The development of a 'flexible learning' strategy for design and technology

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Abstract

Traditional approaches towards the teaching and learning of design and technology are becoming more difficult to sustain and the need to consider alternative strategies is becoming more urgent. A number of factors have contributed to the need to consider strategies intended to be more flexible and accommodating :

> *worsening staff / student ratios;*
>
> *the need to provide an increasingly wide range of technological information at the relevant point of design development;*
>
> *a belief that design students and teachers are entitled to relevant technological knowledge in a form which is appropriate to their needs.*

This paper describes the selection, development and evaluation of trial materials which aim to support individual student learning in design and technology. The initial student groups were identified as first year industrial design and technology undergraduates and A/AS-level design and technology students. This target is continually widening, however, and might also include teachers who wish to develop their own technological capability through INSET.

Why consider more flexible approaches?

The general reasons for engaging in the development of flexible learning approaches tend to concern one or more of :

- coping with increased student numbers;
- maintaining or improving the quality of teaching and learning;
- access for 'non-traditional' students;
- sharing teaching expertise where there are small teaching groups.

Clearly, the learning environment - physical resources, individual or group work, availability of tutorial support etc. - will exert an influence, but the intention is to facilitate learning 'in spite of' rather than 'because of' these reasons. The fundamental strategy employed is to allow the students greater control over their learning so that the learning activities remain closely targeted to the individual student needs.

In design and technology there are additional concerns. Design and technological activity tends to employ a very wide knowledge base and consequently students are always making use of subject areas beyond their immediate expertise. This knowledge base is conventionally divided between the sciences and the arts. Scientifically based designers might need to draw on areas associated with product semantics, aesthetic awareness and human factors and arts based designers might need to consider aspects like materials selection, energy use, manufacturing and electromechanical system design. Our particular considerations have been concerned with the scientific knowledge base of design, but this should not be interpreted as indicative of our long term intentions. The overall aim is to explore the potential of flexible learning for all aspects of design and technology - a non-trivial task!

The aims of the project as originally stated relate to these issues and can be summarised as :

- primarily to support individual student learning;
- to support the maintenance of high quality learning experiences with declining human resources. The aim was to design learning materials for use with Year 1 Industrial Design and Technology students at Loughborough University, and also for use by A-level, BTEC or INSET students at schools and colleges;
- to facilitate the acquisition of individual knowledge and skills at the point of need. Project work is a major component of design and technology courses and it is quite probable that students will need to acquire further specific knowledge or skills which have not been taught as a foundation (perhaps pneumatics, computer control or stress analysis etc.)

During the project there has been a gradual shift of emphasis which is concerned with a growing interest in the idea of *entitlement*. Design students or teachers *should* be able to access information concerning relevant technological ideas if they need to. Traditional textbooks often contain the required information, but they are in a highly condensed format and normally require explanation. Centres of expertise, like colleges or universities, can provide courses, but these require attendance. Designers need to understand technological issues in order to select appropriate technology, and have to be able to gain access to the necessary skills and knowledge. Traditional approaches to teaching technology do not serve designers well.
Figure 1 shows the percentage of information from a lecture which is retained over time [1].

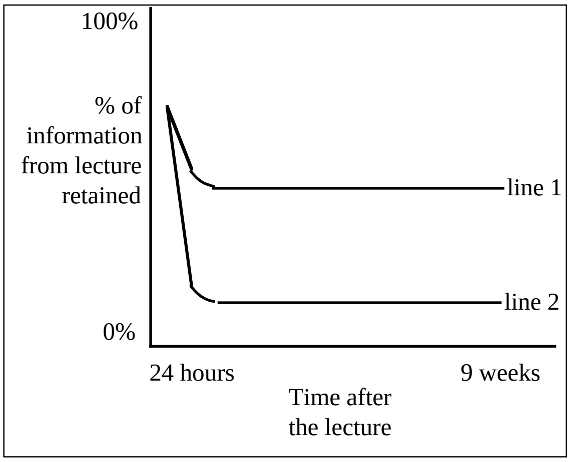

Figure 1 Retention of information following lectures

> "Because most learning in lectures is passive, subsequent forgetting can be dramatic and depressing. Estimates of the proportion of key information which students remember immediately after a lecture vary from about 50% downwards. But the main forgetting happens immediately afterwards. If active use of information is not made shortly after the lecture then much of what was originally retained is lost (line 1). In contrast if active use is made of material then the forgetting curve is very much flatter with relatively good recall even nine weeks later (line 2)" [2]

Clearly there is an implication that material covered during a lecture should be applied as soon as possible, but even then only around 50% is retained in the longer term. This has serious implications for foundation studies in design and technology and the wisdom of trying to cover key areas so that students can build on them in future years.

