Quality Improvement Agency

National Teaching and Learning Change Programme

Improving teaching and learning in

Engineering

Resources for teachers, tutors and trainers

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Improving teaching and learning in:

Engineering

Contents

Foreword

Our mission

QIA will champion and facilitate excellence and innovation in post-16 education and training services in England.

Our promise

QIA will be a critical friend to the further education (FE) system, challenging sector organisations and those engaged in learning, teaching and training to achieve their potential.

We will be respected for the quality of our expertise, appreciated for the insight we offer and valued for the positive difference we make.

We will be an honest broker, creating programmes to help accelerate improvement and connecting organisations with those programmes through delivery partners.

We will work with government to ensure policies are informed by the knowledge and experience of the FE system and help organisations implement new initiatives.

I am delighted to be able to introduce these curriculum resources developed by the Quality Improvement Agency (QIA) as part of the National Teaching and Learning Change Programme. This programme is now managed by QIA and forms a substantial part of our work. It is designed to transform teaching, training and learning in selected curriculum areas.

This re-purposed set of resources has been adapted from those developed with practitioners and piloted with providers around the country. They include approaches to designing and managing teaching, training and learning, provide practical activities for learners, stimulate professional development and will help organisations adopt approaches building on those from the earlier resources. These resources focus on the development of independent learning skills and highlight the importance of harnessing learners' interests, both inside and outside the classroom.

The National Teaching and Learning Change Programme has already been very successful in disseminating exciting teaching and learning resources to the FE system.

The programme has 'three enablers':

- subject-specific teaching and learning resources
- subject coaching networks
- professional training for Subject Learning Coaches.

Together these three enablers support teachers, tutors, trainers and managers to raise standards of practice and deliver learner success.

I hope you find these resources of real benefit to you and your organisation. I am certain you will find they provide an excellent opportunity for your Subject Learning Coaches, tutors, trainers and managers to improve their professional development, and support QIA's mission of excellence for the FE system as a whole.

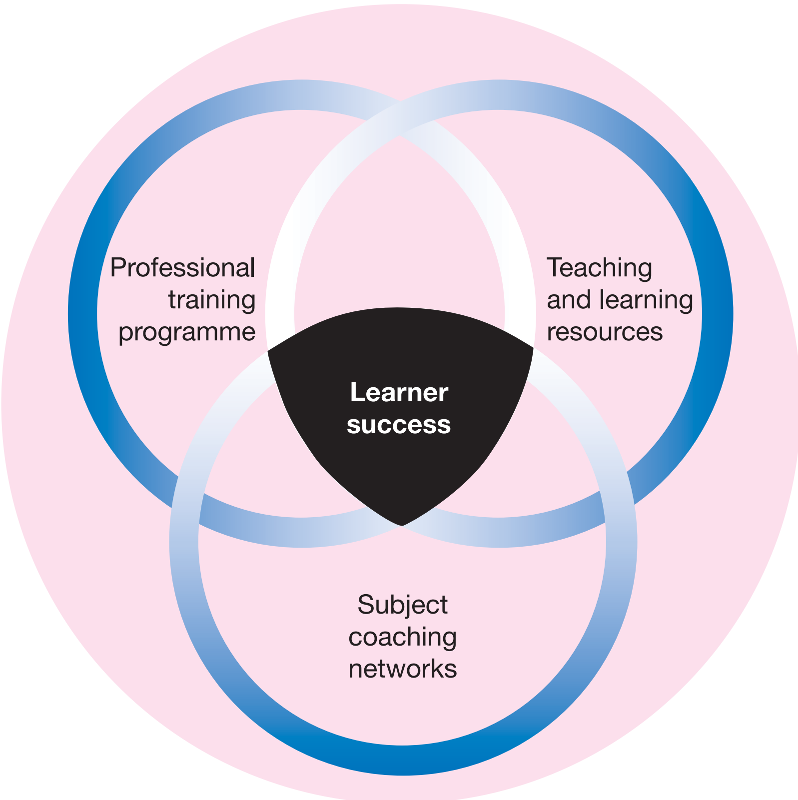
Andrew Thomson
Quality Improvement Agency
for Lifelong Learning (QIA)
Chief Executive

Part 1

1 Introducing the National Teaching and Learning Change Programme

The National Teaching and Learning Change Programme (NTLCP) brings together ‘three enablers’ to support the transformation of teaching, training and learning:

- subject-specific teaching and learning resources
- subject coaching networks
- professional training for Subject Learning Coaches.



Teaching and learning resources

A range of subject-specific resources has been distributed to the FE system as part of the National Teaching and Learning Change Programme started by the DfES Standards Unit and now funded by QIA. The purpose of these resources is to improve the quality of teaching and learning. These

resources for Engineering have been adapted from earlier materials produced for Engineering. They have been developed in trial and pilot centres from the experiences of teachers, tutors, trainers and learners.

These resources aim to stimulate you and your learners to explore learning in a wide range of different contexts. By linking learning inside and outside the classroom or workshop, for example, drawing together learning opportunities from the workplace, community or leisure settings, learners can:

- draw on their own experience
- personalise their learning journey
- make deeper connections between theory and real life practice.

These re-purposed resources for Engineering offer interactive ideas that can enhance the learner's journey and add pace and challenge to their programme. You can download these resources from QIA's Excellence Gateway at: http://excellence.qia.org.uk

The Professional Training Programme

The Subject Learning Coaches meet in subject coaching networks, either regionally or sub-regionally. They participate in the free, national, Professional Training Programme that can lead to accreditation. This programme then prepares them to provide peer coaching for their colleagues to help them adopt the approaches from the teaching and learning resources in their own organisation. This model of support for teachers, tutors and trainers using our subject-specific teaching and learning resources has been designed in accordance with research evidence on the most effective ways to support professional development and the sharing of best practice.

Subject coaching networks

Regular network meetings help to foster the development of subject learning communities and provide the Subject Learning Coaches with peer support from a range of different backgrounds, as well as opportunities for practising their coaching skills with their peers.

If you are a teacher, tutor or trainer wishing to develop your own practice to inspire and motivate learners, or a manager wishing to improve or refresh approaches to teaching and training across your area of responsibility, find out how you can get involved in the National Teaching and Learning Change Programme at: www.subjectlearningcoach.net

National Teaching and Learning Change Programme resources are now available on QIA's Excellence Gateway

All the resources previously produced through the National Teaching and Learning Change Programme (NTLCP), including those produced by the Standards Unit, are now available to view and download online.

This is a major step forward in the Excellence Gateway providing wider access to resources. This is a huge advantage, as practitioners can have flexible access whenever they like and eligible organisations can provide downloadable copies to their staff.

You will be able to navigate through the resources by subject area and access:

- video clips
- PDF and Word files
- interactive resources
- learner activities.

QIA's Excellence Gateway will become the place for advice, information and support for those involved in the FE system.

- examples of good practice from your peers
- networks to support your self-improvement agenda
- supplier of improvement services
- resources, tools and materials to support teaching, training and learning.

The resources can be accessed via the QIA Gateway site (http://excellence.qia.org.uk)

Who are these resources for?

If you want to improve teaching, training and learning in Engineering, then these resources are for you!

Teachers, tutors, trainers and curriculum leaders

The resources offer ideas and approaches that can be applied to a wide range of teaching and learning contexts. Note that the focus is on you working in partnership with learners to make sure that learning is relevant to individual needs and aspirations. The resources will also help you identify and plan formal and informal learning opportunities both inside and outside the classroom in order to harness learners' particular interests and aptitudes.

You may come across techniques with which you are not familiar. The best way to start using these resources is with the support of a colleague or a trained Subject Learning Coach.

Subject Learning Coaches

Subject Learning Coaches are champions of change within organisations. Your role is to refresh approaches to teaching and training, and help to inspire and motivate teachers, trainers and learners.

You will have a crucial role in promoting the new knowledge and skills acquired through the programme, the subject coaching networks, and the teaching and learning resources. Working within your own organisation, you will be able to raise the standard of teaching, training and learning in the subject areas by using the expertise, coaching and other skills developed during the programme.

Many of the ideas and approaches in these resources will inspire you as you work with colleagues, making changes to the way they teach. But these ideas are only a start. Only you and your teams can make a real difference to the learners' experiences in your workshops and classrooms.

Managers

You will find the resources useful to show how teaching, training and learning in Engineering can be refreshed and enlivened. They will also enable you to review practice across your provision and to establish benchmarks for improvement.

The NTLCP is already making a difference by:

- enhancing the learning experience
- boosting retention and achievement
- raising the morale of teachers, tutors, trainers and organisations.

This is confirmed by the Adult Learning Inspectorate who comment: "… the main strength of the National Teaching and Learning Change Programme is its ability to encourage managers and staff to look again at approaches to teaching and learning. … It has provided a valuable catalyst for change, especially through the frameworks." (ALI, 2007).

What learners said

In terms of learner achievement and standards, inspectors noted: "In lessons observed, where good use was being made of framework-related materials, learners enjoyed their work and made good progress. Skilful use of resource materials encouraged less confident learners to participate in lessons, helping them to develop personal and social skills. Learners themselves declared their preference for this activity style of teaching and learning. They contrasted this approach to lessons that were more centred around the activities of the teachers. They felt that their achievements and progress were restricted under the latter approach." Inspectors often noted the good organisational skills of those learners who were used to participating in lessons with more varied and interactive content.

To make a significant impact on the learner's experience, and to embed these ideas successfully into Engineering or across your organisation, it is important to incorporate them into a programme of staff development.

Participation of key staff in the Professional Training Programme for Subject Learning Coaches is the best way to make this happen.

