considerable period of time or by a form of activity sampling where a number of observations are made at random intervals of time. Continuous observation was not possible because the necessary full-time observer was not available. Such observation would have been undesirable anyway because of the effect the presence of an observer on those under observation.

Not only would the continual presence of an observer affect behaviour it would also be likely to cause resentment. Frequent visits to carry out

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* Two students were Sihks who wore turbans constantly. The question arose whether turbans could be regarded as safety hats. This was not resolved, instead it was decided that for the purpose of this research the Sihks would be regarded as though they had short hair and did not need to wear hair protection.

activity sampling would be open to the same objection. It might initially be possible to disguise the reason for the visits but apart from such a practice being ethically questionable, it would not remain long undetected.

A further difficulty in assessing the validity of the questionnaire was that whereas when completing it the students would be asked to choose the responses which described their experience over the whole of their time in the college workshops, any observations made would have to be over a shorter recent period. However, as at any administration of the questionnaire responses would be subject to a marked 'recency' effect, this was not considered to be an impediment. The student's recall of his workshop procedures would be strongly biased by, say, his last month's experiences. Accordingly, it was decided that about one month would be a satisfactory period of observation, providing it contained sufficient workshop class meetings to enable the frequency of specific procedures to be assessed.

It was impracticable to make observations without being seen. The only way to overcome the objections to an external observer was to use someone normally in the workshop when a class was present. This meant using either the lecturer or a student. The lecturer would be likely to feel that his teaching was being scrutinised and be inclined to interpret his findings so that he was seen in a favourable light. Recourse had, therefore, to be made to using students as observers.

The subjects of the validation were in two block release courses. They had not previously taken part in the pilot study. From each group, two students were selected to act as observers. The selection was made on the course tutor's recommendation; he was asked to nominate keen and reliable students. The class lecturer was told that the students were going to take part in a safety experiment and that the nature of the experiment required it to be kept confidential until it was completed. He was promised that he would receive a full explanation when the experiment was completed, in the meantime he was requested not to discuss it with the students.

TABLE 27

Comparison of questionnaire responses and observed workshop procedure of two groups of students

Ref. no.	Item no. in final check-list	Item	No. of resp. to check-list	Per cent responses: Never	Once or twice	Several times	Often	Always	Observations: No. made	Times seen %
Group A										
1	1	Open guard	8	38	63	0	0	0	80	3
2	9	Check oil	8	50	50	0	0	0	18	0
3	17	Throw to	8	75	25	0	0	0	320	0.03
4	20	Wear hat	8	13	88	0	0	0	700	0
5	40,48 58,67 73	Wear safety glasses	40	15	53	18	15	0	700	10
6	71	Adjust rest	8	88	13	0	0	0	16	0
7	34	Loose chuck	8	88	13	0	0	0	24	0
8	5	Switch off	8	75	0	13	0	13	40	25
Group B										
1			7	29	71	0	0	0	80	2
2			10	50	40	10	0	0	25	0
3			9	67	33	0	0	0	400	0.08
4			8	50	13	13	25	0	800	0
5			36	8	14	19	28	31	800	45
6			7	100	0	0	0	0	20	0
7			9	100	0	0	0	0	20	0
8			10	80	10	10	0	0	32	0

Two students from each group were used because it was felt that having a confidant would help a student to carry out a task in which he stood apart from his classmates.

The observations were made over one month of the block release course (32 hours workshop practice). The student-observers were asked to look out for eight specific procedures which the questionnaire had shown to be notable for a high degree of observance or non-observance and which were not of a momentary nature. It was necessary to select items of a kind that students were involved in frequently in order to get results which would give a measure of the frequency of their occurrence. Items of a momentary nature would not give the observer an opportunity of making observations while he was engaged in his own work.

The object of the exercise was explained to the students. It was emphasised that they had been specially selected for the task and that their assistance would not only be of value to the researcher but also to the benefit of students in general. They were asked to keep what they were doing to themselves and it was pointed out that failure to do so would endanger the whole exercise. Contact was maintained with the students by means of three meetings, in which the work was discussed, and by occasional enquiries between the meetings.

At the end of the month, in discussion with me, the observers were asked how often they had made observations, (e.g. was it at the end of a class period?); how many students they had observed on specific occasions; and how often they had seen the several procedures carried out. Their findings are shown in Table 27: they are broadly similar for each group.

If a proportion of the students say that they carried out some action 'always', then it might be expected that this action would have been observed on several occasions. Table 27 shows that this was so in items No. 8 in Group A and No. 5 in Group B. It is less likely that an action carried out 'often' would be observed, two items - No. 5 in Group A and

TABLE 28

Changes in response in re-test of 20 students
for items used in validity test

Ref. no. (As in Table 27)	No. of responses	Change by points shown			
		1	2	3	4
1	20	3	0	0	0
2	20	2	0	1	0
3	20	7	0	0	0
4	20	1	0	1	0
5	100	4	0	3	1
6	20	0	1	0	1
7	20	2	0	0	0
8	20	2	0	1	0

No. 4 in Group B - had a proportion of answers under this heading but none under 'always'. Out of the two items, one was seen to occur by the observers. At the other end of the scale, items No. 6 and No. 7 in Group B, answered 'never' by 100 per cent of respondents were not seen by the observers. The same items in Group A had a low frequency of occurrence and again were not seen. The number of observations of item No. 3 in both groups was too low to be considered meaningful. Taking items 1 and 2, there are fewer 'never' answers to No. 1, where there were observations made, than No. 2 where there were no observations of the action.

Changes in response, as shown by the 20 pairs of questionnaires previously described, were low for the items which had been subject to observation (Table 28).

The observations showed that there was no reason to doubt the validity of responses to the questionnaire. Within the limits indicated by the reliability tests, the responses were a true reflection of the experience of the students.

Questions on damage and injury

During the initial testing, the questionnaire contained questions, supplementary to the main questions, about damage and injury as shown on p. 165. The number of responses obtained to these questions from the 20 students who took part in the test and re-test of the questionnaire was 156 in the test and 110 in the re-test. Not all responses were to the same items. The reasons for the unreliability of response were probably that as a student makes many mistakes when learning, even those which cause damage or injury are not well remembered. Difficulty may also have arisen in linking the accident with the description of the item relating to workshop procedure.

The fact that students had difficulty in recalling accidents was confirmed when they were questioned orally in groups after they had completed the questionnaire. Four groups of students were questioned - there were 9 or 10 in each group and a total of 38. The structure of the questioning was as follows :

'Can any of you recall an accident which caused either damage or injury while you were working the College workshops?'

After students said that they could not remember any more accidents in response to this question, they were probed by asking -

'Can you remember any

(a) cuts or scratches	)	(i)	fingers
	)	(ii)	hands
(b) splinters or punctures	)	(iii)	arms
(c) bruises	) to your	(iv)	upper part of body
(d) sprains	)	(v)	neck
(e) burns	)	(vi)	face
		(vii)	head
		(viii)	lower part of body
		(ix)	back
		(x)	legs
		(xi)	ankle or feet?'

It was found that very few students could think of accidents when the first question was put to them. Response improved as they were asked to examine their fingers, hands and other parts of the body and try to remember any injury they had suffered. There was even less response in the case of damage. This was probed by asking -

'Can you remember accidentally damaging

(i) a workpiece
(ii) a hand tool
(iii) a tool bit
(iv) a machine
(v) any item of equipment
(vi) the benches
(vii) the floor
(viii) any other part of the workshop?'

As students warmed to the subject, one accident remembered usually sparked off the recollection of another and the tenor of the interview often drifted off the definite path. This was encouraged so long as it led to further recollection.

It was obvious that considerable stimulation was necessary before these students could recall what appeared to them to be incidents of a minor nature.

In about 35 minutes of questioning and probing with each group, a total of 69 accidents were recorded, 40 of which caused injury, and 29 damage.

LeShan and Brame (1953) have described how they found that people had forgotten accidents. They said that in their experience of getting people to recall accidents, in 35 interviews at least 30 of the subjects recalled several more accidents after careful probing than they had when simply asked to list all the accidents they had had.

The influence of the two main variables affecting the recall of accidents - seriousness of the event and elapsed time since the event - has been demonstrated by Gordon (1962), albeit in a somewhat different context. Enquiries made in two rural areas in India revealed that although a reasonable estimate of the incidence of the more serious accidents in the population could be obtained by home visits made at monthly intervals, this was not so for the less serious accidents. Only 38 per cent of non-disabling accidents were accumulated by monthly visits compared with the number obtained by making visits at two-week intervals. This result is of value in assessing the completeness of the students' responses. In their 1½ years of experience in the college workshops it is likely that the 38 students had been responsible for many more than the 29 damage accidents which they recalled.

It became obvious that reasonably reliable and complete results about accidents could not be obtained from the questionnaire. The supplementary questions about damage and injury were, therefore, dropped from further testing.

Final testing

The initial tests showed that the body of students in the research sample would be neither highly literate nor highly numerate. They would face difficulties not only in comprehension but also in estimating the frequency with which they engaged in the various procedures itemized on the checklist. These factors had been considered when making up the checklist which was now ready for the final stage of testing. This testing was necessary for the following reasons :

(i) There had been no previous opportunity for testing the whole of the checklist in its new format.

(ii) Second year students, albeit at an early stage of their second year, but after they had spent 4 or 5 months in industry, had been used for the pilot work and initial testing, yet the checklist was intended for first year students who had had college experience only.

(iii) The number of students used at various stages of the initial testing had not been very large at any one stage.

A copy of the checklist used in the final testing and also in the fieldwork is shown in Appendix 5. In 44 items the scoring was 1 point (Never) to 5 points (Always); in the other 29 items of the checklist, the scoring was reversed.

The first objective of the final testing was obtaining an estimate of the reliability of the checklist in respect of its ability to produce constant responses. First year students, attending the same college as the second year students used in the initial testing, were used for this final testing. Reliability was estimated from the results obtained by the test - re-test procedure.

TABLE 29

Group mean scores for full checklist obtained in test and re-test

Number in group	Mean scores		
	Test	Re-test	Difference
10	2.28	2.32	- .04
7	1.97	1.91	.06
10	2.36	2.24	.12
9	2.36	2.39	- .03
7	2.26	2.28	- .02
8	2.21	2.28	- .07
10	2.52	2.61	- .09
9	2.08	2.19	- .11
10	2.29	2.22	.07
7	2.53	2.21	.32

The first administration of the checklist took place in the 31st week of the students' course. Those taking part were asked to put a number of their own choice or an identifying mark on the paper and to remember it in case they were called upon to give some further information which would expand that which they gave on the first occasion. They did not know that they would be asked to complete the same checklist again until they were assembled later for that purpose. As well as being asked to put a mark on their paper, the students were also asked to put the number of the group they were in and the type of FE course they were following. This information made matching of the paper in pairs easy, even when the student had forgotten his mark.

The second administration took place under identical conditions six weeks after the first. The six-week period included an Easter holiday of a week and a day and a Spring bank holiday of 2 days. Ninety-six pairs of checklists were matched - only three could not be matched.

The repeat reliability of scores on the five-point scale was appraised by comparing mean scores in test and re-test.

The coefficient of correlation (Pearson r) was used as the reliability estimate. It was found to have the value 0.73 for the correlation between the 96 results in the first test and the 96 results in the re-test. It was not surprising that this value was lower than the 0.82 obtained in the initial testing. The first year students were at a more formative stage of training than the second year students used in the initial testing and more likely to change in the period of time between test and re-test.

When the individual respondent's scores were arranged in groups corresponding to the groups in which the respondents had been taught, it was found that there had been a comparatively large change in one group. The results for 10 groups are shown in Table 29.