Why energy?

Energy was chosen as the first topic we would consider for a number of reasons:

- it is a vital area for designers both in terms of awareness of issues and the capability to perform technical calculations and assessments;
- it is an area where the prior student learning is very diverse, drawing upon subjects like physics, geography and design and technology;
- it is a 'free-standing' short course in the summer term of Year 1 Industrial Design and Technology at Loughborough University.

The first two reasons imply that if successful there will be major benefits to both the students and the department. The third was particularly important in that if the trials were unsuccessful the resulting damage could be easily limited. Hopefully the teaching and learning in the autumn and spring terms would be unaffected, and revision 'lectures' could always have been organised before the exams.

Project outline

Developing a flexible learning resource is a major undertaking and it was immediately decided to seek external support. It was not considered to be practical for already hard-pressed teaching staff to write the necessary materials. Sponsorship was obtained from British Gas. We were also fortunate in that Loughborough University decided to launch a flexible learning initiative across all departments independently and simultaneously. This provided access to two flexible learning consultants who were employed by the university. Clearly, advice was sought from them, but also from the Supported Self Study Unit in Northumberland who have five years experience in producing materials targeted at A and AS level students. The questions to which we were initially seeking answers fell into three areas and examples are given below:-

1) *What is the distinction between flexible learning and distance learning?*
   Did some areas of the unit need human intervention and feedback whereas others could make use of structured feedback built into the materials?
   How do we identify and classify areas of the material that cannot be put into distance learning textual material?