Subject Learning Coaches have played their part in transforming the culture of teaching, training and learning, but it is clear that they achieve their best results where they are able to embed their work into the organisation's self-assessment and quality improvement processes. The appointment of a Subject Learning Coach can also be a catalyst for change by providing the impetus to review and update those systems. For more information about how you can become involved, look at the Subject Learning Coach website at: www.subjectlearningcoach.net/manager/

Staff development managers

These resources offer ideas for teachers, tutors and trainers who wish to develop their professional practice. They support the Professional Training Programme for Subject Learning Coaches and the subject coaching networks. The Professional Training Programme involves key members of staff becoming trained to use the approaches, and then working with their colleagues to embed the ideas into teaching practice. The resources can also be used as a basis for your centre's own staff development programme or continuing professional development (CPD) programme.

2 About these resources

Purpose and rationale

These re-purposed resources for Engineering fulfil five purposes. They:

- illustrate the experiences of some teachers, tutors and trainers as they changed their practice and reviewed the impact of the approaches on learners, their organisations and their own professional role
- explain how and why using active approaches contributes to learning improvement by making the pedagogy more explicit

- give guidance on how teachers, tutors and trainers can tailor learning to meet individual needs, building on learners' experiences and interests to make learning more relevant
- show how teachers, tutors and trainers might plan for and exploit learning opportunities in formal and informal situations, both inside and outside the classroom, to increase relevance to learners' lives
- are relevant to all teachers, tutors and trainers working with learners in other programmes within the curriculum area.

A further development phase will involve more teachers, tutors and trainers in trial and pilot centres who will be experimenting with new approaches and developing new teaching, training and learning resources for Engineering.

3 Key messages

These resources are part of a priority action 'to embed personalisation and increase learner voice,' as set out in the plan to implement the National Improvement Strategy for the further education (FE) system (QIA, Pursuing Excellence, 2007).

We have adopted seven key principles that put the learner at the heart of the learning process. Petty (2006) analysed the results of several meta-research studies into effective teaching and learning strategies and concluded that the following principles were critical to learner motivation and success:

- Learners must see the value to them of the learning.
- Learners must believe they can do it.
- Learners need challenging goals.
- Learners need feedback and dialogue on their progress.
- Learning needs structuring to give it meaning to learners.
- Learning needs time and opportunities for repetition.
- Learning is about study and thinking skills as well as content.

What this means for teachers, tutors and trainers

Effective teachers, tutors and trainers engage, motivate and enthuse learners by:

- adopting a range of active learning approaches
- co-creating challenging learning tasks with learners
- negotiating achievable individual learning targets and learning plans
- building on learners' own experiences, interests and personal situations
- unlocking learning potential by providing well-structured learning tasks that develop content skills alongside generic learning skills
- harnessing opportunities presented by learning in formal and informal situations, inside and outside the classroom
- giving constructive feedback that focusses on achievement rather than failure and involves learner self-assessment and peer assessment.

In particular, we believe that every learner should be encouraged to develop characteristics of an expert learner. Our vision is drawn from that outlined in the FE White Paper (2006): "We know that knowing how to learn has a positive impact on retention, achievement and a learner's attitude to learning." (DfES, *Further Education: raising skills, improving life chances*, Paragraph 4.16)

We believe these resources can help you to develop your skills to enhance the learning experience for learners. These resources are also structured to enable you to develop effective practice and achieve learner success.

Effective approaches to teaching, training and learning: introducing the pedagogy

In the current resources we are introducing 10 approaches that are known to make an impact on learning. These are underpinned by sound research and build on the National Teaching and Learning Change Programme's experience of developing and promoting the use of active, learner-centred teaching, training and learning resources across a wide range of curriculum areas.

How the resources work together to support effective teaching, training and learning practice

Learning activities

Innovative ideas that illustrate how to:

- engage and motivate learners to search for meaning
- use active, experiential approaches to learning.

Guidance notes with suggested approaches that link theory and effective teaching practice.

Adaptable resources

- Multimedia resources to use with learners.
- Overview session plans.
- Talking teaching, training and learning: card activity to introduce the pedagogy.
- Links to underpinning pedagogy: using theory to explain and support practice.

Continuing professional development

Cognitive activities to:

- develop effective teaching, training and learning practice
- make the learning approaches explicit
- model approaches to use with learners
- explain and signpost the underpinning pedagogy.

Continuing professional development

- Using coaching approaches
- Trying out new active approaches to learning
- Reflecting on experiences
- Modelling learning in action: experiencing the approaches yourself
- Adapting and sharing ideas
- Understanding how the pedagogy explains and supports practice

We have consulted teachers, tutors and trainers in Engineering who have changed their practice in order to evaluate the impact this has had on their learners' experiences. We have also taken account of the perceptions of other experts such as inspectorates, professional bodies, Sector Skills Councils and external evaluators to establish what has had the most effect on learner success.

The responses provide overwhelming evidence of the success of active learning approaches in motivating and engaging learners and supporting their learning. We have now refined and developed our concept of 'active learning' into 10 key approaches (on the next page) that we believe can make a particularly significant impact on learning when used effectively.

There is clearly an overlap between the approaches and they are neither mutually exclusive nor level-related. The pedagogical approaches will be developed in more depth during the next phase of the National Teaching and Learning Change Programme.

To encourage you to become familiar with the ideas and to use the vocabulary of these approaches as you develop your practice, the resources include a card activity, Talking teaching, training and learning, to stimulate thinking and dialogue about a range of approaches to teaching, training and learning.

Pedagogic approach	Brief explanation
Assessment for learning	Checking learning and giving constructive feedback that informs subsequent learning.
Co-operative learning	Structuring group work so that learners develop and adopt clear roles that are relevant for all team work. The teacher or trainer acts as a facilitator.
Differentiation	Underpinning the vision of every learner as an individual.
Embedding literacy, language and numeracy	Supporting skills development by combining the development of literacy, language and numeracy with vocational and other skills.
Experiential learning	Practical, hands-on tasks or experiments that help learners to construct meaning from their experience.
Learning conversations	Dialogue that promotes intrinsic motivation and that challenges and encourages learners to succeed.
Modelling	Places the learner in a situation where they experience a learning process that exposes them to subject content and which also makes the underpinning thinking explicit.
Multi-sensory learning	Highlighting the links between multi-sensory experiences and memory, enriching the learning experience and bringing about emotional and affective change.
Relating theory and practice	Learning in relevant, real-life contexts to ensure that sound links are made between a learner's practical experiences and the underpinning theory.
Using e-learning and technology	Use of new technologies to aid differentiation, accessibility and to enhance experiential learning in breadth and depth.

4 Technical information

Using CD-ROMs

Loading instructions

After inserting the disc into the CD-ROM drive, the first page on the CD-ROM should launch automatically. If it doesn't, launch your web browser and select Open File from the File menu. Then select your CD-ROM drive and select the file called start.htm.

For help with installing Adobe Flash Player and Adobe Reader please navigate to 'About this site', available from the footer menu on this CD-ROM.

System requirements

Hardware: 256 Mb RAM, 24x speed CD-ROM drive, 16 bit sound card, SVGA graphics card, 16 bit colour, 800 x 600 display. CPU (PC): Pentium III 550MHz. CPU (Mac): PowerPC G3.

Software (PC): Operating System: Windows 2000 SP4, Windows XP Edition SP2, Windows Vista. Browser: IE 5.5, IE 6.0, IE 7.0 and Mozilla Firefox 1.5. Adobe Reader 8. Macromedia Flash Player 8.

Software (Mac): Operating System: Mac OS X 10.3. Browsers: Safari 1.3, Firefox 2.0. Adobe Reader 8. Macromedia Flash Player 8.

Creating and using videos for learning

This resource contains a simple, easy-to-use video tool that enables you and your learners. There is an editing facility within the tool where users can 'cut' videos and edit them into shorter clips. You can also save your edited video clip for use later. (Please note, an Internet connection is required to use the 'save' function.)

You might use this:

- with learners to create videos about real-life learning contexts, for example, activities in the classroom, workshop, workplace or community
- to tailor CPD sessions to your participants' particular needs or interests.

When you use the video tool, you will be given two options.

- You can use it directly from the CD-ROM, which will allow you to create your own clips, but not save your work.
- You can use it over the Internet (this will open a new browser window), which will let you save any video clips you create onto your own computer or USB stick.

Guidance on using the video tool for a teaching and learning tool can be found within the resource. You will also be able to access instructions on using the tool.

The resources can be uploaded onto your organisation's VLE or intranet providing the source is acknowledged and that these materials/resources are not used for commercial gain or profit under any circumstances. (Further information about copyright can be obtained from QIA's website.)

References

The Adult Learning Inspectorate (2007) The National Teaching and Learning Change Programme: a review of teaching and learning frameworks.

Department for Education and Skills (2006) Personalising Further Education: developing a vision.

Department for Education and Skills (2006) Further Education: raising skills, improving life chances.

Petty, G. (2006) Evidence-based Teaching: a practical approach, Nelson Thornes.

Quality Improvement Agency (2007) Pursuing Excellence: the National Improvement Strategy for the further education system.

Part 2
Resources for teachers, tutors and trainers

If you are an Engineering Subject Learning Coach (SLC) or teach Engineering, you will find materials and suggestions that will:

- bring life and energy into classroom and workshop sessions
- inspire, challenge and engage your learners
- provide feedback on how your learners are developing
- provide the basis for coaching conversations
- initiate reflection on effective practice.

This booklet will:

- tell you about the materials available and how you might use them
- help you find those that are most useful to you, whether you are an SLC or a practitioner.