Twelve groups, or classes, of students had been under investigation. In each group from 4 to 10 students took part in the re-test. Two groups

TABLE 30

Difference in test and re-test scores of one group

Area	Average reduction per student per item
Apparel	0.42
Dangerous acts	0.46
Swarf, risk to hands	0.36
Switching off, keeping m/c running	0.17
Checks before starting	0.16
Other items	0.44

were not included in Table 29 because only 4 and 5 students respectively had been re-tested and such numbers were felt to be too small to be representative of the groups.

Group 10 showed a change in mean score of 0.32, nearly three times as great a change as the next highest. Investigation of reasons for the change revealed that for various reasons there had been difficulty throughout the course in ensuring that the students in this group were adequately taught in the workshop. In an attempt to improve the standard in the last weeks before completion of the current stage of the course, another lecturer had taken over in the period between the test and re-test.

My omitting the results from respondents in Group 10 from the computation of the correlation coefficient raised the coefficient to 0.78. (The raw data are given in Appendices 6 and 8.)

The 'improvement' shown by Group 10 emphasises the difficulty of testing reliability by the test - re-test method. The greater the period of time allowed to minimise the effects of memory, the more opportunity there is for other factors to influence the respondents habits and attitudes. When the work was in progress, the mere fact that some testing of safety was taking place in the college undoubtedly had some effect. The consequences of this and other factors may be a spuriously low estimate of reliability for the checklist.

All but one member of Group 10 improved his safety score in the re-test (i.e. obtained a lower score). The one that did not improve had a difference of only 0.03 in his scores in test and re-test so was virtually unchanged. When the items of the checklist were grouped into areas, to coincide with the areas in which the items were examined in the last chapter, it was found that the average reduction in score for responses to each item was as shown in Table 30. It is emphasised that the reduction shown is the average per student for each item within the section of the checklist detailed.

The improvement in the Apparel section was due mostly to greater use of eye protection. In the Dangerous Acts section, all items but two showed improvement. These two items related to similar procedures, they were 'stopping the lathe spindle by placing the hand on the chuck or face-plate' (No. 39) and 'stopping the drill spindle by hand' (No. 66). The average recession in score for these two items was 0.43 and 0.55, respectively. In the Swarf, Risk to Hands section, there was an all round improvement with a striking betterment in item No. 38 'not putting fingers on rotating workpiece' which showed an average difference between test and re-test of 1.57. On the other hand, No. 63 'removing swarf from rotating drill' recessed on average by 0.55. There was no other change of note except that in the Other Items section, another item relating to the use of the drilling machine 'drilling strip material without clamping' (No. 64) showed a recession.

It would appear that the lecturer who took over the class had singular views about the way in which a drilling machine should be used. No other explanation is evident in the data, and unfortunately it is not possible to obtain the lecturer's views for he is now in retirement. This raises questions about the safety training of lecturers which will be considered along with other factors when the full situation is reviewed. However, the uniformity of the change of response to drilling and other items, reflecting the influence on the group of a new lecturer, strengthens the evidence in favour of a high value of validity as well as a high value of reliability in the checklist.

The seven checklists of Group 10 were omitted from the next stage of analysis. The results of this stage are shown in Appendix 7. In the table shownthere, the items have been grouped together to form sections of the checklist concerned with similar or related results. For each item, the constancy of response has been measured by obtaining the percentage of identical answers and the percentage within one point of identical, in the 89 pairs of checklists remaining.

Kinsey (1948) used this simple and direct method of showing the stability of an item when testing the constancy of memory of his subjects. When the identical or near-identical percentages are viewed alongside the summated scores in test and re-test for the items, a perception of the accuracy of response is obtained.

Responses varied from 94 per cent identical, coupled with 99 per cent within one point of identical, at the best, to 34 per cent identical, coupled with 66 per cent within 1 point, at the worst. The lowest figure for identical results was 29 per cent, this was coupled with 73 per cent within one point of identical.

By way of comparison, it should be noted that the statement about length of hair, which unlike the other items did not require a response that depended upon recall, produced 86 per cent identical selections and 98 per cent selections within one point, which meant that it ranked fourth in order of constancy of response. Items 62, 34 and 71 were all better. Only three alternative answers were available for selection to describe the length of hair, so the opportunity to change was more restricted than with the other items.

Attention was then turned again to the reliability of the checklist. The next stage of analysis was concerned with the examination of the full checklist; this time the whole of the results obtained from the 11 establishments who provided the 360 student-respondents were used.

The checklist had been administered by me to the students in the students' own classrooms using the same procedure as was used during the development of the checklist (see pp. 167, 173, 175). Emphasis was placed on the fact that it was not sought to reveal the practice or teaching of any particular individual or establishment.

All students were in about the 30th week of their course. The first results obtained from the 96 students who were re-tested, together with others from the same establishment, were included in the total of 360.

TABLE 31

Number of respondents in establishments and groups within them

		Establishment										
Group	:	1	2	3	4	5	6	7	8	9	10	11
1	:	19	10	23	16	9	15	24	18	23	11	14
2	:		8			7	15	20			8	
3	:		10			7					9	
4	:		11								9	
5	:		10								3	
6	:		10									
7	:		8									
8	:		10									
9	:		9									
10	:		11									
11	:		8									
12	:		5									
Total	:	19	110	23	16	23	30	44	18	23	40	14

Full details of the disposition of the students are given in Table 31. The raw data are given in Appendix 8.

Most students completed the checklist in 25 to 30 minutes, the shortest time taken was 17 minutes, one student took 45 minutes.

An estimate of reliability may be obtained from a single administration of a test by dividing the test into two half-lengths and finding the correlation between them. A familiar way of making the division is to place odd-numbered items into one half and even-numbered items into the other half. The correlation gives the reliability not of the full test but of a test half as long. From principles of sampling it is known that the larger the sample (and therefore the more items in the checklist) the more precise the estimate and the smaller the error is likely to be on any particular testing. The reliability of the full test may be estimated from the half test using the Spearman-Brown formula. This is given by Ghiselli (1964) as follows :

$$r_{11} = \frac{2r_{\frac{1}{2}\frac{1}{2}}}{1 + r_{\frac{1}{2}\frac{1}{2}}}$$

where :

r_{11} = the reliability coefficient of the total test

$r_{\frac{1}{2}\frac{1}{2}}$ = the reliability coefficient of half the test

The object of dividing a test into two parts is to produce equivalent samples of items from the same universe. If the two samples are equivalent, very similar scores should be obtained for each. For this reason the correlation between them is often called the 'coefficient of equivalence'.

The odd - even method was used to find the reliability of the checklist based on the whole of the sample of 360 student-respondents. When the items were allocated, the division of items into odd- and even-numbered parts was broken as soon as item No. 5 was reached. As the response to this item was dependent on the response to the previous item, it was placed

TABLE 32

Correlation coefficient between parts of checklists

Part		Correl. coeffic. 73 items	54 items
Odd no. items - Even no. items	:	0.73	0.74
Apparel - remainder of checklist	:	0.42	0.41
Dangerous acts - remainder	:	0.67	0.61
Swarf, risk to hands - remainder	:	0.56	0.48
Switching off, keeping m/c running - remainder	:	0.53	0.53
Checks before starting - remainder	:	0.51	0.49
Other items - remainder	:	0.15	-

into the same half as the previous item, that is into the Even half. The division was continued by placing the next item, and every other item into the Odd half until No. 20 was reached. No. 21 could not be answered unless a positive response was made to No. 20, therefore, No. 21 was placed into the Odd half along with No. 20. From this point, odd numbered items went into the Odd half and even-numbered items into the Even half. A mean score was obtained for each half-length. The correlation coefficient between pairs of scores on the 360 checklists was then calculated. It was found to be 0.73. When corrected with the Spearman-Brown formula, the value of 0.84 was obtained for the total test.

I had now established that the checklist had a test - re-test reliability of 0.78 and a corrected split-half reliability of 0.84. This was a satisfactory standard but I was concerned that perhaps the equivalence shown by the checklist as a whole would not be maintained when specific areas of procedure were compared with others.

This was shown to be so when the correlations between different sections of the checklist and the remainder were calculated. The division of the checklist into sections was described in connection with Table 30. The correlations between each of these sections and the remainder of the checklist are shown in Table 32. A marked difference between the correlation in connection with Other Items and the rest of the correlations was revealed. It showed that Other Items appeared to be measuring something different to the rest of the checklist.

The Other Items section was removed and the correlations between each of the sections left and the remainder re-calculated. This gave the results shown in Table 32. The new split-half reliability of 0.74 became 0.85 on correction by the Spearman-Brown formula. In this respect the equivalence of the checklist was maintained, even though the test length had been reduced and the effect (mentioned previously in relation to the Spearman-Brown formula) of reducing the sample size would operate.

TABLE 33

Scores for 54-item checklist obtained by establishments and groups within them

		Establishment										
Group	:	1	2	3	4	5	6	7	8	9	10	11
1	:	2.44	2.37	2.25	2.04	2.31	2.37	2.43	2.33	2.19	2.74	2.12
2	:		1.87			2.52	2.12	2.49			2.55	
3	:		2.43			2.58					2.69	
4	:		2.50								2.55	
5	:		2.46								2.77	
6	:		2.39									
7	:		2.41									
8	:		2.65									
9	:		2.16									
10	:		2.51									
11	:		2.63									
12	:		2.10									
Overall score	:	2.44	2.28	2.25	2.04	2.46	2.24	2.46	2.33	2.19	2.65	2.12

Paradoxically, the removal of the Other Items section had the effect of reducing the correlation coefficients pertaining to the rest of the sections.

Calculation of the test - re-test reliability of the shortened checklist (hereafter called the 54-item checklist) from the 89 results previously used in the final calculation for the 73-item checklist gave a value of 0.80.

When the dispersion of results from the two forms of the checklist were compared, the following statistics were obtained :

	Mean	Range	Std. deviation
73-item checklist (N = 360)	2.28	1.33 - 3.28	0.36
54-item checklist (N = 360)	2.37	1.26 - 3.57	0.40

Aside from considerations of content, these figures showed that, because of its wider dispersion of results, the 54-item checklist would discriminate better between respondents than the 73-item checklist.

Results

The 54-item form of the checklist was, therefore, used to investigate the use of safe working procedures in establishments and in groups of students within the establishments. To constitute a group in the meaning used here, students in a workshop class had to have been taught entirely by one lecturer, with only occasional exceptions. When lecturers had moved from one group to another within an establishment, the students in that establishment were classified as belonging to one group. This meant that some groups, as shown in Table 31 were much larger than others. In order that results from groups might be compared, mean scores for groups were used when making up Table 33. For establishments, the overall scores shown in the table are the means of the scores of individual students, not the means of the groups within the establishments. The apprentice training school was designated Establishment 11.

Two groups, identified in Table 33 as Establishment 2, Group 12 and Establishment 10, Group 5, contained very small numbers of students, 3 and 5 respectively; this was not because the classes were as small as this but because not all the students had been available for testing. When these two groups were omitted, because of their small size, statistics relating to the dispersion of results were as follows :

	Mean	Range	Std. deviation
Groups	2.40	1.87 - 2.74	0.207
Establishments	2.31	2.04 - 2.65	0.176

At the beginning of this chapter I explained why it seemed reasonable to assume that the students in the sample which I tested had been drawn from the same population. I looked to see whether there was any verification for this assumption in the group results. Establishment 2 was the only establishment that had groups composed exclusively of one category of student. Group 1 was composed of ONC students; Group 2, general; Group 4, technician; and Group 8, mixed general and technician. Group 7 was mixed craft and other students. All the other groups were made up of craft category students. The scores of the four non-craft groups included the highest and lowest scores of groups in the establishment. This is limited evidence but it supports the evidence previously considered. There is no reason to suppose that there is a tendency for groups composed of different categories of student to obtain significantly different scores, all other factors being equal.