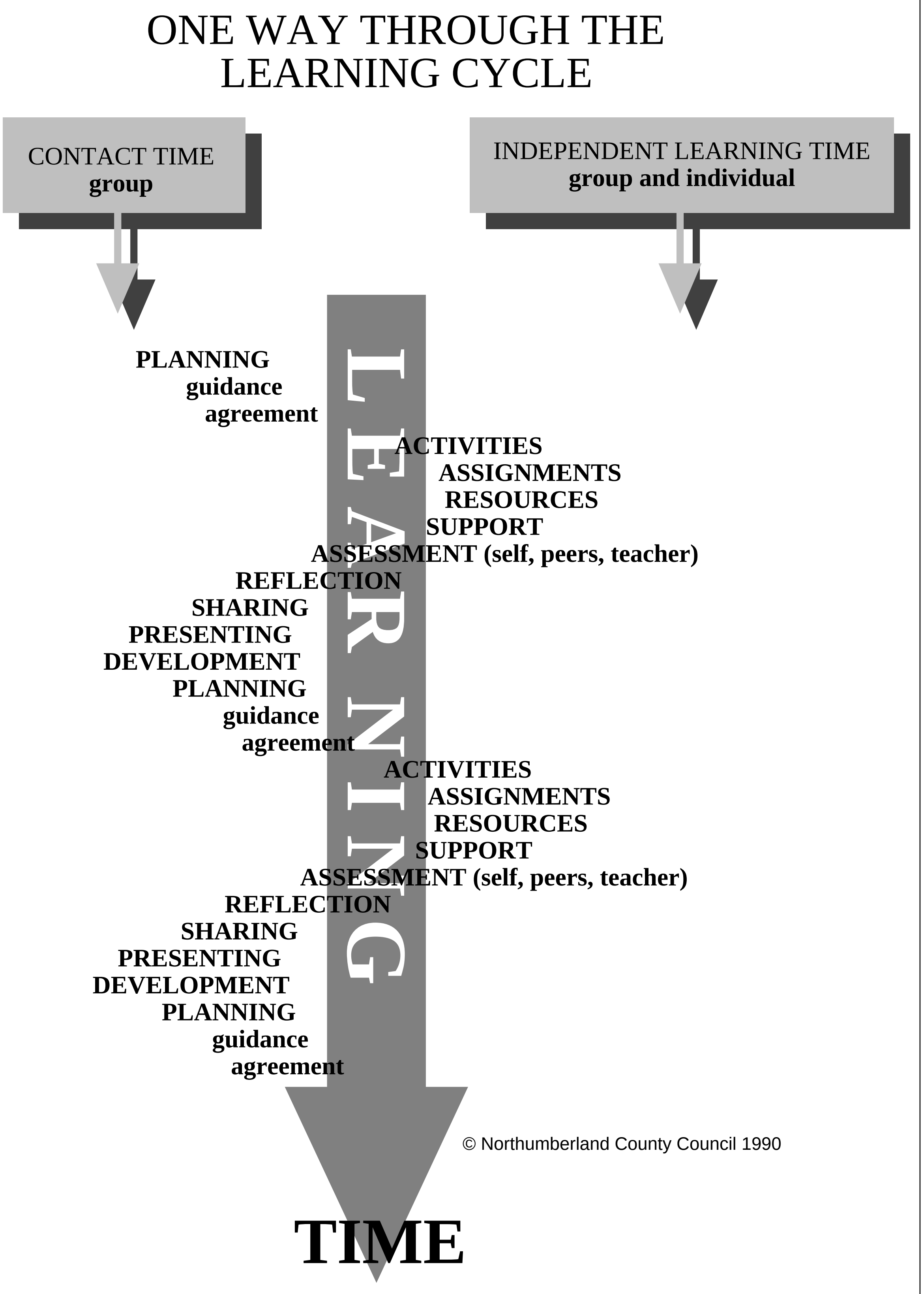

Figure 2 The model of learning developed by the Northumberland Supported Self Study Unit

2) *How can we ensure that the learning materials fulfil our aims?*
How can we create suitable diagnostic procedures to ensure that the material is truly flexible for students with differing backgrounds?
Would different learning materials be required for 16-18 year olds and for adult learners?

3) *How can we ensure that the study units are used effectively?*
Should there be an initial teacher input and, if so, how long should it be?
Should there be tutorials at set points in the course to cover extra material or to pick up on student problems or should they be by request only?

After consultation and consideration of these questions we were able to arrive at a number of policy decisions . We decided to:

- write a *flexible*, rather than a *distance,* learning package;
- provide only the support material for a current text;
- use a diagnostic exercise to assess previous learning and plan the most appropriate learning route; [3]
- provide a short initial teacher input to help students work through the self-study materials;
- provide a main folder of learning materials to be retained by the department and separate sheets for students to keep;
- provide as wide a variety of activities as possible, in addition to SAQs;
- encourage group discussion and activities;
- provide glossary sheets to help students collate important information;
- use different media where appropriate;
- teach all students as flexible learners and not have a 'control' group for the purpose of research evaluation;
- use this initial project to determine the most appropriate staff intervention in flexible learning materials.

Many of these decisions could be the subject of extensive discussion and the following notes only touch on some of the more important issues. Figure 2 shows the learning model developed by the Northumberland Supported Self Study Unit. This is important for a number of reasons but most significantly because it shows the kind of student-teacher interaction which is inherent in this kind of learning. There is 'planning, guidance and agreement' and then the students largely take control. Hence the need for planning sheets to record objectives and well-documented activities and resources.

Our distinction between flexible and distance learning really relates to the extent to which we have removed the administrative constraints on learning. The materials currently require facilities which are only available in our own department. Similarly tutorial support was primarily available during timetabled periods. We could have written the material in a truly distance format - ensuring there was no constraint necessitating attendance - but there seemed no reason to do so.

We decided against any attempt to establish a control group largely because it was not clear how two groups with identical prior learning experiences and comparable learning environments during the trial could be formulated. All the advice we received, as well as our own discussions, led to the conclusion that it was both more realistic and important to gauge the learning experiences and outcomes against previous years where traditional approaches had been used. This also means that we could attempt to correct anything that appeared to be going wrong with the flexible learning materials using 'traditional' routes without worrying about undermining our evidence.

The learning materials were to be trialed with about a hundred first year undergraduates taking foundation courses as part of their 'progress year' for degrees in Industrial Design and Technology. The initial conclusions of these trials are described later in this paper and more fully at the associated poster where the learning materials can also be viewed.

The learning materials on energy

The energy unit has been written to enable students to gain a clear understanding of energy sources, energy conversion and energy use in the home. In the future it could be easily extended to include topics like energy use in industry and energy in transport.

The unit is divided into four sections:

- heat and energy
- energy and its conversion
- energy sources
- use of energy in the home

The first student activity requires them to discuss in groups the meaning of particular technical terms

	Definition	Units of Measurement
Mass		
Weight		
Force		
Work		
Power		
Electrical Power		
Energy		
Electrical Energy		

State the relationship between *Force* and *Work*

....

....

State the relationship between *Energy* and *Power*

....

....

Figure 3. Glossary sheet 1 from the energy unit

and then individually to fill in 'Glossary Sheet 1', which is shown in Figure 3.

Figure 4 shows their route through the unit once this first activity has been completed. Depending on the level of difficulty encountered with the concepts associated with 'Glossary Sheet 1', the students either try the diagnostic sheet or undertake some preliminary work. When the students are ready, they attempted diagnostic questions which were designed to test their understanding. After checking their answers and according to their confidence and ability, they then planned their route through the unit entering at section 1,2, 3 or 4 as appropriate.