Contents of the resources

Developing the expert learner in the classroom

There are four themes in this section, each with illustrative video footage:

a managing groups (in the context of electrical and electronic symbols)

b listening to learners' thinking (learners talk about re-arranging equations)

c assessment for learning (learners construct a simple electrical motor)

d active learning (bringing risk assessment to life).

Each theme is supported by:

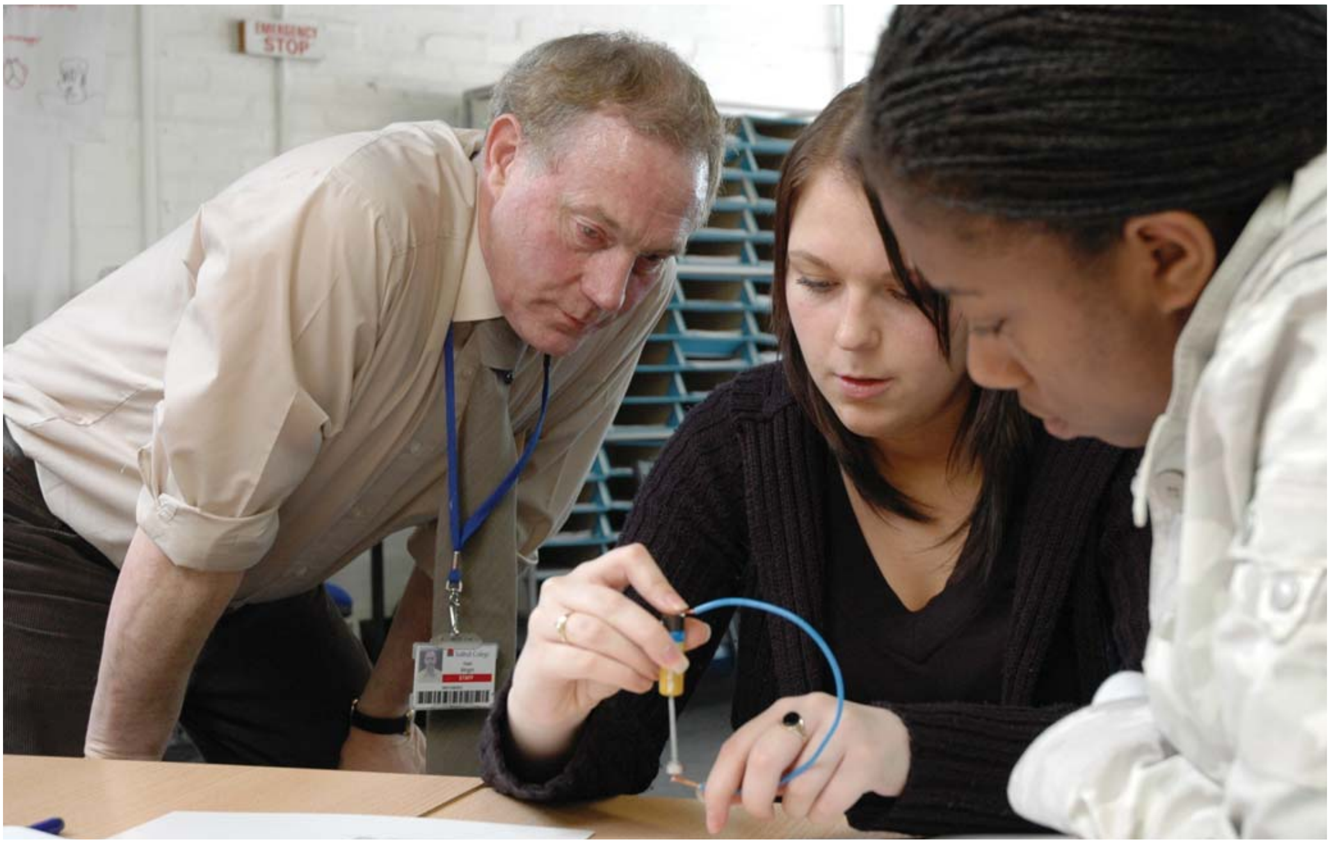
- Observations: suggestions about what to look out for in the video.
- Session plan: detailed guidance on setting up a group activity. These plans are reproduced in Section 3, starting on page 21 of this booklet. For the materials and software to use and adapt the activities, you will need access to the NTLCP Engineering resources.
- Session guide: highlights some aspects of teaching and learning that are embodied in the detailed plan.
- Activity resources: describes resources needed to run the activity.
- Approach: some teaching strategies embedded in the activity, and how they promote learning.

Beyond the classroom

This section shows a group of learners reflecting on the links between the classroom and the workplace, and how their work experience has deepened their learning and increased their ability to learn independently. The two video-based sections are:

- Theory into practice (linking the classroom to the workplace)
- Work projects that work (exploring why the learners' project was so successful).

There are downloadable resources to support each of these sections.



Developing and sharing practice

This section invites you to use the video footage to:

- reflect on coaching in your own organisation
- explore how practitioners have adapted activities similar to those illustrated in this resource
- assess how best to engage with the subject coaching network.

Talking teaching, training and learning

Use this card sort activity with your colleagues, to explore the pedagogy that underpins the resources for use with learners.

Resources

This section gives you access to the resources on the CD-ROM:

- Session plans
- Session guides
- Activities
- Videos
- Pedagogy
- Adaptations

Part 3
Session plans

Activity R1
Introduction to electrical and electronic symbol: teacher, tutor and trainer notes

The purpose of this session is to help learners develop their knowledge and understanding of circuit symbols and components through a range of short, interactive learning activities. These are particularly useful to reinforce, or consolidate, existing learning. The activities are designed to:

- allow learners to work collaboratively in small groups, developing their knowledge through discussion as they work to complete the tasks
- promote thinking and reasoning skills by providing artefacts (cards) for learners to handle
- encourage high level thinking skills which promote deep learning.

Thinking skills approaches to teaching have been found to improve learning in many areas of the curriculum. These approaches emphasise processes of thinking and learning that can be applied in a range of contexts. Thinking skills in the National Curriculum[1] include information processing, reasoning, enquiry, creative thinking and evaluation.

Many problems cannot be solved in your head, so these activities introduce and develop some simple 'thinking tools (card s), which help learners to think about conceptual ideas in a concrete way. They encourage peer interaction, discussion and reasoning, which are essential to effective thinking. They also give learners a structure in which they can think and record their thoughts systematically and to change their minds if necessary.

The session is presented in the context of electrical engineering using electrical symbols and components. This is only one of many possible contexts and the activities lend themselves to wide-ranging adaptations.

[1] Department for Education and Skills: The Standards Site www.standards.dfes.gov.uk/thinkingskills/

For example, the cards and worksheets can easily be adapted for use in hydraulics or pneumatics circuits or motor vehicle circuits and components. Even the electrical circuit context presented could be refined to focus on either analogue or digital electronics.

Learning objectives

Learners should be able to:

- name an electronic component from its circuit symbol
- recognise the function of the component
- match the circuit symbol to the physical component
- develop reasoning and evaluative skills.

Materials required

For each group of learners you will need:

- two sheets of flip chart paper
- a marker pen
- Card set A (yellow) – *Circuit cards* (name and function)
- Card set B (blue) – *Circuit symbols*.

The card sets are available in activity box 3 of the NTLCP Engineering resource.

For each learner you will need:

- copies of Worksheets 1, 2 and 3 and an answer sheet for the name and function activity
- example session plan from CD-ROM *Resources*.

Time needed

About 2 hours.

Starting points

This is a revision activity and you might use it at the end of the relevant module. The first part of the session aims to help learners recall the circuit symbols they have met previously. This is to establish prior knowledge and will help learners to put their new learning into a context. Effective learning only takes place when learners ‘construct’ meaning for themselves and make links between old and new knowledge and understanding. These links can only be created by learners and are best achieved by using active learning approaches. This first activity will also allow you to establish your learners’ starting points and help you plan to differentiate your session.

Suggested approach

The session is organised in two parts.

Organise the learners into pairs. You may want to plan who works with whom, or you may be content for random pairs to form. Ask the pairs to draw on their mini-whiteboards as many circuit symbols as they can remember in a few minutes. They might choose to draw them or name them.

Then join two pairs together to form groups of four. Each group of four should be provided with a sheet of flip chart paper to produce a poster showing their combined set of circuit symbols.

Ask each group of four in turn to display their poster on the wall and to name the symbols they have drawn. Ask other groups if they agree and explore any differences or misunderstandings through whole class discussion.

To end, ask each group to add any additional symbols to their flip chart. In this way learners can learn from each other.

As the groups work, observe and listen to the discussion. This will help you monitor the extent of each learner's understanding and give you a feel for which learners have a good grasp of circuit symbols from previous learning.

By this point you will have enough information to help you decide:

- how to organise learners into groups
- whether you should ask less confident learners to work initially with fewer cards, adding in more, or more complex, components and symbols when they have gained confidence
- whether you should ask more advanced learners to work with all, or more complex, components and symbols
- whether you need to offer different learners adapted worksheets.

Developing the session

For the second part of the session, organise learners into new groups of up to three. To make sure that everyone is actively involved, groups need to be small; in groups larger than three, some learners become ‘passengers’ and are not engaged.

Ask each group to head a flip chart page with four columns: ‘meters’, ‘power supplies’, ‘transducers’ and ‘other components’.

Use question and answer to run a whole class discussion drawing out the meaning of the terms ‘meters’, ‘power supplies’, ‘transducers’ and ‘other components’. Ask for one or two examples from the flip charts. Ask other learners if they agree or disagree, or want to challenge or expand points. Promote learning through use of learner explanation rather than addressing the points yourself.