The groups were all doing the same practical work under virtually the same conditions. The factor that varied between one group and another was the lecturer.

In order to see whether the group means were significantly different from each other, and thereby obtain some indication of the influence of lecturers on students, a single-factor analysis of variance for 28 groups was computed. It gave the following results :

Source	SS	DF	Mean square	F
Between groups	12.885	27	0.477	3.606
Within groups	42.882	324	0.132	
Total	55.767	351		

Entering a table of the variance ratio (F), 1 per cent points, at 24 and 200 degrees of freedom gives an F-value of 1.95. Since the value I obtained was much greater, I concluded that there is a significant difference between the means of the groups, with at least 99 per cent confidence.

I felt that a 95 per cent confidence level would have been acceptable and, therefore, worked at this level when investigating where the differences lay. I compared each group score with each other group score and determined whether or not the difference between each pair of results was statistically significant.

First, the 95 per cent confidence limits for each difference were found. In general terms what I have called a group score is the mean value of a sample based on n observations. The 'within groups' mean square in the analysis of variance, the only measurement of error available, is 0.132. The standard error of the difference of two mean values $\bar{x}_1$ and $\bar{x}_2$, the first based on n_1 observations and the second on n_2 observations, is given by

$$S.E.\ (\bar{x}_1 - \bar{x}_2) = \sqrt{0.132\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

As we are looking for a difference, irrespective of the way the difference lies, we have to carry out a two-tail test. The 'within groups' mean square is based on 324 degrees of freedom. The deviate for 95 per cent confidence limits based on the number of degrees of freedom is 1.96. Hence 95 per cent confidence limits on each difference are

$$\pm\ 1.96 \times \sqrt{0.132\left(\frac{1}{n_1} + \frac{1}{n_2}\right)}$$

FIGURE 5

Difference matrix of A - B

B: E	B: G	A: 1	2											3	4	5			6		7		8	9	10				11
	G	1	1	2	3	4	5	6	7	8	9	10	11	1	1	1	2	3	1	2	1	2	1	1	1	2	3	4	1
1	1	-		O											O					O				O	X				O
2	1		-	O											O										X				
	2			-	X	X	X	X	X	X		X	X	X		X	X	X	X		X	X	X	X	X	X	X	X	X
	3				-										O					O									O
	4					-					O				O					O				O					O
	5						-								O					O									O
	6							-							O										X				
	7								-						O										X				
	8									-	O			O	O	O				O			O	O					O
	9										-	X	X				X	X				X			X	X	X	X	
	10											-		O	O									O					O
	11												-	O	O					O			O	O					O
3	1													-				X				X			X	X	X	X	
4	1														-		X	X	X		X	X	X		X	X	X	X	
5	1															-									X		X		
	2																-			O				O					O
	3																	-		O				O					O
6	1																		-								X		
	2																			-	X	X			X	X	X	X	
7	1																				-			O	X				O
	2																					-		O					O
8	1																						-		X		X		
9	1																							-	X	X	X	X	
10	1																								-				O
	2																									-			O
	3																										-		O
	4																											-	O
11	1																												-

E = Establishment

G = Group

X = +ve difference

O = -ve difference

If we take the first two values shown in Table 33 as an example: these are 2.444 and 2.370, to three decimal places. The number of observations is 19 for the first and 10 for the second. The difference

$$\bar{x}_1 - \bar{x}_2 = 0.074$$

The 95 per cent limits are

$$1.96 \times \sqrt{0.132 \left(\frac{1}{19} + \frac{1}{10} \right)} = 0.281$$

and 95 per cent of values of differences are contained between

$$0.074 \pm 0.281 = 0.355 \text{ to } -0.207$$

This calculation was carried out, with the aid of a computer, for each pair of results in the 28 results which had been obtained from groups of a reasonable size. Where it was found that the two calculated values included zero, as in the example, it was concluded that $\bar{x}_1$ and $\bar{x}_2$ were not significantly different.

These differences which were found to be significant are indicated in Figure 5. To read this, take Establishment 4, Group 1, as an example: the value for this group is significantly less than most other groups, hence when each one is subtracted in turn the result is negative. This is shown in the vertical line of results under Group 4.1 in the table. Naturally, when the direction of the subtraction is reversed the result is positive. This can be seen in the horizontal line of results for Group 4.1. Any significant differences between groups in the same establishment occur to the left of the stepped line. Results indicated on the right of the stepped line are where significant differences occur between groups in different establishments.

The range of differences between group scores is 0.87, this is approaching one-point on the safe - unsafe scale. I believe this indicates that there is a difference of practical, as well as statistical, significance in the results from groups and that, in this way, I have established that there is a significant difference in the teaching of the

TABLE 34

Establishment scores (overall and for groups within establishments) in respect of protection of long hair, as obtained from answers to Item 20. (Number of students answering is shown in brackets)

	Establishment										
	1	2	3	4	5	6	7	8	9	10	11
Group scores	5.00	1.56 (9)	4.53	1.92	2.87 (8)	5.00 (8)	2.50 (20)	4.93	3.00	4.80 (10)	2.36
		3.67 (6)			3.57 (7)	4.75 (12)	3.88 (17)			4.12 (8)	
		3.25 (8)								5.00 (7)	
		3.10 (10)									
		3.00 (9)									
		3.30 (10)									
		4.10 (10)									
		4.90 (10)									
		4.62 (8)									
Overall score	5.00 (18)	3.55 (92)	4.53 (19)	1.92 (12)	3.50 (20)	4.85 (20)	3.14 (37)	4.93 (14)	3.00 (16)	4.52 (33)	2.36 (11)

lecturers concerned.

Whether the establishments influenced the lecturers cannot be determined so conclusively. In most establishments there were not enough, if any, separate groups, also the number of groups varied greatly. But we can see from the difference matrix that, except for the largest establishment, groups within an establishment did not differ significantly among themselves, and that in the largest establishment only two groups were significantly different from the others. So possibly the teaching of the lecturers was influenced by the establishment in which they worked. Beyond this, these results do not allow us to go. I would, however, argue that had the establishments made positive efforts to ensure good safety teaching, then we would have seen less difference in the results from the groups; the differences are largely due to variations in the lecturers' individual approach to safety.

By considering specific items, I was able to reveal further differences in the practice of the groups. The wearing of hair protection was one example. It was measured by item No. 20 -

'I have ... worn a safety hat or net when working on the machines.'

Only if a student wore his hair below the bottom of his ears, as checked by item No. 74 was protection assumed to be necessary. Item No. 20 had shown 61 per cent identical-response answers, and 94 per cent within one point of identical in the re-test (see Appendix 7). The coefficient of correlation between test and re-test was found to be 0.85. Table 34 shows the different group and establishment results; groups containing less than six students with long hair have been omitted.

There was not much doubt that in the wearing of hair protection there was a difference of practical significance. The range of scores from Establishment 2 showed that little direction, if any, had been given to the lecturers in this matter. In Establishment 1 apparently none of the lecturers regarded the wearing of hair protection as something to enforce

TABLE 35

Establishment scores (overall and for groups within establishments) in respect of protection of eyes, as obtained from answers to Items 40, 48, 58

	Establishment										
	1	2	3	4	5	6	7	8	9	10	11
Group scores	3.91	2.18	3.03	1.85	3.00	3.72	4.60	3.98	2.51	4.21	1.48
		1.90			3.38	3.12	4.41			3.79	
		2.27			3.67					4.17	
		2.82								4.17	
		2.70									
		2.79									
		4.10									
		3.50									
		2.27									
		3.06									
		2.78									
Overall score	3.91	2.71	3.03	1.85	3.32	3.42	4.50	3.98	2.51	4.14	1.48

although, as it was in their syllabuses (see p. 146) they were, presumably, teaching it to the students. The results from several other establishments showed that the situation was the same in their case.

In the consideration of the extent which safe procedures for eye protection were followed, three out of the five items relating to eye protection were used. These three items were the ones that showed the greatest consistency of response, they were Nos. 40, 48, and 58.

'I have ... left off my goggles or safety glasses when using a lathe not fitted with an eye shield.'

'I have ... worn goggles or safety glasses when using the shaper.'

'I have ... used the milling machine without wearing goggles or safety glasses.'

These three items had an identical response in the re-test of 57, 56, and 57 per cent respectively, coupled with 92, 89, and 93 per cent within one point of identical. The test - re-test correlation coefficients were 0.66, 0.76, and 0.73. An estimate of the test - re-test reliability (correlation) coefficient, for the three items combined, was a figure of at least 0.80. This was assumed from a correlation between test and re-test for groups which gave a coefficient of 0.93.

The results obtained from administration of the checklist are shown in Table 35, as practically all students answered all three questions; the number answering is not shown in this table. The range of scores was not quite as much as with hair protection but it was still large enough to be of practical significance. The apprentice training school, Establishment 11, was much better than the colleges in respect of eye protection.

I had found a difference in their approach to eye protection when I visited establishments and this was reflected in the scores. At one establishment it became clear from questions asked by students and subsequent discussion with them that they had been told that it was not necessary to wear safety glasses when working mild steel. At another

TABLE 36

Establishment scores (overall and for groups within establishments) in respect of dangerous acts by students as obtained from answers to Items 3, 18, 24, 39, 66

	Establishment										
	1	2	3	4	5	6	7	8	9	10	11
Group scores	1.92	1.38	1.45	1.61	1.62	1.77	1.59	1.29	1.65	2.04	1.38
		1.25			1.51	1.56	1.60			1.98	
		1.58			1.94					2.00	
		1.44								1.76	
		1.56									
		1.33									
		1.60									
		2.12									
		1.60									
		1.70									
		1.87									
Overall score	1.92	1.59	1.45	1.61	1.68	1.67	1.59	1.29	1.65	1.94	1.38

college the head of department illustrated his appreciation of the need for eye protection by describing a case in his experience where a bad eye injury had occurred. The first establishment had the highest score (4.50) of all establishments for lack of eye protection; the second establishment the lowest but one (1.85), being outshone in this respect by the apprentice training school.

Items classified as Dangerous Acts were also examined to see how their scores varied from group to group. These items were those which I felt were not mere precautions against accidents but actions which seemed to invite accidents. Item No. 14 (compressed air) was answered by only 111 students, item No. 17 (throwing to another student) had fewer identical responses and a lower test - re-test correlation coefficient than the others, these two items were, therefore, excluded. The remaining items were Nos. 3, 18, 24, 39, 66.

'I have ... left a machine running when I have moved away from it.'

'I have ... thrown anything at another student.'

'I have ... used a file or scraper without a handle.'

'I have ... stopped the spindle (of a lathe) by placing my hand on the chuck or faceplate.'

'I have ... stopped the drill spindle by hand.'

In the re-test responses to the items averaged, over the five items, 73.4 per cent identical, 97.6 within one part of identical. The test - re-test correlation coefficients were 0.65, 0.57, 0.53, 0.53, 0.77, respectively. The coefficient for group scores was 0.95 so the reliability coefficient for the five items together was probably at least 0.80.

Scores awarded for groups and establishments are shown in Table 36. Again, almost every student answered all items. The scores were much lower than the other items that were considered but their range was approaching one point (0.79). There was no more uniformity than with the other items except that the apprentice training school came out well and Establishment 10 was again the worst.

Considering now the responses as a whole, responses to each item are shown in Appendix 9; the grand mean score for all responses to all items was 2.30, hence the average procedure measured by the checklist was an unsafe act practised at a frequency which lay somewhere between 'once or twice' and 'several times' on the category scale or conversely, a safe act neglected as frequently. That is assuming that when the safest action was at the upper end of the scale, 'nearly always' bore the same relationship to 'always' as 'once or twice' did to 'never'.