As a snapshot of the kind of activities contained within the unit Figure 5 shows an abbreviated form of the beginning of section 2.

Trialling the unit

The energy unit was trialed with two different groups of undergraduates. Group A were approximately 50 first year undergraduates taking a three year degree in Industrial Design and Technology. Group B were approximately 50 first year undergraduates taking a four year degree in Industrial Design and Technology with Education. Some key activities associated with each section were made compulsory e.g. an analysis of the lifting action of a weightlifter on interactive videodisc at the end of section 2.

Group A were split into two classes. They had an introductory session and 2 x 2 hours timetabled sessions in alternate weeks and were not required to complete section 4. The timetabled sessions were used to distribute and support the flexible learning materials as well as being specific work time for the students. Assessment was by individual 10 minute tutorials following completion of the unit. The assessment sheet used in the tutorials is shown in Figure 6.

Group B remained as one group. They had 4 x 2 hours timetabled sessions and met each week. This group were expected to cover section 4. The timetabled sessions were used to distribute and support the flexible learning materials and included one 'impromptu' lecture (30-45 minutes) at the students' request. This group's files were taken in for assessment at the midway point as well as on completion of the unit. They were also asked to complete a questionnaire.

Initial observations

It was clear that both groups had worked conscientiously and in a manner which suited their own style and pace of learning. They were also generally happy to be given the responsibility to work in this way. Students rarely worked within the Department, choosing instead to make their own arrangements to meet at home or to work at some other time. Many students commented on the useful way in which the flexible learning materials provided ready-made revision notes. For these reasons the materials were popular with most students.