Name and function activity

Give each group Card set A (yellow, name and function) and ask them to shuffle them. The activity requires learners to sort and classify the components into four groups. Ask them to:

- place the cards face down on the table
- take turns to pick a card from the top of the pack and read it out.

The group should discuss and agree into which column of the flip chart it should be classified. If the group cannot place a card it should be returned to the bottom of the pack and another taken from the top.

As group work progresses, you should:

- move between the groups listening to the learners
- identify misconceptions
- explore misconceptions by asking open questions
- avoid the tendency to close down discussion by providing the correct answer
- ensure learners remain focused on the task by reminding them of the objectives and the time remaining
- ensure all learners contribute to the group.

If there are cards left that learners cannot classify, you may need to prompt in more detail with questions and answers.

Ask groups to walk round checking each others’ classifications until they are all in agreement and think they have found the correct solution. Then distribute answer sheets for a final check. If there are still misconceptions ask successful groups to explain their reasoning to others.

Circuit symbol activity

Now ask groups to relate the names of components with their symbolic representation. Distribute Card set B (blue, circuit symbols) to each group. Ask learners to:

- share out the blue circuit symbol cards between the group members
- take it in turns to show and discuss each symbol card and then pair it up with the correct name and function card.

When all the cards have been arranged on the flip chart, ask learners to view each other's pairings and discuss any differences.

You should monitor the group discussions as before. If you are thorough in doing this and explore any misunderstandings as they arise with questions and answers, you should find that the groups reach the correct solution independently and this empowers learners.

However, if learners are in any doubt about the identity of any symbols, this is a good point at which to refer them to a reference source such as BS3939 or a similar text. This will increase confidence in using their support material.

Consolidating and checking learning

Worksheet activity: creating a permanent record of your work

Distribute copies of three worksheets to learners:

- Worksheet 1 – *Components*
- Worksheet 2 – *Transducers*
- Worksheet 3 – *Power supplies and meters*.

Ask learners to complete the blank boxes on the worksheets. When they have finished, ask them to exchange their completed worksheets with a partner to check their answers. If necessary, use questions and answers to help them to work it out for themselves.

Additional suggestions

- This is a good opportunity for differentiation by modifying the worksheets to contain more or less blank boxes. (Download from CD-ROM *Resources*.)
- You could ask learners to record their work in different ways, for example by using a digital camera to capture the card classifications, or by encouraging learners to use their own mobile phone cameras. The photographs could be printed or placed on an intranet.

'Find the component' activity

This would be a good time for a 'find the component' exercise to reinforce understanding. Provide a box of assorted components and ask learners, working in pairs, to find a component and to place it on the appropriate card circuit symbol.

Alternatively, if you are working in a workshop or laboratory, encourage learners to find out where the equipment is stored by selecting components from the store and matching them with their symbol.

It is good practice to ensure that you leave sufficient time for learners to replace the equipment tidily in the correct storage before the end of the session.

You might decide to use this hands-on activity earlier in the session to enable learners to identify the symbols and relate them to the components more meaningfully. This practical and visual reinforcement could help them to recall the symbols more reliably.

What learners might do next

When they have successfully completed the tasks above, learners might investigate a selection of circuit diagrams to find symbols not on their worksheets, for example transistor, op amp, relay. They should identify any unknown symbols, possibly using a computer with an Internet connection or using suppliers' catalogues.

Many providers receive suppliers' component catalogues on CD and these could be saved and used to develop an extension activity. Learners could be directed to the Learning Resource Centre (or equivalent) where a member of staff could distribute the CDs, logging that the learner has been to collect one. This is a useful way to help learners recognise the links between teaching, learning, independent study, Information technology and the Learning Resource Centre.

Worksheet 1 – *Components*

Circuit symbol	Name	Function
	Variable capacitor	Changes capacitance by varying area of overlap. It can be used in a radio tuner
	Resistor	Limits the flow of current in a circuit, for example through a light-emitting diode (LED)
		A connection to earth. This is at 0 V (zero volts) on the power supply
	On/off switch	A device with two contacts that will stop the flow of current if the contacts are ‘opened’
		A safety device which will melt (blow) if the current flowing through it exceeds a given value
	Capacitor	Stores electrical charge
	Variable resistor (rheostat)	Usually with two contacts. Is used to control current, for example lamp brightness, motor speed
		Only allows current to flow through it in one direction
		Stores electrical charge. Must be connected the right way round
	Variable resistor (potentiometer)	A resistor with three connections, two of which are fixed. The output pd will be a fraction of the pd across it
	Wires joined	A ‘blob’ to show where wires have been joined
	Wire	To pass current easily from one part of a circuit to another

Worksheet 2 – *Transducers*

Circuit symbol	Name	Function	Energy conversion	
			From	To
	Motor	A machine that converts electrical energy into kinetic energy (motion)		
		A component that creates a magnetic field when a current flows through it		
	Loudspeaker	A device that converts electrical energy into sound energy		
	Microphone	A device that converts sound energy into electrical energy		
		A component that converts electrical energy into light		
	Bell	A mechanism that converts electrical energy into sound		
	Buzzer	A mechanism that converts electrical energy into sound		
	Light-dependent resistor (LDR)	A component that converts brightness (light) to resistance (an electrical property)		
	Thermistor	A component that converts temperature (heat) to resistance (an electrical property)		
		A piece of equipment that converts electrical energy into heat energy.		
	Lamp (lighting)	A component that converts electrical energy into light, for example car headlamp, torch		

Worksheet 3 – *Power supplies and meters*

Circuit symbol	Name	Function
	AC supply	Supplies electrical energy using an alternating electromagnetic field
		Supplies electrical energy. The current flows in one direction
	Battery	Supplies electrical energy. A battery is more than one cell, for example a car battery is made up of six 2 V cells
	Cell	Supplies DC electrical energy, for example an AA cell you may put in your MP3 player
		Used to measure resistance in ohms
		Used to measure pd in volts
		Used to measure current in amperes
	Galvanometer	Used to measure tiny currents, usually 1 mA or less

Solution sheet

Meters	Power supplies
Ohmmeter Voltmeter Ammeter Galvanometer	AC supply DC supply Battery Cell
Transducers	**Other components**
Motor Inductor or coil or solenoid Loudspeaker Microphone Light-emitting diode (LED) Bell Buzzer Light-dependent resistor Thermistor Heater Lamp	Variable capacitor Resistor Earth On/off switch Fuse Capacitor Variable resistor (rheostat) Diode Polarised capacitor Variable resistor (potentiometer) Wires joined Wire

Activity D3
Rearranging equations: teacher, tutor and trainer notes

Teachers, tutors and trainers in engineering seem to agree that learners find some topics particularly challenging. Manipulating and solving equations appears to be one of these. This activity develops the ideas presented in the DfES Standards Unit resource *Improving learning in mathematics*: Session A2 *Creating and solving equations*.

The activity has been carefully structured to enable learners to take progressive steps through the basic principles and the approach has been shown to work well. You may find that the following guidance appears overly prescriptive. A ‘script’ format has been used to illustrate the sequence of learning processes clearly, to suggest how you might present the activities to your learners and how you might structure the dialogue. When you have looked through the sequence, or perhaps used it once or twice, you will probably find your own preferred way of presenting it or of adapting it for your own situation.

Learning objectives

Learners should be able to:

- develop confidence with the notation used in equations
- develop the use of brackets by creating and solving equations
- develop the skills needed to change the subject of a range of different equations
- develop an understanding of the nature of an equation and the principles that are applied when rearranging them
- learn from each other.

Materials required

Each learner will need the following.

For working in groups part 1:

- Sheet 1 – *Creating equations*
- Sheet 2 – *Solving equations*.

For working in groups part 2:

- Card set A – *Tasks*
- Card set B – *Equations*
- Card set C – *Instructions*

Each small group will need a set of equation cards. More straightforward equations are pale yellow, more challenging equations are deeper yellow.

- example session plans from CD-ROM *Resources*.

Time needed

About 3 to 4 hours. Example session plans are provided for two separate sessions but you might want to divide the work up differently to suit your own learners and the timetable.

Starting points

Most learners, in their earlier education, will have been taught rules for solving equations. Some may have been taught 'change the side, change the sign' while others may have learned that 'you always do the same to both sides'. When used without understanding, however, such rules result in many errors. For example:

$3x = 5 \Rightarrow x = \frac{5}{-3}$ (change the side, change the sign);

$3(x-2) = 6 \Rightarrow x - 2 = 3$ (take 3 from both sides).

'Doing the same to both sides' is perhaps the more meaningful method, but there are two difficulties to be overcome, one technical and one strategic:

- knowing how to change both sides of an equation so that equality is preserved
- knowing which operations lead towards the desired goal.

It is helpful if learners have already encountered the following ideas:

- addition is the inverse of subtraction (and vice versa)
- multiplication is the inverse of division (and vice versa)
- brackets or fraction bars may be used to group expressions together when multiplying and dividing.

Suggested approach

Build an equation

Write down a letter and its value on the board, for example $x = 3$. (This may be done on an OHT of Sheet 1 on page 4.108).

Using learners' suggestions for operations, build up an equation, step by step, using each of the four rules, +, –, ×, ÷, and whole numbers between 1 and 10. It might look something like this:

$$x = 3$$

Add 5

$$x + 5 = 8$$

Divide by 4

$$\frac{x+5}{4} = 2$$

Subtract 1

$$\frac{x+5}{4} - 1 = 1$$

Multiply by 3

$$3\left(\frac{x+5}{4} - 1\right) = 3$$

As learners suggest each operation, you supply the notation and explain it carefully. For example, explain that we use brackets to show that a whole expression is being multiplied and that we use the fraction bar rather than the usual division symbol (÷).