When the grand mean score was used as a datum mark to distinguish the above average items from the below average items, the following unsafe procedures were found to be of above average occurrence -

(i) Apparel: lack of protection throughout; except in the case of eye protection when using the off-hand grinding machine.

(ii) Handling swarf and other risk to hands: specifically removing swarf with a rule and cleaning it up with a hand rag, placing fingers on a rotating workpiece and handling a milling cutter without protection.

(iii) Not switching off machines at the isolating switch at appropriate times.

(iv) Not even switching off the motor of a lathe while removing or refitting a lathe chuck or setting up work on a shaper. Using a dial test indicator without switching off the motor of the machine. Keeping a machine running while fixing guards in position and while adjusting the position of a coolant pipe.

(v) Checks not carried out before starting on oil level of machine, turning chuck and transversing carriage by hand, checking depth of cut, feed rate and cutting speed of lathe. Not checking gap between rest and workpiece on grinding machine, and tightness of rest.

(vi) The miscellaneous items of keeping sharp tools in pockets, not keeping tools tidy on bench, or in trays on machines; not clamping material when using drills greater than 8 mm diameter; leaning on a machine while it is running; using a file or emery cloth on a rotating workpiece; using a double-ended grinding machine at the same time as someone else.

Not all these items are of equal importance from the point of view of safety. Those that have been shown to be of particular importance (see Chapter 12) were all items relating to apparel; placing fingers on rotating workpiece; not switching off at isolating switch and motor; not checking workrest on grinding machine; not clamping material when drilling, and using a file or a piece of emery cloth on a rotating workpiece. In view of the concern expressed by H.M. Factory Inspectorate about the use of emery cloth in this way, it was unfortunate that it was not made the subject of a single item in the checklist, but the report drawing attention to this practice in colleges and training schools did not become available to me until after the checklist had been tested. The result shows that H.M. Factory Inspectorate's views did not get through to the establishments, or if they did, they were not acted upon.

Items which although they had a below average score were felt to be important enough for the results still to be serious, were as follows :

(i) The dangerous acts which have already been examined.

(ii) Carrying out adjustments, etc. to machines without even switching off the motor.

(iii) Opening or removing a guard before the machine stops.

(iv) Leaving chuck keys in chucks.

(v) Not clamping strip material for drilling.

<u>Safety activities and workshop practice</u>

To find out whether the safety activities in establishments, which had been evaluated as described in Chapter 5, could be seen to influence

TABLE 37

Establishment scores for safety activities and working procedures

Estab. no.	Safety provision	Hair protection	Eye protection	Dangerous acts
1	56	5.00	3.91	1.92
2	32	3.55	2.71	1.59
3	14	4.53	3.03	1.45
4	43	1.92	1.85	1.61
5	23	3.50	3.32	1.68
6	61	4.85	3.42	1.67
7	41	3.14	4.50	1.59
8	68	4.93	3.98	1.29
9	30	3.00	2.51	1.65
10	42	4.52	4.14	1.94
11	86	2.36	1.48	1.38

TABLE 38

Correlation coefficients(r) between safety activities and safe working procedures

	Hair protection	Eye protection	Dangerous acts
Safety activities	- 0.40	- 0.39	- 0.01

the practice in workshop classes, I compared scores awarded for safety activities with scores for Hair Protection, Eye Protection and Dangerous Acts. These scores are shown in Table 37. Correlation coefficients between scores for activities and each of the three items of procedure were calculated. The apprentice training school was omitted because the method of evaluation of safety activities could not strictly be applied to this type of establishment. The coefficients obtained were all positive but as the upper end of the scale for procedures signified an unsafe act, the coefficients between safety activities and safe working procedures were negative, as shown in Table 38. None of them were, however, significant even at the 0.1 level. Thus the scale of safety activities in an establishment could not be seen to influence the use of safe working procedures, even in such a fundamental safety matter as the protection of eyes.

Summary

I have shown by thorough testing that lecturers varied in what they required of their students in the way of safe working procedures and hence what they were effectively teaching the students. The safety activities carried on in an establishment did not apparently affect the practice of safety in the workshops, probably this was because the establishments relied on each lecturer being his own safety officer. The extent to which they were deficient in this was shown by the failure of their students to observe necessary safe working procedures. These were procedures which have been shown to be necessary both from the point of view of the present safety of students in the establishments and their future safety when they practice in industry the skills they have acquired.

Additionally, in the checklist, I had developed a reliable means of measuring procedures affecting safety which with appropriate modifications might find applications outside workshop procedures and outside education establishments.

CHAPTER 14

SUMMARY OF FINDINGS, AND CONCLUSIONS

In this work I have shown the importance of the questions that were put in Chapter 3. The evidence on which answers to these questions can be based has been presented in the text. This evidence is strong enough to allow a negative answer to be given to each question with reasonable confidence. The evidence allows me to establish my thesis.

A summary of my findings, and brief conclusions are as follows :

Question: (i) Are substantial efforts being made to implement the principal official recommendations on safety, and to carry out activities generally thought to be beneficial to safety?

Evidence: The postal survey showed that efforts made by both FE and HE establishments to set up a safety organisation were uneven and generally not forceful. Detailed examination of a small sample of FE establishments showed that efforts directed towards safety activities were generally weak with very little being done in some establishments.

Strength of evidence: High for FE. Moderate for HE. (Investigation of activities in HE was limited.)

Conclusion: Substantial efforts are not being made in most establishments either to implement the principal official recommendations on safety, or to carry out activities generally thought to be beneficial to safety.

Question: (ii) Is knowledge of accidents occurring in the establishments adequate for steps to be taken to improve safety in work activities of staff and students, and to show where improvement is required in the teaching of safety?

Evidence: No national accident information available. The postal survey showed that the accident reporting systems were not such that adequate information for safety purposes was produced. It was also found that reports were often not seen by those who should be taking action.

Strength of evidence: High for FE and HE.

Conclusion: Knowledge of accidents occurring in the establishments is inadequate for steps to be taken to improve safety in work activities of staff and students, and to show where improvement is required in the teaching of safety.

Question: (iii) Does the practice of safety display to students at first hand proper concern for safety and what to do about it?

Evidence: The accident survey showed that many lecturers and technicians failed to set a high standard of safe working. It also showed that lecturers and technicians apparently did not understand their role in promoting safety. Faults in building design were left uncorrected. Students were not able to observe proper safety organisations at work.

Strength of evidence: Moderately high for FE and HE.

Conclusion: The practice of safety often fails to display to students at first hand proper concern for safety and what to do about it.

Question: (iv) Is the practical significance of classroom teaching demonstrated to students at a personal level?

Evidence: The accident survey revealed that lecturers condoned unsafe practices and that students were allowed to take needless risks. The examination of the use of safe working procedures in FE engineering workshop classes showed that lecturers did not insist on the observance in practice of what was taught in the classroom.

Strength of evidence: Very high for FE. Moderately high for HE.

Conclusion: The practical significance of classroom teaching is generally not demonstrated to students at a personal level.

Question: (v) Are the necessary steps being taken to ensure that precautions known to be essential to safety in work activities are being observed?

Evidence: The accident survey disclosed that elementary safety precautions were not taken by academic and service staff. Also, that students in research and teaching situations failed to take elementary precautions. The examination of workshop classes showed that the way safety was enforced was left largely to the individual lecturer.

Strength of evidence: Very high for FE. High for HE.

Conclusion: The necessary steps are not being taken to ensure that precautions known to be essential to safety in work activities are being observed.

Question: (vi) Are service staff competent to carry out safely the tasks required of them?

Evidence: The accident survey showed that service staff lacked training in many of the tasks they were required to carry out.

Strength of evidence: High for FE and HE.

Conclusion: Service staff are not competent to carry out safely many of the tasks required of them.

Question: (vii) Is safety taught in a positive way, particularly in connection with skills that students will use in industry?

Evidence: The accident survey provided many examples of failure to teach the observance of safety practices that are necessary in industry. The examination of engineering workshop classes revealed serious shortcomings in teaching safety and that students were not being prepared to face industrial conditions. The testing of attributes showed that lecturers in FE believed that fault for accidents lay in the students.

Strength of evidence: Very high for FE. Moderately high for HE. (Investigation in HE was limited.)

Conclusion: Safety is not taught in a positive way. This is particularly the case with skills that students will use in industry.

Question: (viii) Have safety activities in the establishments been effective in improving the teaching and learning of safety?

Evidence: Comparison of safety activities in FE establishments with the practice in their engineering workshop classes failed to show that activities had any influence.

Strength of evidence: Moderate.

Conclusion: Safety activities in FE establishments cannot be seen to improve the teaching and learning of safety.

Overall conclusion

My thesis - that safety is not seen by establishments of FE and HE as an explicit objective in their work, despite many recommendations that it should be - has been established within the limits of my investigation on this evidence. The special attention which I gave to engineering workshop procedures shows that the failure to see safety as an explicit objective is particularly relevant to the teaching of practical skills to FE students.

Notwithstanding the limitation of the research to establishments that were willing to cooperate, I feel that the results are sufficiently uniform for my findings to be applicable to FE and HE establishments generally.

CHAPTER 15

IMPLICATIONS AND APPLICATIONS

Implications

From the research I have drawn up general implications and identified certain applications of my findings. These are described under the headings which were used when the problems to be faced were examined in Chapter 2.

Firstly, from a broad overall viewpoint I can say that I found serious shortcomings, indicating a lack of direction in safety considerations, in both FE and HE establishments. Those items which were particularly striking were, the lack of record systems of value in accident prevention, how lecturers permitted unsafe practices in their classes, the way in which technicians and other staff ignored elementary safety precautions. Also conspicuous were deficiencies in safety knowledge and the weakness of safety activities. Comparison of the activities in FE colleges with the provision in an industrial situation showed how much progress is needed. The hopes identified in the historical background (Chapter 4) have not materialised as good health and safety practice.

The teaching of occupational safety

The most important and far-reaching implication based on the many examples from the accident information which were described in the text, and on the detailed and tested investigation, carried out by means of the checklist, was that the teaching of good safety practice in FE establishments fell below what was desirable to equip students for industry. The variations, in different groups of students, in the procedures that I examined, and the general low level of performance, showed that lecturers were deficient in knowledge of what to teach about safety, and how to teach it. A positive approach to safety in the teaching of skills which students would practice in their occupations was not in evidence. The accident information obtained from universities pointed towards a similar situation in those establishments.

This implication is important because the main purpose of the establishments is to teach and in doing this they, and all concerned, would wish for a high standard of achievement. It is far-reaching because of the effect that weaknesses in safety teaching would have on the future well-being of students and those they would influence or control in their occupational life.

Secondary to the main implication, based on the accident information which was collected with care from an FE establishment, was the implication that the large number of minor accidents to students, treated on the spot, could be reduced if more attention was paid to the way in which they occurred and remedial action taken. In particular, it was shown that better training in setting up machines and in carrying out operations, other than actually operating them, might be an effective method of reducing slight injuries.

Lecturers in FE establishments believed that students who had accidents were less interested, less well behaved, and slower to learn than other students. Their belief was well tested but whether or not the attributes of the students were actually so could not be determined. However, the investigation showed that there was a general tendency on the part of lecturers to assume that fault for accidents lay in the students. Possibly this was why the lecturers failed to adopt a positive approach.

Safety activities

A wide variation was found in the approach to safety in both FE and HE establishments. The country-wide postal survey showed that although a full safety committee and safety officer/adviser organisation had been set up in some establishments, in others there was scarcely any organisation for safety at all. A closer, more detailed look, in which various activities were evaluated in a small, selected sample of FE establishments, showed that the general level of safety activities was low; in some establishments it was extremely weak, in all of them it was below the standard found in a good apprentice training school in a factory.