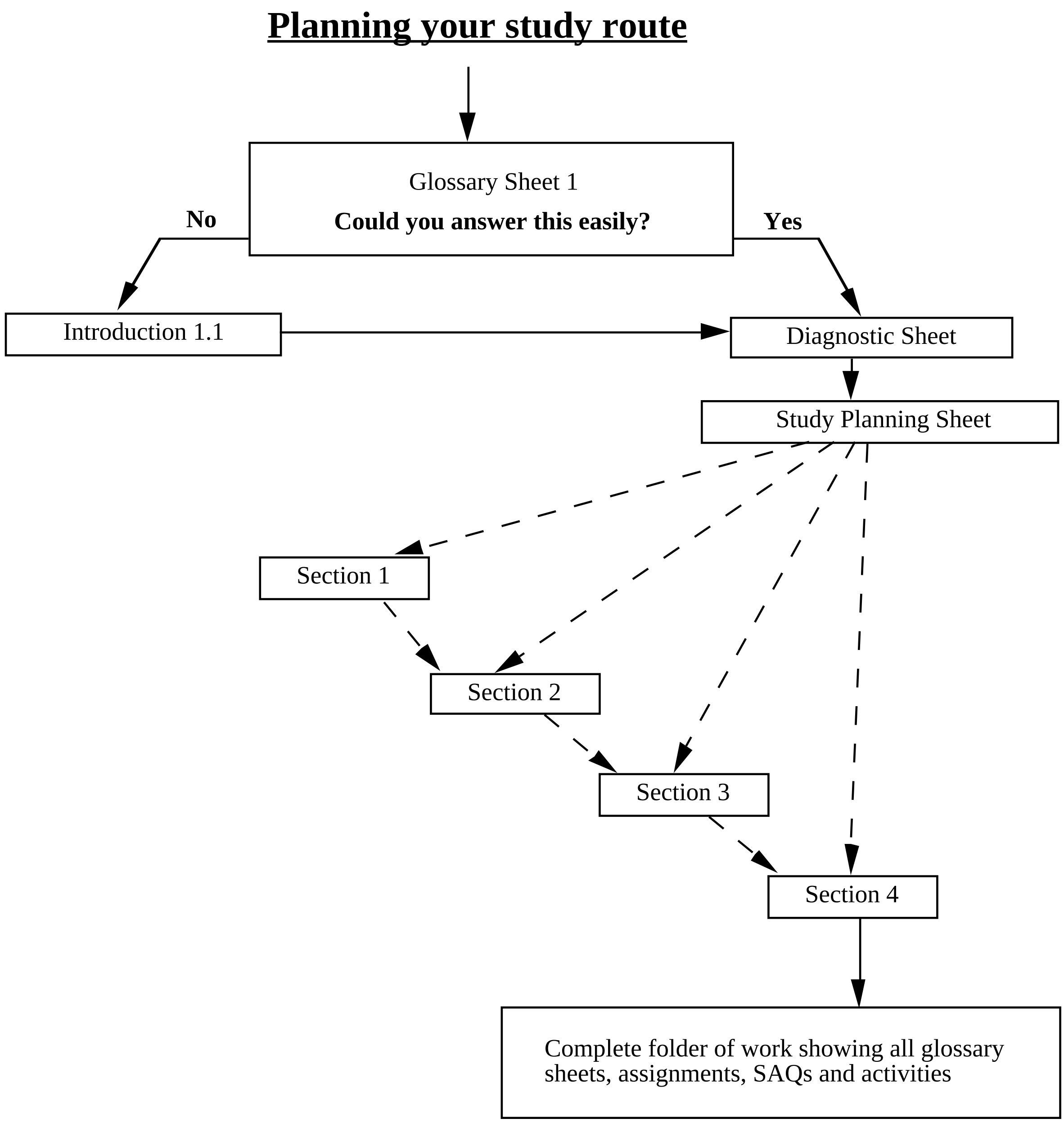

Figure 4 Possible routes through the unit

The materials were also popular with tutors who agreed that substantial teaching time had been saved and yet they were also confident that the quality of student learning had been maintained.

Group A had completed work which was generally of a higher standard than that of last year. For example, the IV exercise was only completed successfully by 50% of last year's undergraduates, but this year all students had completed the exercise. Some students had used the diagnostic test in a way which had not been anticipated. They answered all the diagnostic questions by referring to small, but relevant, sections of the learning materials i.e. they chose to design what they felt was a more relevant route! A few, less well motivated/organised students felt under pressure as a result of the need to take greater responsibility for their own learning.

Group B students were not as confident with the learning materials and appreciated regular feedback from tutors, even though this was often little more than a 'pat on the back'. Some requested more testing and assessment, recognising that it might be computer based if tutors were unable to devote more time to these activities.

Future developments

Any future developments will be based on more rigorous appraisal of student questionnaires and examination results. However a number of possible developments have been identified in principle :

- modify the existing materials based on feedback

SECTION 2 ENERGY AND ITS CONVERSION

Objectives

By the end of section 2 you should:-

- be able to apply the principle of conservation of energy
- be able to calculate potential and kinetic energies for point mass and fluid systems
- be able to calculate the work done against resistance to motion
- be able to calculate energy conversion efficiencies
- understand heat engines and why there is a limiting efficiency
- understand heat pumps and refrigeration and be able to perform appropriate calculations

2.1 Conversion of energy

You are now familiar with the definitions of work, power and energy but have not yet considered how they are converted from one form to another.

SAQ 2.1 Complete the following passage by adding one of these terms in each blank space. (You will find a duplicate passage in your folder of work that you can complete.)

kinetic energy, friction, electrical energy, thermal energy, chemical energy, power

Alison cycles home from school and uses the _________ from the food that she has eaten to provide her muscles with the ________ to ride the bike. The energy supplied is converted mainly to ________ to give ....

The principle of the conservation of energy

The principle of the conservation of energy states that ....

Fig.5 The beginning of section 2 from the energy unit

from students and tutors;
- look towards the greater use of information technology as a means of delivery;
- develop the use of diagnostic testing to assess previous learning and apply this approach to other units of foundation technology work;
- disseminate the flexible learning materials on energy through a major publisher, perhaps targeting A-level and INSET students in addition to those in institutes of higher education.

References

1 Gibbs G *Twenty Terrible Reasons for Lecturing* Paper No. 8, Birmingham: Standing Conference in Educational Development (1981)

2 Gibbs G *Lecturing to More Students* The Polytechnics & Colleges Funding Council (1992)

3 Norman E W L, Riley J L, Urry S A, Whittaker M, *Advanced Design and Technology 1990*, Longman (1990)

LOUGHBOROUGH UNIVERSITY OF TECHNOLOGY
DEPARTMENT OF DESIGN AND TECHNOLOGY
H775 Year 1 Mechanics - Energy Package Individual Assessment Sheet

Name

Diagnostic test	***Ignored***	0	1	2	***Completed perfectly***
Planning sheet	***Did not bother***	0	1	2	***Completed thoroughly***
SAQs	***Not done***	0	1	2	***Done as necessary***
Activity 3 (IV exercise)	***Not done***	0	1	2	***Completed perfectly***
Activity 9	***Not done***	0	1	2	***Able to identify key issues***

Notes

Mark prior to questioning ______

Questions on sections not completed -	2 on section 1	-2	-1	0
	2 on section 2	-2	-1	0
	2 on section 3	-2	-1	0
Random questions		-2	-1	0

Final score ______

Issues for week 6 seminar

Figure 6 Assessment sheet used with Group A for the individual tutorials