During this process, experience has shown that it is better not to simplify the left hand side of the equation at any stage. For example, if learners suggest the four operations +5, −1, ÷4, ×3, then we write $3\left(\frac{(x+5)-1}{4}\right)$ rather than $3\left(\frac{x+4}{4}\right)$.

Check the equation

Ask the class to check that the original value of x still satisfies the final equation.

$$3\left(\frac{3+5}{4}\right)-1 = 3\left(\frac{8}{4}-1\right) = 3(2-1) = 3\times 1 = 3$$

Solve the equation

Hide all the steps except the final equation and ask the class to recall each operation in sequence.

> "This equation tells the story of 'a day in the life of x'.
> What happened to it first? How can you tell by looking only at the equation?
> What then?
> And what then?
> What was the last thing that happened?"

In this way, show that the final equation tells the story of the operations used.

> "Suppose you had started with this equation and you wanted to find the value of x. How could you do this?
> How can you undo what we have just done?
> You take your socks and boots off in the reverse order to the order you put them on. It's the same here."

Gradually get the class to unpick each step in reverse order. As they do this, uncover the preceding equations one by one and write the corresponding operation to the right of each equation (with upward arrows):

$$\begin{array}{ccc}
 & x = 3 & \\
\text{Add 5} \downarrow & & \uparrow \text{Take 5} \\
 & x + 5 = 8 & \\
\text{Divide by 4} \downarrow & & \uparrow \text{Multiply by 4} \\
 & \dfrac{x+5}{4} = 2 & \\
\text{Subtract 1} \downarrow & & \uparrow \text{Add 1} \\
 & \dfrac{x+5}{4} - 1 = 1 & \\
\text{Multiply by 3} \downarrow & & \uparrow \text{Divide by 3} \\
 & 3\left(\dfrac{x+5}{4}\right) - 1 = 3 &
\end{array}$$

You will probably need to work through one or two more examples like this with the class, until they get the idea. It is worth changing the letter used (from x) each time, just to make the point that there is nothing special about it.

Create your own equation

Ask learners to create two equations of their own in a similar way. Sheet 1 *Creating equations* provides a structure for this. After creating each equation, learners should check that it works by substituting the answer back into it.

You could ask learners who find this difficult to restrict themselves to fewer steps and operations to start with.

When learners are satisfied that their equations work (and maybe when they have checked them with you), ask them to write the equations on Sheet 2 *Solving equations*.

Developing the session – Working in pairs and groups: part 1

Each learner should then give their Sheet 2 to a partner. The partner should try to ‘undo’ the operations, step by step. Partners may call on originators for help if they get stuck. Encourage learners to help each other as much as possible.

As learners get the idea, the structured sheets may be discarded and learners may enjoy creating more challenging equations. Encourage them to do this by having more steps to the equation, rather than by using harder numbers. You might also like to encourage the use of some more imaginative operations, such as squares and square roots, as the learners become more confident.

At this point you could introduce an engineering example, perhaps in a topic that they might be meeting elsewhere on the course.

Reviewing and extending learning

Ask learners to write their 'favourite creations' on the board and ask other learners, working in pairs, to solve them.

Ask learners to use their mini-whiteboards to write down algebraic equations that correspond to some 'think of a number' problems. For example, you might say:

> "Think of a number, call it *n*.
> Double it.
> Add 4.
> Divide your answer by 7.
> Multiply your answer by 2.
> The result is 4.
> Show me the equation."

And your learners might respond: $2\left(\frac{2n + 4}{7}\right) = 4$

Or:

> "Start with x.
> Square it.
> Add 4.
> Multiply the answer by 5.
> Divide the result by 2.
> This final result is equal to 20.
> Show me the equation."

Your learners should have the following written down:

$$\frac{5\left(x^2 + 4\right)}{2} = 20$$

Rearranging equations

Introduce an equation with an engineering application such as the equation for the volume of a cylinder:

$$V = \pi r^2 h$$

Explain what each of the symbols represents and then explain that this allows us to find the volume of a cylinder if we know the radius of the cross section and its height.

Ask the group to calculate the volume of a cylinder that has a 2 cm radius and is 8 cm high. They might like to use their mini-whiteboards. The answer is about 100 cm^3.

Ask them to estimate (a guess will do …) the radius needed for the same height cylinder to have a volume of 200 cm^3 … or 50 cm^3 … or 1 000 cm^3.

Start a discussion as to how best to carry this out. Steer the conversation towards the need to rearrange the equation so that it reads:

$$r = \ldots$$

…and then we can solve the problem no matter what the numbers.

Ask the learners to use the same technique as before to rearrange the equation. Agree the solution as a group.

If you feel that the group would benefit from a second example, introduce an equation with an engineering application such as the equation for the time period of a pendulum:

$$T = 2\pi\sqrt{\frac{l}{g}}$$

Explain what each of the symbols represents and then explain that this allows us to find the length of a pendulum if we know the time period, T, of a simple pendulum of length l.

Ask the group to calculate the time period of a pendulum of length 1 m. See what happens when you double the length to 2 m. Ask what might happen if you doubled it again.

Ask what length would be needed for a time period of 1 s. You might like to ask the group why a pendulum with a time period of 1 s is useful.

There will be some discussion as to how to best carry this out. Steer the conversation towards the need to rearrange the equation so that it reads:

$$l = \ldots$$

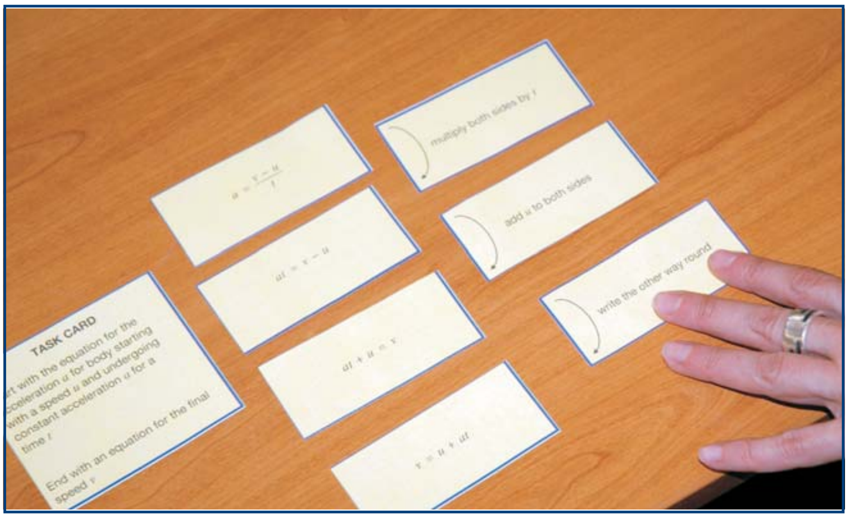
…and then we can solve the problem no matter what the numbers.

Ask the learners to use the same technique as before to rearrange the equation. Agree the solution as a group.

Working in groups: part 2

Ask the learners to work in small groups. Give each group Card set A *Tasks*, Card set B *Equations* and Card set C *Instructions*. If some learners are finding this topic difficult, ask them initially to rearrange the more straightforward equations cards (coloured pale yellow) and then to move onto the more challenging equation cards (coloured deeper yellow).

Starting with a task card, learners take turns to place cards to show each step required to rearrange the equations as stated on the task card. Card set B shows the steps, Card set C shows the instructions.



Remind the learners that each card placed must be justified to the group and that members of the group should challenge a card that they feel is placed incorrectly.

Ask each group to choose the solution that they found trickiest and paste the cards onto an A3 poster, annotating the solution to show the main points of the discussion that they have had.

You might like to ask some groups to talk through what they have produced, either to you or to the whole group in a short plenary towards the end of the session.

Consolidating and checking learning

The main point should always go back to the meaning of the equals sign.

Discussion may focus on the order in which we carry out operations. For example, when solving $y = 3x + 2$ we would suggest subtracting 2 before dividing by 3. If the problem is raised it is worth allowing learners to try this the other way round and see what happens.

There might well be some discussion that focuses on why you can turn round an equation so that one that reads … = y, is exactly the same as y = … Again it is worth returning to the meaning of the equals sign.

If you do spot a misconception, try to encourage the learners to articulate what they are doing or what they are thinking. Try to avoid simply giving the correct answer.

What learners might do next

Learners may enjoy introducing further operations, such as $1/x$ (the inverse operation) and +/– (the 'change the sign' operation). Both are self-inverses.

Using these, learners may create more complex equations, such as $1 - \frac{1}{n-3} = \frac{1}{2}$.

This was created by starting with $n = 5$ and then operating as follows:

-3, $1/x$ (invert), +/– (change the sign), $+1$.

To undo this sequence, we simply do:

-1, +/– (change the sign), $1/x$ (invert), $+3$.

There are many similar examples in engineering to draw on and you should select examples relevant to the context in which your learners are working.

Sheet 1 – *Creating equations*

Name . . . .

1. Create two equations in the spaces below.
   Show, step by step, how you make your equations, by writing an operation next to each arrow.

Operations

	$x =$
....	....
....	....
....	....
....	....

This is equation 1

Operations

	$y =$
....	....
....	....
....	....
....	....

This is equation 2

2. Check that your equations work by substituting the original value.

Check equation 1

Check equation 2

Sheet 2 – *Solving equations*

3. Rewrite your final equations in the spaces below.
   Give this sheet to your partner and ask them to solve your equations.