From the comparison I made between the evaluation of safety activities and the responses to the checklist in the same establishments, coupled with information about the provision forsafety in establishments throughout the country, and accidents which occurred in them, I obtained fairly strong evidence that the scale of safety activities in establishments generally, did not effectively influence either the teaching or the learning of safety. The level of activities was too feeble for me to be able to say with certainty whether their ineffectiveness was due to either the scale of the activities or to their nature, or both, but I believe that the fundamental deficiency lay in the failure to adopt a positive approach and to pursue it with vigour.

Setting an example

Neither FE nor HE establishments set an example of high all-round safety for their students to follow. The accident information provided strong evidence that they commonly failed to ensure the safety of students either by furnishing protective devices or by insisting on the wearing of protective equipment. FE lecturers themselves suffered injury in front of their students through not wearing protective equipment. They also allowed practices which would be illegal in industry. In both spheres of education, lecturers and technicians failed to take elementary precautions to protect themselves when carrying out potentially dangerous tasks. Many establishments did not have a complete safety organisation for students to see at work. The poor response in returning accident report forms in the accident survey was further indication of the low priority given to safety.

There was less strong evidence from the accident information supported by a limited inspection of buildings that establishments did not take steps to ensure that their buildings were constructed in accordance with the best principles of design for safety of users, neither did they attempt to correct faults that were there for all to see.

Safety at work

The actions of technicians, maintenance staff, and porters which led to accidents revealed their lack of appreciation of safety needs. There was strong evidence of this from the accident information obtained from both FE and HE establishments. Most cases revealed the primary cause of the accident to be a lack of skill, or failure to take elementary precautions, in carrying out potentially dangerous operations. This raises doubts as to the ability of many service staff to carry out safely tasks assigned to them. In their lack of skill and ignorance or disregard of elementary safety precautions, they set a bad example to students.

From the reports of some accidents it was apparent that the apparatus or equipment in use was inadequate but it was not possible to determine to what extent this was due to the failure of an establishment to provide what was necessary and to what extent it was due to the failure of staff to use proper equipment which had been provided.

Other factors affecting safety in the sphere of work of staff and students - safety activities, and safety building design, have been discussed under other headings.

Accident information

Investigation showed that existing methods of reporting accidents in establishments did not make use of the opportunity to obtain information of value in accident prevention, either on a local or national level.

My compilation of accident information showed conclusively that a single uniform reporting system would yield useful information about safety generally, and would indicate areas where teaching might be improved. Knowledge of the activity of persons at the time of their involvement in accidents was found to be particularly informative.

The lack of response from many establishments and the drop out of others showed that reliable statistical data could not be obtained in a voluntary system of reporting accidents.

Applications

In the present work I have necessarily taken a critical view of safety in the establishments in order to expose the weaknesses that exist. I have attempted to be objective and in doing so, I believe that I have shown that the intuitive, unscientific, and undisciplined approach to safety in educational institutions is failing in several serious ways. I believe that this research has been the first of its kind in the field. It has shown a need for it to be followed by further studies. Meanwhile, the results of the present work have highlighted certain applications which should be beneficial.

General

Beyond what I shall suggest for specific items, no single solution to the general safety problem in FE and HE establishments is apparent from the research. Because of the range of interacting variables that lie at the roots of accidents, all facets of accident prevention should be pursued. An establishment should adopt a policy of total involvement. Some of this may be in the nature of 'making a show' but the evidence of a lax attitude to safety precautions suggests that it may be necessary to do this to keep staff and students aware that safety is a definite objective of the establishment.

The weaknesses revealed in the safety activities of establishments, and the general failure to present a good example, show that the efforts of all sectors of the community, students, academic staff, and service staff, should be utilised and coordinated so that it is always apparent that an establishment is concerned about safety and is doing something constructive about it.

The new Health and Safety at Work Act might well provide the incentive for a considerable step forward of safety in education.

The teaching of occupational safety

The general approach of lecturers to safety which was revealed in the unsafe ways in which they worked and allowed their students to work showed that in order to substantially improve safety in the establishments efforts should be directed principally towards improving the safety knowledge of lecturers. Their present views of what constitutes a desirable level of safety have most likely been formed either during industrial experience, where a now unacceptable degree of risk was considered to be part of the job, or in research work where dangers were ignored in the pursuit of progress.

Lecturers will have to be shown the importance of following the best safety procedures at all times. They will need to be given more knowledge about the way accidents happen and how to prevent them. We have seen how the history of industrial safety can provide examples from which lessons can be drawn on the way in which, after current opinion has assumed that nothing more can be done to prevent accidents, progress has continued; this should be emphasised in the safety training for lecturers which will be necessary.

We have seen how FE lecturers believe that those students who have accidents are less interested, less well-behaved, and slower to learn than the mass of students. If they wish to make these students safer, they must ensure that their teaching of safety, particularly in the classroom, is presented at the personal level, it should not be allowed to appear theoretical and technical.

To increase the students' participation in the total safety effort which I have advocated, in course work to a reasonable extent problems set in all subjects should embody aspects of safety (the electrical resistance of the human body affords one example). Project work should require students to argue the case for safety alongside other considerations. More should be done to integrate safety into skill training; this is most important for FE establishments otherwise, as we have seen in their engineering training, they are in danger of throwing away one of the great advantages which planned instruction has over learning by imitation and practice.

Because minor injuries are an important part of the total accident problem in industry, lecturers should give serious attention to means of reducing their occurrence.

Safety activities

The present work has shown that there is a lack of positive direction for safety in the establishments. This can come from safety committees and safety officers. Therefore, establishments should make arrangements for them to provide the spur that is required. The committee, with the assistance of the safety officer, should see that the usual activities advocated by safety practitioners are carried out, but the committee should also be concerned as much with the future safety of students and others, as with present safety in the establishments. This means that as well as initiating and encouraging safety activities, the committees should give attention to the teaching of safety; not the technical details which are the province of the subject teacher but matters common to all subjects. Among these would be items such as the approach to adopt to make safety acceptable to young people, commensurate with fostering their initiative and sense of adventure, and the attitude to develop in students towards safety for themselves and other people.

The need which I have shown for the training of lecturers in the teaching of safety requires a person of senior status to be appointed for the task. A qualified safety technologist appointed to the academic staff is required. In a FE establishment, his status and position would be similar to that of an educational technologist, in a university his position would depend upon the structure of courses provided.

As well as lecturing to staff, and supervising other safety activities the safety technologist would cooperate with specialist lecturers in organising special courses on aspects of safety in industry.

Setting an example

The situation which this work has revealed in the establishments shows that there should be more emphasis on teaching safety by example. Particular attention should be paid to safety in and about the buildings of an establishment. The highest standards should be insisted upon in new buildings, and all that is possible done to rectify faults in existing buildings. In this way, all who visit the stablishment, or work or study in it, can observe its concern for safety.

Those establishments that pride themselves on offering a service to industry should be ready to offer advice and to provide examples of the best safety practice at any time. This will be an incentive for their lecturing staff to make good those deficiencies in their safety knowledge which I have shown to exist.

Safety in work activities

The research has showed that establishments need to give safety training to technicians and to impress upon them their responsibility for their own safety. This is particularly necessary when they will be called upon to undertake tasks which lie outside the range of their original occupational training. Additional training may also be necessary because in an educational establishment, the technicians' methods may be taken as an example to follow by impressionable adolescents. An establishment should define where the responsibility lies for ensuring that technicians know about safety.

Maintenance staff as well as technicians are also required to be versatile in their work, and they need similar safety training.

The handling accidents that were reported point up the need for -

(i) a careful survey in all establishments of the handling work they require to be done, and the hardware they are using;

(ii) a scrutiny of the training needs, followed by the introduction of training;

(iii) introduction of improvements in the hardware;

(iv) monitoring.

The need has been demonstrated for establishments to insist on the observation of legal requirements and codes of practice at all times by both academic and service staff.

Accident information

The results of the surveys undertaken in the present work showed the value of accident information obtained from establishments. Arrangements should be made to collect this on a national basis with the following objectives :

(i) The continuous assessment of the significance and extent of the safety problem as it applies to FE and HE establishments.

(ii) The monitoring of the effectiveness of attempts to improve safety.

(iii) The comparison of safety in one establishment with the general level of safety in similar establishments.

(iv) The provision to bodies having a concern, and to the public at large, of reliable information on the general state of safety in establishments.

Use should be made of the information obtained as follows :

(i) The professional training and re-training of lecturers.

(ii) The training of safety technologists and safety officers for work in educational establishments.

(iii) Advice to establishments on safety provisions.

Further work

Because of the way that within the educational field young people of similar age, ability and background are collected together, it offers many opportunities for research pertaining to safety. The apparently different liabilities of men and women to have accidents suggests itself as a subject for study in these circumstances.

Research into the teaching of product (or consumer) safety is surely one of the most urgent requirements of any further work.

The results obtained from the rating of attributes of students who had accidents might form the basis of further research into the influence of speed of learning, interest, and conduct, on the liability of a student to have an accident. This could have important connotations for the teaching of safety.

The views of young people on industrial safety are important because of their implications for safety education. This would be a useful area of research.

The relevance of safety in colleges of education appears to be a suitable topic for further research.

There are possibilities that could be explored of further development of the 'checklist' and of its application to a variety of situations in industry as well as in education.

The possibility of the re-design of hand tools, for example, knives and files, to improve safety might be investigated.

A topic that has so far been neglected is that arising from the problems of converting learners to industrial conditions after they have been taught on specially designed machines (lathes, for example) and of preparing them to face hazards in industry which have been eliminated from the sheltered environment of a training workshop or laboratory.

APPENDIX 1

RAB/6(c)

LONDON AND HOME COUNTIES

REGIONAL ADVISORY COUNCIL FOR TECHNOLOGICAL EDUCATION

ACCIDENTS IN FURTHER EDUCATION ESTABLISHMENTS 1973/74

(comments by H.M. Factory Inspectorate are given in brackets)

ENGINEERING WORKSHOPS

A serious incident occurred in the casting bay of the School of Art when a pot of molten aluminium contained within a casting furnace suddenly erupted showering the metal over a wide area of the casting bay. About seven pounds of molten metal was thrown out and injury was caused to the lecturer in charge and to two students. The main injuries were burns and these were serious enough to require admission to the Hospital Burns Unit.

Possible causes for the eruption have been investigated and the most likely cause of the eruption in the view of a consultant metallurgist is as follows:

A ceramic collar made from refractory cement in segments had been built to stand on the furnace top and thereby increase the height of the lid above the crucible in order to obtain higher temperatures of melting, without prolonged heating, particularly for metals such as Nickel/Silver.

During the course of time the refractory collar had deteriorated and the segments had become friable. Burnt pieces could be readily broken off.

On the day in question the aluminium metal had been through the melting process, the furnace head had been switched off and the pot was prepared for removing to the de-gassing bin. The furnace lid had been removed. Crucible tongs had been placed around the crucible but the collar prevented a satisfactory purchase on the crucible. One of the operators collected a pair of tongs to remove a piece of the collar, replaced the tongs and was returning to start lifting the crucible, when the eruption took place. It is suggested that at this stage a piece of the refractory collar broke off and penetrated the melt.

It is likely that the localised cooling caused by the foreign body would produce a partial supersaturation of the metal with respect to gas, so allowing the excess gas to be ejected from the furnace together with the contents of the pot.

Since the incident a review of procedures for casting has taken place and a much more stringent application of safety measures is in force, particularly over the wearing of safety clothing and means of escape from the casting area.

An accident occurred whilst a foot-operated sheet metal guillotine was in use. In this machine a foot pedal runs the whole width of the frame and foot power is used directly to cut the metal. To prevent the possibility of the operator's other foot being squashed by the pedal, a large metal stop is fixed to one end of the pedal and this prevents the latter from being depressed fully to the ground level. The stop is however, part of the pedal and itself rises and falls as the pedal is operated. The accident occurred when another student was waiting to use the guillotine and was standing with his foot under the end of the pedal - DIRECTLY UNDER THE SAFETY STOP. When the pedal was depressed, the stop crushed the spectator's foot. The manufacturers have been contacted with a view to modifying the machine.

A plastic injection moulding machine was being used to produce test specimens. A group of students were using the machine under the supervision of a lecturer.

Some difficulty was experienced in making the plastic eject from the machine cylinder into the mould, and the lecturer was investigating when there was an explosion which blew molten plastic into the lecturer's face in the region of his left eye.

Subsequent investigation has shown that a spring in the injection nozzle had become choked with solidified plastic, and was probably the cause of the incident.

The lecturer's injuries were only superficial with the eye itself being unharmed. Eye protection is now mandatory for all students and staff operating these machines.

MISCELLANEOUS

A student in a cabinet-making workshop threw a chisel back on to a workbench after using. The chisel bounced off the bench hitting a passing student on the back. The chisel cut the clothing and, fortunately, only caused a minor cut on the back of the passing student.

(Carelessness in handling edge tools is always liable to cause injury and lecturers should be alert to secure thei· self discipline that students must exercise if they are to avoid the risk of injuring themselves and others, and try to ensure that the necessary self discipline is exercised at all times).

An unusual accident during the year was due to contractors' negligence in the installation of the overhead air-line and fittings. The main supply terminated, with a shut-off valve, about 4 ft. above the level of the bench tops, and was then continued for another 3 ft. with a flexible plastic hose which was fixed on the supply line, immediately under the shut-off valve, with a light crimping ring.

The pressure in the line was approx. 80 p.s.i. and in use, due to the poor fixing, these flexible extension pieces were partly blown off and moved around in a most dangerous manner. Fortunately no one was hurt. All outlets have now been modified with a fixed outlet and standard bayonet fitting.

SCIENCE LABORATORIES

A lecturer was attempting to reclaim some silver from silver residues, and was using a solution of silver residues in ammonia. This was impure and had some solid in the bottom. He decided to reprecipitate the silver as silver oxide, boil off the ammonia, wash the precipitate, and redissolve it. He added some solid sodium hydroxide, and warmed over a bunsen burner in the fume cupboard. Ammonia was evolved, and silver oxide precipitated. He then diluted the solution with tap water, and after 3-4 times the original volume of water had been added there was an explosion which soaked his jacket, shirt, underclothes, trousers, socks and shoes with a hot solution of sodium hydroxide, containing silver oxide.

On investigation it was found that during the addition of sodium hydroxide to silver/ammonium solutions, silver oxide is formed which detonates (but usually only when dry).

(Silvering solution used in industry (e.g. in the manufacture of mirrors and vacuum flasks) involves the use of Silver Nitrate, Ammonia and Caustic Soda or Caustic Potash. It is known that the use for storage of such solutions may in certain circumstances result in the formation of small quantities of silver azide or silver imide, both of which are highly unstable explosive substances. It seems possible that a reaction of this kind occurred in this case. The main precautions observed in industry are designed to ensure that the silver nitrate solution is not allowed to become concentrated by evaporation, and that silver nitrate solution to which ammonia has been added is used at once and not stored).

A visiting Science Adviser noticed a bottle of diisopropyl ether in stock and drew attention to the danger of its forming explosive peroxides. The compound had been ordered by a teacher for molar refraction experiments (needing 0.5cm^3) and was only available in half-litre quantities. After disposing of it according to Gaston, the other ethers were tested. Dioxan and dibutyl ether were found to be heavily contaminated and were disposed of. The technicians have now been instructed to test all ethers at the end of each term and only order and keep a year's supply at a time.

A student was following a recognised procedure for characterization of an unknown substance.

The addition of sodium hydroxide would be a normal test in such a procedure and one object would be to note a gas or vapour and recogition of its odour would be significant.

The student carrying out the experiment reported an inability to recognise a characteristic odour. The Lecturer further heated the test tube until it boiled. As the tube was moved to her face to test for characteristic odour, the contents spurted into her face, presumably due to delayed formation of a bubble of vapour.

Some of the solution entered her mouth and eyes causing great distress.

(Heads of Departments might consider whether suitable visors should not be worn when experiments or investigations of this kind are being carried out).

An accident occurred with an experiment involving catalytic hydrogenation of an unsaturated organic compound. The removal of air and filling the hydrogenation apparatus with hydrogen was demonstrated by a technician, who then supervised the process which was performed by two of the students. The technician stated that he finally flushed the hydrogen from the apparatus once by evacuation and filling with air, telling the students to repeat this twice more to ensure complete removal of hydrogen, when it would be safe for them to begin the actual hydrogenation experiment. The technician then left the room in search of some apparatus. The student, who eventually sustained the accident, then simply opened the apparatus to air and removed the reaction flask, into which he commenced to pour the catalyst. Presumably the flask contained a hydrogen air mixture, which then exploded in contact with the catalyst. It would appear that the student failed to comprehend his instructions. Possibly the apparatus should not have been left in an unsafe condition when handed over to the student. The apparatus has been inspected, and it has been reported that, under normal conditions, in the hands of a competent operator, it would
In future, it is proposed that only the technician will charge the apparatus with hydrogen and flush with air before removing the reaction vessel.

(The practice of purging a vessel which has contained flammable gas or vapour with air is intrinsically extremely hazardous, and is contrary to sound industrial practice. A safe method of purging would be to use an inert gas such as nitrogen. There appears to have been a failure here to warn the students adequately, or to ensure that the apparatus was in fact made safe before it was handed over to them; Heads of Departments might well consider whether they should insist on the adoption of methods of purging chemical apparatus that are safer than flushing with air.)

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The University of Aston in Birmingham. Safety and Hygiene Group

ACCIDENT REPORT

(Use also for occupational diseases)

Report all cases where injury requires treatment
*Underline items as applicable. Other instructions overleaf.

INJURED PERSON – STAFF OR STUDENT – NAME NOT REQUIRED.		
Male*/Female*	If staff give occupation:	
Student's course:	Stage or year:	Age of Student: yrs.
Nature of injuries and parts of body affected:		
Estimated*/actual* time before normal activites can be resumed: min. hr.*/over 24 hours*		
Treatment by doctor*/nurse*/hospital accident dept.*/name other:		

ACCIDENT	
Date:	Location: lect. rm.*/lab.*/w'shop*/stores*/corridor*/name other:
What directly inflicted the injury?	If a machine, was it in motion?
Exactly what activity was the injured person engaged in at the time of the accident?	
Describe how the accident occurred:	
(a) What did the injured person, or someone else, do or fail to do, that contributed to the accident? (b) What conditions of machines, apparatus, buildings, etc. contributed to, or had a part in, the occurrence of the accident?	

CLASS IN WHICH ACCIDENT OCCURRED – NOT APPLICABLE TO DEGREE-LEVEL STUDENTS					
Type of class: Practical*/Theoretical*/Physical Ed.*/			Staff/Student ratio:		
Student's attitude and ability in this class (Please tick appropriate squares)					
INTEREST	Not interested 1	2	Average interest 3	4	Very keen 5
CONDUCT	Unruly 1	2	Transgresses occasionally 3	4	Exemplary 5
LEARNING	Very slow 1	2	Average ability 3	4	Learns quickly 5

Initials: .... Date: .... College or University: ....

LEAVE BLANK	
1 M	31 D
2 O	32 O
3 C	33 O
4 O	34 C
5 S	35 O
6 S	36 N
7 A	37 A
8 G	38 G
9 I	39 E
10 N	40 E
11 J	41 T
12 P	42 S
13 A	43 S
14 R	44 I
15 E	45 C
16 T	46 L
17 A	47
18 L	48
19 D	49
20 I	50
21 R	51
22 E	52
23 M	53 T
24 A	54 E
25 C	55 S
26 T	56 T
27 A	57 C
28 C	58 A
29 C	59 R
30	60 D

APPENDIX 3

EVALUATION OF SAFETY ORGANIZATION AND METHODS IN FURTHER EDUCATION ESTABLISHMENTS

	Maximum score (Grand Total = 100)	
1. College Safety Officer		
Provision of College safety officer	6.30	
Professional qualifications or training in safety (Course of 3 days' duration = 3.60)	5.40	
If member of teaching staff, teaching programme reduced to allow time for safety duties. If not member of teaching staff, is of comparable standing and has similar time allowance (2 hours remission of teaching i.e. $\frac{1}{2}$ day = 6.30)	6.30	
		18.00
2. Action by Academic Board or Other Policy Making Body		
Written safety policy for the College or written instruction of any sort informing staff of the standard expected of them in safety matters	5.10	
Notice in prospectus or elsewhere informing students of the general standard of safety they are expected to observe	4.25	
Special provision for safety equipment in annual estimates	4.25	
College affiliated to RoSPA or similar body (2.55) and to District Safety Group	3.40	
		17.00
3. Safety Inspections and Appraisals		
Organized observation tours made in past year by safety committee or senior staff Safety appraisals of workshops and laboratories made in past year	12.00	
Visit by Factory Inspector in last 3 years	4.00	
		16.00

4. Fire Precautions

Fire drills held regularly and attempts made to involve part-time staff in them	6.50	
Fire appliances checked regularly	3.90	
Staff trained in the use of portable hand extinguishers and other fire fighting equipment	2.60	
		13.00

5. Departmental Safety Advisers/Officers

Provision of safety advisers in science and technology departments	3.50	
Safety advisers, members of lecturing staff or of similar standing	3.00	
Reduction in teaching duties or time allowance	3.50	
		10.00

6. Safety Training for Staff

Special safety lectures organised for staff in last 3 years	2.40	
First-aid training organised for staff in last 3 years	1.60	
Lecturers provided with their own personal protective devices e.g. safety spectacles, safety hats	2.40	
Lecturers required to give special talks about safety to students in workshops and laboratories which are new to them and repeat such talks at intervals	1.60	
		8.00

7. Safety Committee

College safety committee representative of all sections of work - academic, administrative, service (care-taking, maintenance, refectory), and students	3.50	
Chairman, a senior member of the administration (Head of Department = 1.00, Principal or V.P. = 1.75)	1.75	
Frequency of committee meetings: attendance at last three meetings	1.75	
		7.00

8. Accident Procedures

Onus of accident registration made clear	1.00	
Reported accidents investigated and recommendations made for the prevention of similar accidents together with effective follow up procedure for such recommendations	3.00	
Accident analysis	1.00	
		5.00

9. Booklets and Leaflets

Safety booklets for college, or preferably individual departments	2.00	
Printed instructions applicable to a particular workshop, laboratory or job, given to individual students	2.00	
		4.00

10. Notices

Clearly displayed notices regarding the following :

(i)	the use of safety equipment	0.50	
(ii)	what to do in the event of (a) an accident	0.50	
	(b) a fire	0.50	
(iii)	names of persons qualified in first-aid	0.50	
			2.00

The University of Aston in Birmingham. Safety and Hygiene Group

Dear

As part of a research project I have obtained an assessment of the attitude and ability of students who have been involved in accidents. I now wish to see how these students compare with a different sample of students.

I should be grateful for your assistance in obtaining this information. If you are willing to help, please complete the report forms below (without revealing names) for the first three students on the register who are in attendance in your next class.

Yours sincerely,

W. R. Sinnott.

Area of study of course (e.g. Prod. Eng.) ....

Level (e.g. C.1, T.2) ....