Name of partner. . . . .

4. Solve the equations, showing what you do at each step.

Operations	**Equation 1**
	....
....	....
....	....
....	....
....	....

Operations	**Equation 2**
	....
....	....
....	....
....	....
....	....

5. Correct your partner's work. Did they follow the steps and solve the equation correctly? Describe any difficulties that they had.

Comments

Card set A – *Tasks*

TASK CARD Start with the equation for the final length l_2 of a rod of material of original length l_1 and coefficient of linear expansion α given a temperature rise of $\theta°$ End with an equation for coefficient of linear expansion α	**TASK CARD** Start with the equation for the density ρ, of any substance of mass m and volume V End with an equation for volume V
TASK CARD Start with the equation for the time period T End with an equation for the length l, of a pendulum	**TASK CARD** Start with the equation for the voltage V, if a current I flows in a resistance R End with an equation for resistance R
TASK CARD Start with the formula for calculating the equivalent resistance for two parallel resistors, R_1 and R_2 End with an equation for equivalent resistance R_T	**TASK CARD** Start with the equation for the acceleration a for a body starting with a speed u and undergoing constant acceleration a for a time t End with an equation for the final speed v

Card set B – *Equations, page 1*

$l_2 = l_1(1 + \alpha\theta)$	$\rho V = m$
$\dfrac{l_2}{l_1} = 1 + \alpha\theta$	$V = \dfrac{m}{\rho}$
$\dfrac{l_2}{l_1} - 1 = \alpha\theta$	$a = \dfrac{v - u}{t}$
$\dfrac{\dfrac{l_2}{l_1} - 1}{\theta} = \alpha$	$at = v - u$
$\alpha = \dfrac{\dfrac{l_2}{l_1} - 1}{\theta}$	$at + u = v$
$\rho = \dfrac{m}{V}$	$v = u + at$

Card set B – *Equations, page 2*

$V = IR$	$R_T = \dfrac{R_1 R_2}{R_1 + R_2}$
$\dfrac{V}{I} = R$	$T = 2\pi\sqrt{\dfrac{l}{g}}$
$R = \dfrac{V}{I}$	$\dfrac{T}{2\pi} = \sqrt{\dfrac{l}{g}}$
$\dfrac{1}{R_T} = \dfrac{1}{R_1} + \dfrac{1}{R_2}$	$\left(\dfrac{T}{2\pi}\right)^2 = \dfrac{l}{g}$
$\dfrac{1}{R_T} = \dfrac{? + ?}{R_1 R_2}$	$g\left(\dfrac{T}{2\pi}\right)^2 = l$
$\dfrac{1}{R_T} = \dfrac{R_2 + R_1}{R_1 R_2}$	$l = g\left(\dfrac{T}{2\pi}\right)^2$

Card set C – *Instructions, page 1*

divide both sides by l_1	multiply both sides by t
subtract 1 from both sides	add u to both sides
divide both sides by θ	write the other way round
write the other way round	
multiply both sides by V	
divide both sides by ρ	

Card set C – *Instructions, page 2*

divide both sides by I	square both sides
write the other way round	multiply both sides by g
find a common denominator for the RHS	write the other way round
what needs to go on the top of the RHS to make the fraction correct?	
invert both sides	
divide both sides by 2π	

Activity E2
Introducing magnetic fields and the electric motor effect: teacher, tutor and trainer notes

While many learners are de-motivated by traditional ‘chalk and talk’, didactic approaches to teaching theory, hands-on learning has great appeal, particularly when presented in a problem solving context and when it is used to develop theoretical constructs.

This activity provides an opportunity for learners to use basic knowledge of magnetic fields to explore how magnets can be used to create motion. It is an exploratory activity and, as such, learners must be allowed to try out and test their ideas with minimum intervention from you.

Hands-on, exploratory learning is challenging as it entails learning by taking risks and making mistakes. If this is a new approach for your learners, you should reassure them that if we never took risks and learned from mistakes, we would never learn anything new. Share some relevant personal examples to open up a discussion about how learning by doing has influenced your life and work and how this approach has moved pioneering engineering forward.

To ensure independent learning, it is important that you:

- check that all learners start off with the minimum knowledge needed to be successful
- ensure that all learners are clear about the purpose of the activity and its learning objectives
- ensure that all learners are clear what they have to do
- ensure that everyone experiences hands-on learning
- manage the learning environment sensitively, ensuring that those who need additional support receive it discreetly, preferably through peer support
- plan and manage feedback and summary effectively to ensure that everyone reaches the correct understanding
- stand back and let them get on with it, monitoring discussion discreetly.

Learning objectives

Learners should be able to:

- state the origin of the two magnetic fields (permanent magnet, electromagnet)
- provide a basic explanation of how the interaction of two different magnetic fields can cause movement.

Materials required

For each learner you will need (see Figure E2.1 below):

- a mini-whiteboard
- one AA cell
- one short piece of wire with the insulation removed at each end
- one nail
- two strong cylinder magnets (provided in the resources pack).

Strong magnets are available from a number of suppliers via the Internet. Typing 'super magnets' into a search engine will give a number of options. High strength NdFeB magnets were used in the pilots.

- example session plan from CD-ROM *Resources*.

Fig. E2.1

Time needed

About 45 minutes for the initial activity plus 15 minutes if the further activity is used.

Starting points

Learners should have some basic knowledge of magnetic fields, including fields from electromagnets, but do not need any prior knowledge of electric motors.

This activity can be used at the start of the electric motor topic as full explanations of motor principles are not expected from the learners at this stage.

The main purpose of this activity is to engage, intrigue and motivate learners and to inspire an interest in, and a focus for, the theory and practical work that will follow.

Suggested approach

To set the scene for the activity, check the extent of learners' understanding of magnets and their properties. You could have some magnets for learners to handle to start off the session and to renew their knowledge. For example:

- Ask the group to give you as many 'facts' as they can about magnets and develop a list or spider diagram on the classroom board. Ideas might include:
  - two magnets attract or repel
  - a compass is deflected by the Earth's magnetic field
  - there is a field around a magnet: evidence – iron filings
  - used to sort drinks cans
  - can be permanent or temporary.
- Ask learners to show you on their whiteboards:
  - If I bring two north poles of a bar magnet together what will happen?
  - Can I stop a bar magnet being a magnet?
  - What sort of magnets can I turn on and off?
    - > How does a crane in a scrap yard move scrap metal? An electromagnet.
    - > How do they work? By current flowing through a wire.

Allow thinking time and writing time before you ask learners to hold up their whiteboards. Use these responses to probe and clarify basic understanding if necessary. Ask learners to expand points themselves rather than doing so yourself.

Alternatively, you could invite learners to come forward to create a diagram or spider diagram of their understanding of magnets and magnetic fields on the class whiteboard. This can serve as a visual memory prompt as they make their motors and it can form a useful focus for feedback and review of learning at the end of the activity.

Revisit the learning objectives and link them to the recap on properties of magnets. Then set the learning challenge. For example:

> "Using what you know about magnets and the equipment you have in front of you, see if you can make an electric motor.
>
> Work in pairs or small groups to share ideas about what might work, what might not, and why, but then try your own ideas out for yourself.
>
> When you have each got a working motor, try to explain how and why it works."

As you will have knowledge of each learner's starting point, you might want to organise the pairs or groups so that each includes a more confident learner. Peer support can benefit everyone.

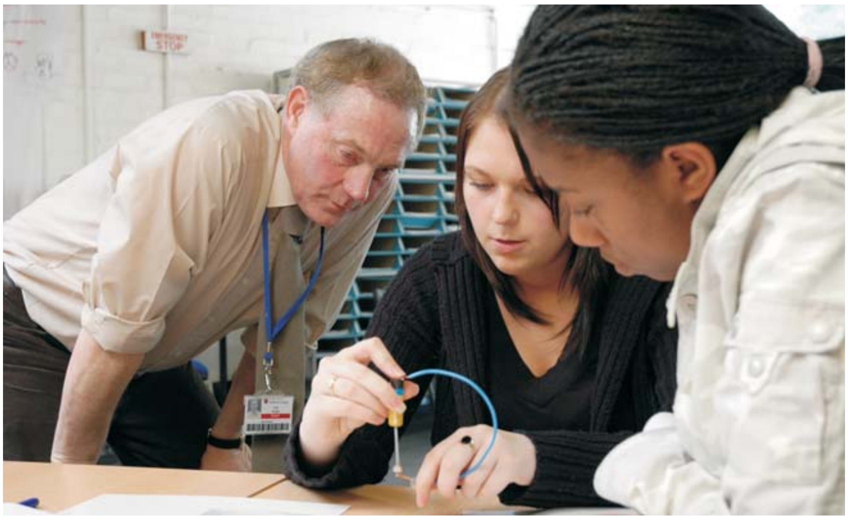
Teachers, tutors and trainers who piloted this activity found that it was necessary to:

- emphasise the importance of avoiding a direct short circuit of the battery with the wire
- provide occasional, timely hints on how to assemble the motor. For example, some useful prompts might be:
  - decide which parts of the motor are going to turn and which parts will remain stationary (two will turn; two will remain stationary)
  - the two magnets are kept together in the assembly
  - try fitting the nail between the battery and the two magnets.

However, allow learners to work independently as far as possible and do not intervene unnecessarily.

Once they each have a working model, the learners should start to discuss and agree in their pairs or groups on a simple explanation as to how the motor works.

Ask pairs to explain their own understanding orally to each other before they try to record anything. This is a useful 'rehearsal' of understanding and acts as a personal check.