Student's attitude and ability in this class (Please tick appropriate squares)					Male Female
INTEREST	Not interested 1	2	Average interest 3	4	Very keen 5
CONDUCT	Unruly 1	2	Transgresses occasionally 3	4	Exemplary 5
LEARNING	Very slow 1	2	Average ability 3	4	Learns quickly 5

Student's attitude and ability in this class (Please tick appropriate squares)					Male Female
INTEREST	Not interested 1	2	Average interest 3	4	Very keen 5
CONDUCT	Unruly 1	2	Transgresses occasionally 3	4	Exemplary 5
LEARNING	Very slow 1	2	Average ability 3	4	Learns quickly 5

Student's attitude and ability in this class (Please tick appropriate squares)					Male Female
INTEREST	Not interested 1	2	Average interest 3	4	Very keen 5
CONDUCT	Unruly 1	2	Transgresses occasionally 3	4	Exemplary 5
LEARNING	Very slow 1	2	Average ability 3	4	Learns quickly 5

Kindly return these, when completed, to: ....

Office Use

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The University of Aston in Birmingham. Safety and Hygiene Group

Students' Workshop Experience

SELF-COMPLETION CHECK-LIST

Directions: Ring the word(s) applicable to your experience then read the completed sentence through to make sure that it is correct.

General Items

I have | never / once or twice / several times / nearly always / always | opened or removed a guard before a machine has stopped . . . (1)

I have | never / once or twice / several times / nearly always / always | leaned on the machine I have been using while it has been running . (2)

I have | never / once or twice / several times / nearly always / always | left a machine running when I have moved away from it . . . (3)

I have | never / once or twice / several times / nearly always / always | switched off the machine I have been using at the isolating switch at the end of the class period . . . . (4)

When I have not switched off at the isolating switch, I have | never / once or twice / several times / nearly always / always | checked that the motor of the machine is switched off . . . . (5)

I have | never / once or twice / several times / nearly always / always | switched off a machine at the isolating switch before removing or refitting a chuck, faceplate, cutter, drill, etc. . . . . (6)

General Items—*continued*

Before setting up work I have | never / once or twice / several times / nearly always / always | switched off the machine at the isolating switch (7)

When I have used a dial test indicator I have | never / once or twice / several times / nearly always / always | switched off the motor of the machine I have been using . . . . (8)

Before using a machine I have | never / once or twice / several times / nearly always / always | checked the oil level . . . . . . (9)

I have | never / once or twice / several times / nearly always / always | used a rule to remove swarf . . . . (10)

I have | never / once or twice / several times / nearly always / always | used a hand rag to clean up swarf . . . . (11)

I have | never / once or twice / several times / nearly always / always | removed swarf with my bare hands . . . . (12)

I have | never / once or twice / several times / nearly always / always | used a swarf brush or rake on a machine while the cutter has been in motion . . . . (13)

When I have used compressed air I have | never / once or twice / several times / nearly always / always | taken care to keep it directed away from myself and other people . . . . (14)

General Items—*continued*

I have	never once or twice several times nearly always always	kept sharp tools in my overall pockets	(15)

I have	never once or twice several times nearly always always	kept spanners, hammers, or other loose tools on a machine while it

was running, other than in the trays provided . . . . (16)

I have	never once or twice several times nearly always always	thrown tools or material or anything else <u>to</u> another student . .	(17)

I have	never once or twice several times nearly always always	thrown anything <u>at</u> another student	(18)

I have	never once or twice several times nearly always always	lifted a workpiece by inserting my fingers in a hole or slot . .	(19)

I have	never once or twice several times nearly always always	worn a safety hat or net when working on the machines . . .	(20)

The safety hat or net I have worn has	never once or twice several times nearly always always	enclosed my hair completely . .	(21)

I have	never once or twice several times nearly always always	worn rings, watches, or anything else on my fingers or wrists when

using a machine . . . . (22)

Bench Work

I have | never / once or twice / several times / nearly always / always | used hand tools knowing they were not sharp enough for the job . (23)

I have | never / once or twice / several times / nearly always / always | used a file or scraper without a handle . . . . . . (24)

I have | never / once or twice / several times / nearly always / always | kept tools and equipment tidy on benches when not in use . . (25)

Lathe Work

I have | never / once or twice / several times / nearly always / always | switched off the lathe motor before removing or refitting a chuck or faceplate . . . . (26)

I have | never / once or twice / several times / nearly always / always | removed or refitted tools in the toolpost with the motor running . (27)

Before starting the lathe I have | never / once or twice / several times / nearly always / always | turned the chuck round by hand . . (28)

I have | never / once or twice / several times / nearly always / always | traversed the carriage by hand before starting the lathe . . . (29)

I have | never / once or twice / several times / nearly always / always | started the lathe before I have checked the depth of cut, the feed rate and the cutting speed . . . . (30)

Lathe Work—*continued*

I have	never once or twice several times nearly always always	wound the tool clear of the work before engaging the feed . .	(31)
I have	never ‹several times› several times nearly always always	held work being parted off in my fingers	(32)
I have	never once or twice several times nearly always always	left the chuck key in a stationary chuck after removing the workpiece	(33)
I have	never once or twice several times nearly always always	left a chuck or faceplate loose or partially secured during a tea break or interruption of work	(34)
I have	never once or twice several times nearly always always	had the tool or toolpost contact the chuck when it was running .	(35)
I have	never once or twice several times nearly always always	found the feed in the wrong direction when I started cutting . .	(36)
I have	never once or twice several times nearly always always	used a file or piece of emery cloth on a rotating workpiece . .	(37)
I have	never once or twice several times nearly always always	put my fingers on a rotating workpiece to check its finish or smoothness	(38)

I have | never / once or twice / several times / nearly always / always | stopped the spindle by placing my hand on the chuck or faceplate . (39)

I have | never / once or twice / several times / nearly always / always | left off my goggles or safety glasses when using a lathe not fitted with an eye shield . . . . (40)

Shaping

I have | never / once or twice / several times / nearly always / always | switched off the shaping machine motor before setting up work on the machine . . . . (41)

I have | never / once or twice / several times / nearly always / always | started the shaper before having checked that the vice is secured to the table and the workpiece is secured in the vice . . . . (42)

Before I have started the shaper I have | never / once or twice / several times / nearly always / always | made sure that the ram and the tool will clear the vice and workpiece . . . . (43)

I have | never / once or twice / several times / nearly always / always | checked that automatic feeds are disengaged before starting . . (44)

I have | never / once or twice / several times / nearly always / always | manually adjusted the stroke without switching off the shaping machine motor . . . . (45)

Shaping—*continued*

I have | never / once or twice / several times / nearly always / always | made sure that the tool has been clear of the workpiece when setting up and adjusting the workpiece . . . . (46)

I have | never / once or twice / several times / nearly always / always | checked a slot with gauges or calipers without stopping the machine (47)

I have | never / once or twice / several times / nearly always / always | worn goggles or safety glasses when using the shaper . . . . (48)

Milling

I have | never / once or twice / several times / nearly always / always | started the milling machine without making sure that the cutter is rotating in the right direction . . . . (49)

Before making a cut with the milling machine I have | never / once or twice / several times / nearly always / always | satisfied myself that the work piece is held securely in the vice or fixture and that the vice or fixture is held securely on the table . . . . (50)

I have | never / once or twice / several times / nearly always / always | fixed guards in position when the milling machine was running . (51)

I have | never / once or twice / several times / nearly always / always | adjusted the position of the coolant pipe when the machine has been running . . . . (52)

Milling—*continued*

I have | never / once or twice / several times / nearly always / always | changed cutters without switching off the motor of the milling machine (53)

When lifting or fitting a cutter I have never / once or twice / several times / nearly always / always used a cloth or anything on my hands (54)

I have | never / once or twice / several times / nearly always / always | stopped the machine before changing the spindle speed . . . (55)

I have | never / once or twice / several times / nearly always / always | tried to reverse the direction of a spindle while it has been in motion (56)

I have | never / once or twice / several times / nearly always / always | wound the cutter clear of the work piece before engaging the feeds . (57)

I have | never / once or twice / several times / nearly always / always | used the milling machine without wearing goggles or safety glasses . (58)

Drilling

Before I have changed pulley speed belts I have | never / once or twice / several times / nearly always / always | first switched off the drilling machine at the isolating switch . . . . (59)

I have | never / once or twice / several times / nearly always / always | switched on a drilling machine without having replaced the cover after changing belt positions . . . . (60)

Drilling—*continued*

After using a chuck key I have	never once or twice several times nearly always always	removed it immediately from the chuck .	(61)

I have	never once or twice several times nearly always always	used the end of a file to remove a chuck or drill	(62)

I have	never once or twice several times nearly always always	used any means of removing swarf from a rotating drill . . .	(63)

I have	never once or twice several times nearly always always	drilled strip material without clamping it to the table . . .	(64)

When using drills greater than 8 mm (5/16") diameter I have	never once or twice several times nearly always always	clamped the	

vice holding the workpiece to the table or used stop bars to prevent it turning . . . (65)

I have	never once or twice several times nearly always always	stopped the drill spindle by hand	(66)

I have	never once or twice several times nearly always always	left off my safety glasses or goggles when using a drilling machine .	(67)

Off Hand Grinding (Tool bits, etc.)

I have	never once or twice several times nearly always always	used a double-ended grinding machine at the same time as anyone	

else . . . . (68)

When using a grinding machine where work-rests are provided I have | never / once or twice / several times / nearly always / always | made sure that the gap between the rest and the grinding wheel was not more than 2 mm (1/16") . (69)

Before using a work-rest I have | never / once or twice / several times / nearly always / always | checked that it was not loose . . . (70)

I have | never / once or twice / several times / nearly always / always | adjusted a work-rest when the wheel has been running . . . (71)

I have | never / once or twice / several times / nearly always / always | held an article being ground in a cloth or any form of pliers . . (72)

I have | never / once or twice / several times / nearly always / always | worn goggles or safety glasses when using a grinding machine not fitted with an eye shield . . . . (73)

The length of my hair is / above the bottom of my ears / between the bottom of my ears and my shirt collar / below my shirt collar / . . . . (74)

For office use (75)

(76)

(77)

(78)

(79)

(80)

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#LISTING OF :ESP0603.REAN(1/) PRODUCED ON 18JUN74 AT 14.08.39

#G7.7E AT ASTON IN ':ESP0603.RAWDATA' ON 30APR75 AT 19.20.19

DOCUMENT REAN

APPENDIX 6

Retest data

Student No. | Group No. | Estab. No. +10

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89 ****
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APPENDIX 7

Comparison of test and re-test responses to 74 checklist items obtained from 89 students
(Scored 1 to 5 for safe and unsafe responses)

Item no.	DESCRIPTION OF ITEM	No. of resp.	Percentage Ident. resp.	Percentage Within 1 pt. of ident.	Mean Score Test	Mean Score Re-test	Mean Score Diff.
	Apparel						
20	Safety hat or net worn when machining	72	61	94	3.44	3.53	-0.08
21	Hair completely enclosed	44	55	84	3.95	4.09	-0.14
22	Rings or watches worn when machining	86	59	86	3.26	3.05	0.21
	Eye protection worn when using :						
40	Lathe	88	57	92	2.59	2.52	0.07
48	Shaping machine	87	56	89	3.13	3.13	0.00
58	Milling machine	88	57	93	2.32	2.48	-0.16
67	Drilling machine	87	39	80	3.24	3.29	-0.05
73	Off-hand grinding machine	77	52	83	2.22	2.31	-0.09
	Dangerous acts						
3	Leaving machine running	89	71	99	1.98	1.97	0.01
14	Dangerous use of compressed air	23	61	91	1.43	1.52	-0.09
17	Throwing to another student	89	57	94	1.85	1.82	0.03
18	Throwing at another student	88	77	97	1.64	1.47	0.17
24	Using file without handle	87	79	99	1.24	1.28	-0.03

Cont'd...

APPENDIX 7 (Cont'd)...

39	Stopping lathe by hand	88	67	95	1.36	1.51	-0.15
66	Stopping drill by hand	88	73	98	1.61	1.68	-0.07
	Swarf: risk to hands						
10	Removing swarf with rule	88	47	89	2.44	2.27	0.17
11	Cleaning up swarf with hand rag	88	42	88	2.14	2.25	-0.11
12	Removing swarf with bare hands	87	59	91	2.31	2.06	0.25
13	Using swarf brush while cutter in motion	85	45	89	2.01	2.18	-0.16
63	Removing swarf from rotating drill	85	53	82	1.86	1.84	0.02
19	Lifting workpiece by hole or slot	89	40	91	1.76	1.70	0.07
32	Holding work being parted off	87	79	95	1.41	1.37	0.05
38	Fingers on rotating workpiece	89	49	92	2.39	2.39	0.00
54	Handling milling cutter without protection	83	48	87	4.30	4.16	0.14
	Switching off, keeping machine running						
	Switching off machines at isolating switch:						
4	at end of class	89	53	82	2.20	2.30	-0.10
6	before removing chuck, etc.	88	50	70	3.90	3.59	0.31
7	before setting up work	88	56	82	4.09	3.85	0.24
59	when changing drilling machine pulley belts	80	38	70	2.61	2.67	-0.06
	Switching off machines at motor:						
8	when using dial test indicator	83	40	75	3.29	2.98	0.31
26	before removing or refitting lathe chuck	89	52	74	2.79	2.81	-0.02
27	when removing or refitting tools in toolpost	89	47	67	2.42	2.35	0.07
41	before setting up work on shaper	87	39	67	2.61	2.55	0.06

Cont'd...

APPENDIX 7 (Cont'd)...

45	when manually adjusting stroke of shaper	86	50	69	1.91	2.12	-0.21
53	when changing cutters of milling machine	86	50	74	1.94	1.81	0.13
5	Checked motor off if isolating switch left on	45	33	76	1.98	2.38	-0.40
	Keeping machine running:						
47	when checking a slot with gauges or calipers (shaping)	83	76	93	1.31	1.24	0.07
51	when fixing guards in position (milling)	85	29	73	2.62	2.62	0.00
52	while adjusting coolant pipe	68	41	82	2.71	2.65	0.06
55	when changing spindle speed	88	69	91	1.55	1.48	0.07
56	when reversing direction of spindle	89	72	94	1.28	1.17	0.11
71	while adjusting work-rest (off-hand grinding)	70	87	99	1.11	1.11	0.00
	<u>Checks before starting</u>						
9	Oil level of machine (general)	87	78	93	4.72	4.62	0.10
28	Turning chuck round by hand (lathe work)	88	44	86	3.08	3.25	-0.17
29	Traversing carriage by hand	86	34	66	2.55	2.90	-0.35
30	Depth of cut, feed rate, and cutting speed	88	35	75	2.52	2.40	0.13
31	Winding tool clear before engaging feed	89	47	85	2.13	2.27	-0.13
42	Vice and workpiece secure (shaping)	89	49	79	1.44	1.92	-0.48
43	Ensuring that ram and tool will clear vice etc.	89	55	87	1.44	1.70	-0.26
44	Automatic feeds disengaged	87	39	77	2.34	2.37	-0.02
49	Cutter rotating in right direction (milling)	88	44	77	2.16	1.98	0.18
50	Workpiece held securely	87	63	90	1.32	1.51	-0.18
57	Winding cutter clear before engaging feeds	88	50	75	1.78	1.87	-0.09
69	Gap between rest and workpiece (off-hand grinding)	75	49	75	3.83	3.48	0.35
70	Work-rest not loose	75	45	67	3.56	3.20	0.36

Cont'd...

APPENDIX 7 (Cont'd)...

	Other items						
1	Opening or removing a guard before machine stops	88	55	95	1.73	1.75	-0.02
60	Switching on drill without replacing cover	77	66	88	1.34	1.44	-0.10
15	Keeping sharp tools in pocket	89	47	89	2.08	2.18	-0.10
16	Keeping loose tools in trays on machine	88	36	78	2.74	2.82	-0.08
23	Using blunt hand tools	88	55	95	1.65	1.76	-0.11
25	Keeping tools tidy on bench	89	49	79	3.53	3.42	0.11
33	Leaving key in lathe chuck	89	70	97	2.00	1.90	0.10
61	Leaving key in drill chuck	89	63	96	1.34	1.48	-0.15
34	Leaving lathe chuck loose	88	88	97	1.16	1.09	0.07
64	Clamping strip material for drilling	86	40	78	2.45	2.47	-0.01
65	Clamping material when drill greater than 8 mm	85	39	75	2.73	2.85	-0.12
2	Leaning on machine when it is running	89	47	90	3.04	2.90	0.15
37	Using file or emery cloth on rotating workpiece	89	52	92	3.34	3.22	0.11
46	Tool clear of workpiece when setting up	88	48	88	1.50	1.70	-0.20
62	Using file to remove chuck or drill	84	94	99	1.06	1.08	-0.02
68	Using double-ended grinder at both ends	76	51	92	2.22	2.32	-0.09
72	Holding article being ground in cloth, etc.	79	73	90	1.35	1.58	-0.23
35	Contact between tool or toolpost and chuck	88	75	99	1.62	1.64	-0.01
36	Feed in wrong direction on lathe	89	58	100	2.15	2.16	-0.01
74	Length of hair	84	86	98			

APPENDIX 9

Responses to 74 checklist items obtained from 360 students

Item no.	DESCRIPTION OF ITEM	No. of responses	RESULTS: Percentage responses, Safe - unsafe categories: 1	2	3	4	5	Mean Score
	Apparel							
20	Safety hat or net worn when machining	295	8	17	13	15	48	3.79
21	Hair completely enclosed	157	10	20	10	10	50	3.68
22	Rings or watches worn when machining	355	25	13	12	14	35	3.21
	Eye protection worn when using :							
40	Lathe	341	14	23	28	19	15	2.96
48	Shaping machine	358	11	20	13	17	40	3.56
58	Milling machine	355	18	24	14	16	28	3.12
67	Drilling machine	352	10	20	21	20	30	3.39
73	Off-hand grinding machine	332	52	22	10	8	7	1.96
	Dangerous acts							
3	Leaving machine running	358	25	58	14	2	1	1.95
14	Dangerous use of compressed air	111	57	26	5	4	9	1.82
17	Throwing to another student	359	43	43	11	1	1	1.73
18	Throwing at another student	356	50	39	10	1	1	1.63
24	Using file without handle	359	82	16	2	0	0	1.21

Cont'd...

APPENDIX 9 (Cont'd)...

39	Stopping lathe by hand	357	64	24	10	1	1	1.51
66	Stopping drill by hand	357	46	32	15	4	3	1.84
	Swarf: risk to hands							
10	Removing swarf with rule	358	17	42	32	6	4	2.37
11	Cleaning up swarf with hand rag	357	25	29	30	11	5	2.42
12	Removing swarf with bare hands	356	16	53	24	5	2	2.23
13	Using swarf brush while cutter in motion	356	42	34	19	4	1	1.88
63	Removing swarf from rotating drill	356	44	33	14	6	3	1.89
19	Lifting workpiece by hole or slot	356	42	40	14	3	1	1.82
32	Holding work being parted off	355	80	6	9	3	2	1.41
38	Fingers on rotating workpiece	360	16	40	26	13	6	2.53
54	Handling milling cutter without protection	346	10	15	10	18	47	3.76
	Switching off, keeping machine running							
	Switching off machines at isolating switch:							
4	at end of class	360	28	33	10	12	19	2.61
6	before removing chuck, etc.	358	21	14	8	15	42	3.44
7	before setting up work	359	7	13	13	21	46	3.85
59	when changing drilling machine pulley belts	335	50	13	8	10	18	2.32
	Switching off machines at motor:							
8	when using dial test indicator	347	34	16	5	17	27	2.86
26	before removing or refitting lathe chuck	357	51	10	8	13	17	2.35
27	when removing or refitting tools in toolpost	359	47	17	13	13	9	2.21
41	before setting up work on shaper	360	43	18	10	12	17	2.41

Cont'd...

APPENDIX 9 (Cont'd)...

45	when manually adjusting stroke of shaper	357	58	11	13	9	9	2.00
53	when changing cutters of milling machine	352	66	12	8	7	7	1.78
5	Checked motor off if isolating switch left on	271	53	25	6	8	8	1.93
	Keeping machine running:							
47	when checking a slot with gauges or calipers (shaping)	357	80	10	5	2	4	1.41
51	when fixing guards in position (milling)	350	24	23	16	24	13	2.77
52	while adjusting coolant pipe	313	11	18	40	21	11	3.03
55	when changing spindle speed	351	79	12	3	3	4	1.41
56	when reversing direction of spindle	352	77	15	6	1	2	1.36
71	while adjusting work-rest (off-hand grinding)	326	84	8	6	1	2	1.29
	Checks before starting							
9	Oil level of machine (general)	356	1	5	4	18	72	4.54
28	Turning chuck round by hand (lathe work)	357	11	26	29	17	16	3.01
29	Traversing carriage by hand	353	16	25	29	16	13	2.85
30	Depth of cut, feed rate, and cutting speed	360	28	34	17	14	6	2.38
31	Winding tool clear before engaging feed	357	42	34	10	7	8	2.04
42	Vice and workpiece secure (shaping)	360	65	21	5	5	4	1.62
43	Ensuring that ram and tool will clear vice etc.	360	71	23	3	2	1	1.39
44	Automatic feeds disengaged	359	28	43	9	12	7	2.26
49	Cutter rotating in right direction (milling)	356	38	36	15	5	6	2.05
50	Workpiece held securely	353	69	23	3	2	2	1.44
57	Winding cutter clear before engaging feeds	354	58	26	7	6	3	1.70
69	Gap between rest and workpiece (off-hand grinding)	332	16	18	9	13	44	3.53
70	Work-rest not loose	332	17	20	14	16	33	3.28

Cont'd...

APPENDIX 9 (Cont'd)...

	Other items							
1	Opening or removing a guard before machine stops	356	38	42	17	3	1	1.87
60	Switching on drill without replacing cover	335	67	21	5	2	4	1.53
15	Keeping sharp tools in pocket	360	23	39	25	9	4	2.30
16	Keeping loose tools in trays on machine	358	15	31	26	18	9	2.77
23	Using blunt hand tools	359	40	48	12	0	0	1.72
25	Keeping tools tidy on bench	358	7	31	18	23	21	3.20
33	Leaving key in lathe chuck	360	26	58	13	3	1	1.94
61	Leaving key in drill chuck	355	68	27	1	2	1	1.40
34	Leaving lathe chuck loose	354	87	10	2	1	0	1.17
64	Clamping strip material for drilling	350	33	33	21	6	6	2.18
65	Clamping material when drill greater than 8 mm	349	34	26	14	15	11	2.41
2	Leaning on machine when it is running	359	5	24	38	26	8	3.08
37	Using file or emery cloth on rotating workpiece	360	4	23	53	13	7	2.96
46	Tool clear of workpiece when setting up	359	63	31	4	1	1	1.47
62	Using file to remove chuck or drill	352	93	5	1	1	1	1.10
68	Using double-ended grinder at both ends	329	15	39	32	10	4	2.50
72	Holding article being ground in cloth, etc.	336	81	13	4	1	1	1.27
35	Contact between tool or toolpost and chuck	359	47	49	4	0	0	1.57
36	Feed in wrong direction on lathe	358	21	54	23	2	0	2.06
			Above bottom of ears	Between ears & collar	Below collar			
74	Length of hair	355	17	34	48			

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