Taking feedback

You might try this in several ways.

1 Ask learners to use just one mini-whiteboard to record the pair or group explanation. Using the mini-whiteboards will help learners to draw out their ideas, change their minds and alter their explanations as their ideas develop. As you view the responses ask some to expand on what they have written. Encourage others to challenge, expand and improve on these responses until you have a class response that is correct.

2 If your learners are well bonded and confident as a group and familiar with you and each other, you might take feedback using learner demonstration. Ask a group to summarise and explain their findings on the board. Then ask others if they agree or would add or change anything. The aim is not to criticise the answer but for the class to agree a 'class answer'. You facilitate this without evaluating the answers but by

using probing questions. This approach needs to be introduced gradually, initially using volunteers, until learners become confident.

3 Ask learners to produce a poster to summarise and present their findings. This helps them to organise their understanding visually and can form the basis of an explanation or presentation to teach others. Many learners prefer their learning to be assessed in this way, particularly if they have a visual or kinaesthetic learning preference.

Consolidating and checking learning

Close the activity using a whole class discussion and encourage learners to establish the following key points:

- there is a magnetic field due to the permanent magnets
- there is an electromagnetic field due to the current flowing through the permanent magnets
- these two magnetic fields interact, causing motion.

Take time to listen to your learners, and pick up and correct any misconceptions by asking learners to challenge, expand and improve the ideas themselves. Do this by asking open, probing questions and resist providing quick-fix answers. Make sure all learners participate in the class discussion.

Finally revisit the learning objectives and check, with the learners, that they have been achieved.

What learners might do next

Display a variety of different motors, for example:

- an electric drill motor
- a motor with permanent magnet and electromagnet
- a motor with two electromagnets.

Ask learners if they can identify the key components, providing help if required.

Activity A4 Understanding risk assessment: teacher, tutor and trainer notes

What is risk assessment?

Risk assessment is nothing more than a careful examination of what could cause harm to people, to weigh up whether sufficient precautions have been taken or more should be done to prevent harm.

The purpose is to make sure that no one gets hurt or becomes ill. Accidents and ill-health can ruin lives and affect business too. If output is lost and machinery or equipment is damaged, you may have to go to court, pay a fine or go to prison.

Risk assessment of the workplace is a legal requirement.

Learning objectives

By the end of this activity you should be able to:

- identify and record hazards in the workplace
- determine the level of risk posed by a hazard using the Risk Graph
- make recommendations to remove hazards or reduce risks.

Materials you will need

- Risk assessment form.
- Risk graph.

There are **five principles of risk assessment** (see *Five Steps to Risk Assessment*, available at www.hse.gov.uk/risk/).

1 Identify hazards.
2 Decide who might be harmed, and how.
3 Evaluate the risks and decide whether existing precautions are adequate, or more should be done.
4 Record the findings of the assessment.
5 Review the assessment and revise it, if necessary.

Definitions

Hazard:	Something that can cause harm, illness or damage to health or property.
Risk:	The likelihood or chance that harm, illness or damage from a hazard will occur, and the degree of harm (how many people might be affected and how badly).
Control measure:	Something that reduces or eliminates exposure to a hazard.

Table A4.1 shows an extract of a risk assessment for a motor vehicle repair workshop. Note that it explains the standard of safety that is expected to be reached.

Table A4.1. Five steps to risk assessment

1. Hazard	2. Who might be harmed?	3. Existing controls	4. Standard to be reached	5. Future action(s)
Manual handling In the stores; movement of components.	All employees, particularly those in the stores.	Forklift truck used to move materials into store and take components to workshop. Manual handling still required.	Avoid the risk of injury by removing need for manual handling or provide mechanical aids. If risk cannot be avoided, a more detailed assessment is needed (Manual Handling Operations Regulations).	Supervisor to arrange manual handling training for the staff in the store. More detailed assessment to be carried out.
Noise Particularly in body repair work.	All employees, particularly those involved with body work.	Ear defenders must be worn when panel beating. Ear defenders available in vehicle repair for use with certain equipment, for example air saw.	Exposure to noise must be assessed and controlled. Where risk cannot be adequately reduced, hearing protection should be provided.	Supervisors to monitor use of ear defenders.
Welding Toxic fumes, sparks, arc-eye.	Employees performing the task. Others nearby.	A range of head and body protection used depending on the type of welding operation. Local exhaust ventilation (LEV) in place.	Exposure to radiation must be prevented. COSHH applies.	Screens to be provided to protect others from radiation. Arrange periodic testing of LEV plant.

Table A4.1. Five steps to risk assessment – continued				
1. Hazard	**2. Who might be harmed?**	**3. Existing controls**	**4. Standard to be reached**	**5. Future action(s)**
Slips, trips and falls on the level	All employees. Visitors.	Good housekeeping standards maintained through training and monitoring. Floors degreased weekly. Absorbent granules put on spills as soon as possible. Entrances and exits maintained.	Condition and type of flooring, amount of lighting and standard of housekeeping should be such to prevent injury.	Walkways and storage areas designated by yellow lines.

Guidelines for determining the level of risk

To decide on what level of risk arises from a hazard, you have to think about:

- the likelihood of an incident and
- the potential effect or severity of an incident.

The **likelihood** can be decided on a scale of 1 to 5.

1 Highly unlikely: not known to occur.
2 Remote possibility: known to occur.
3 Occasional: has happened before.
4 Fairly frequent, some occurrences.
5 Frequent occurrences.

The potential effect or **severity** can also be decided on a scale of 1 to 5.

1 Minor injury.
2 Over three day injury.
3 Temporary incapacity/disease.
4 Permanent incapacity.
5 Fatality.

You use the numbers from these two factors to draw horizontal and vertical lines on the risk graph shown on the next page. You will find the level of risk where the two lines cross.

Action to be taken

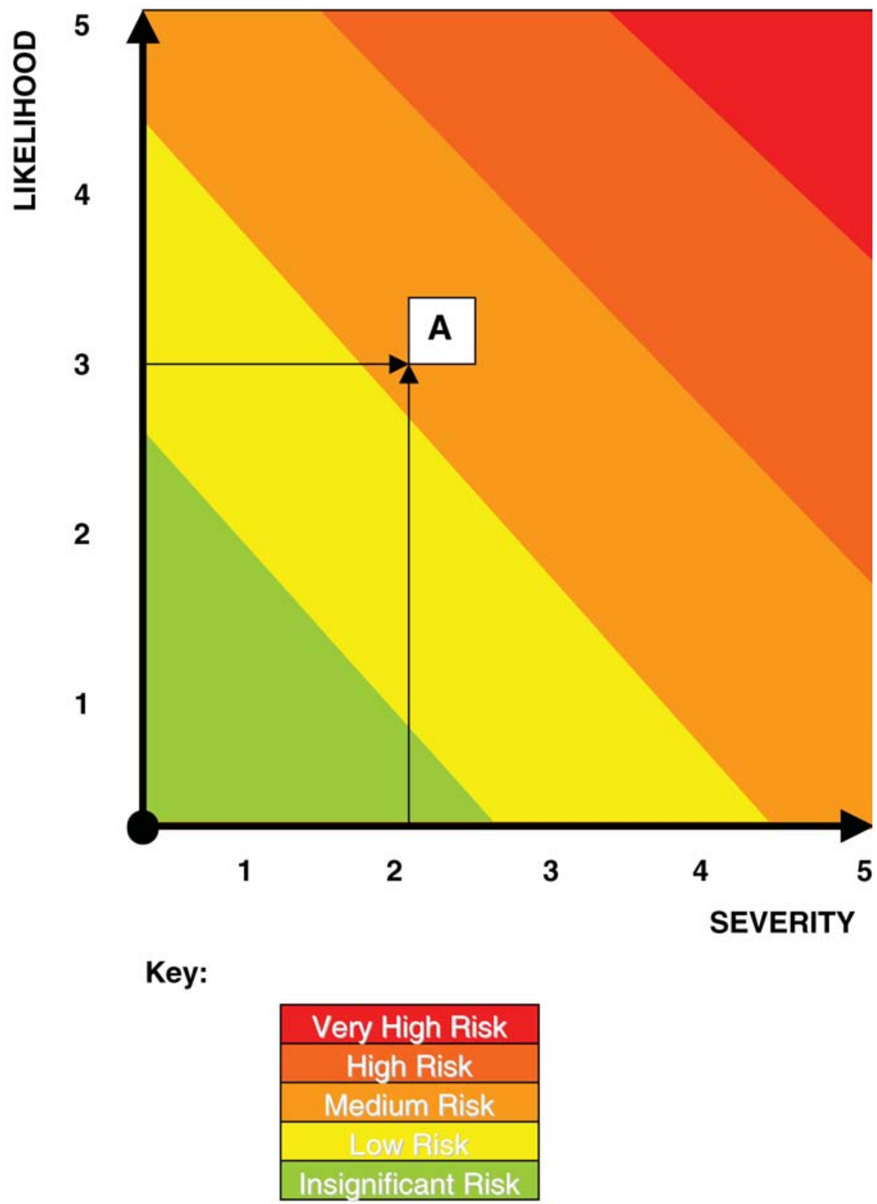
The level of risk that you identify will decide what action should be taken:

Level of risk	Action to be taken
Very high risk	Stop activity. Take immediate action.
High risk	Take action the same day.
Medium risk	Take action within one week.
Low risk	Monitor the situation.
Insignificant risk	No action required.

Example A shows an accident that occasionally happens (**Likelihood number 3**) resulting in an over-three-day injury (**Severity number 2**).

Where the lines cross is identified as a **Medium risk** and action should be taken within one week.

Risk graph



Carry out a risk assessment

Stage 1

Working in small groups, use the risk assessment form to identify and record:

- any hazards in the workplace
- who may be exposed to the hazard
- what control measures are in place – your teacher, tutor or trainer can give guidance on how to identify these.

Stage 2

Assess the level of risk of identified hazards by plotting a graph.

Stage 3

Evaluate the risk.

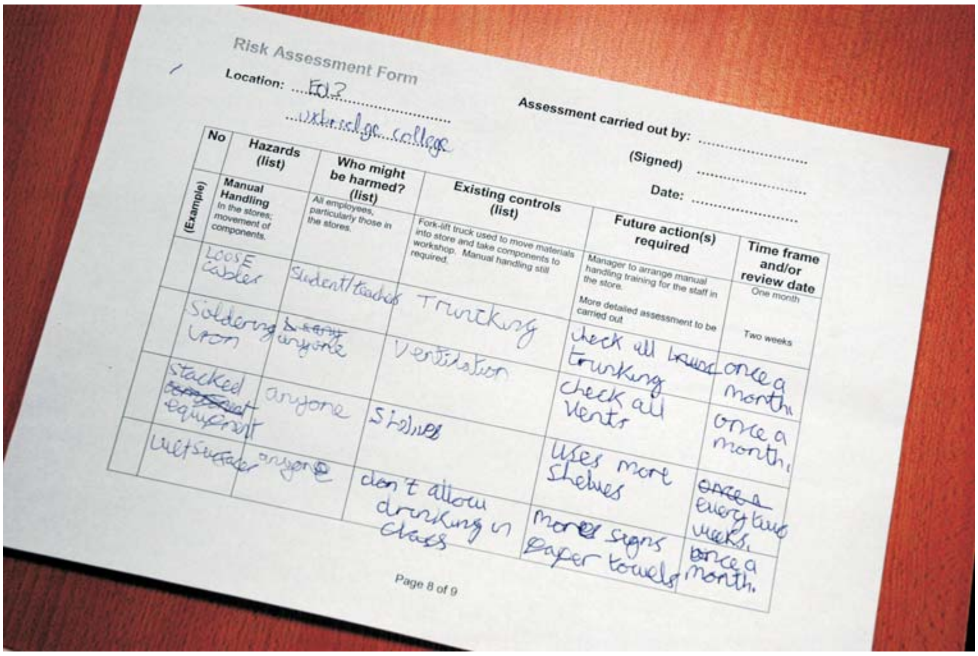
Decide:

- if the existing controls are adequate
- what future actions are recommended
- the time frame to eliminate or minimise the risk.

Record your findings in the ‘future actions’ column of the risk assessment form.

Stage 4

Provide feedback. Be prepared to discuss your findings and explain your reasoning to the whole class if your teacher, tutor or trainer asks you.



Risk assessment form

Location: . . . .   carried out by:. . . . .   date:. . . . .

No	Hazards (list)	Who might be harmed? (list)	Existing controls (list)	Future action(s) required	Time frame and/or review date
(Example)	**Manual handling** In the stores; movement of components.	All employees, particularly those in the stores.	Powered pallet truck used to move materials into store and take components to workshop. Manual handling still required.	Supervisor to arrange manual handling training for the staff in the store. More detailed assessment to be carried out.	One month (enter specific date). Two weeks (enter specific date).

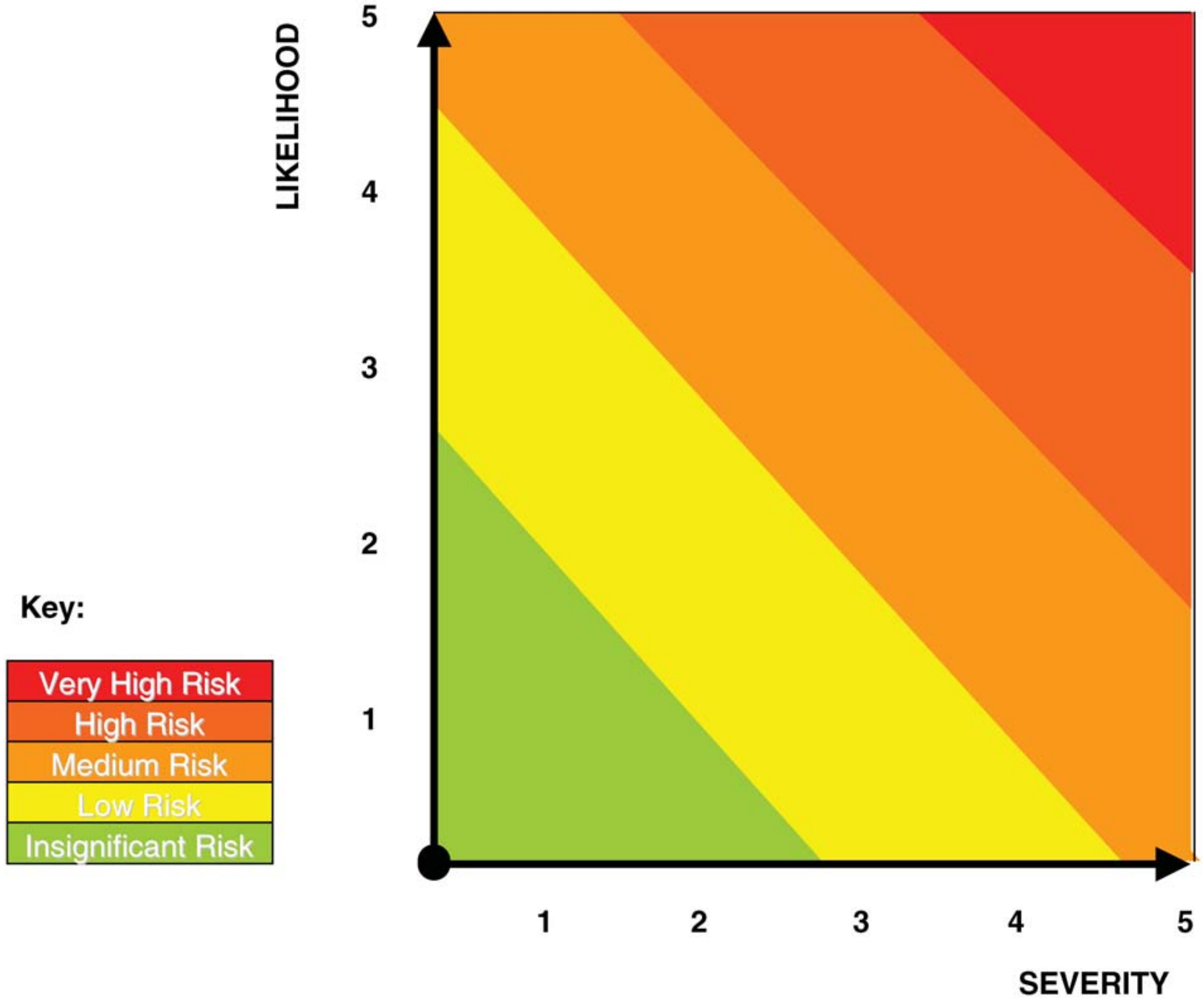
No	Hazards (list)	Who might be harmed? (list)	Existing controls (list)	Future action(s) required	Time frame and/or review date

Risk graph

Location: . . . . Date: . . . .

Hazard: . . . .

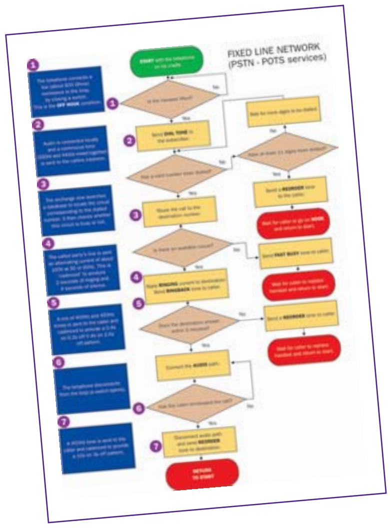
Level of risk: . . . .



Assessment carried out by: . . . . Signed: . . . .

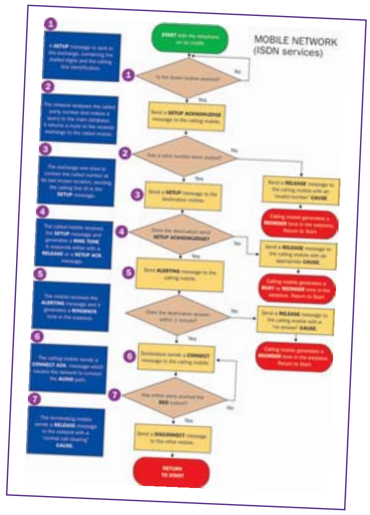
Adapting an approach: using a card sort to explore telecommunications networks

This activity provides an opportunity for learners to learn the two main telecommunication processes using a card sort activity. This activity provides an opportunity for learners, working in small groups, to develop two flow charts one representing the fixed line network and call process (POTS) and the other the mobile phone network and call process (ISDN).



To achieve the lesson objectives it is important that you:

- check that all learners have the minimum knowledge needed to be successful
- ensure that all learners are clear about what they have to do
- ensure that everyone takes part in the activity
- ensure that all groups contain a mix of learning abilities
- manage the learning environment sensitively, ensuring that those who need additional support receive it discreetly, preferably through peer support
- plan and manage feedback and summary effectively to ensure everyone shares a common understanding
- stand back and let learners get on with it, monitoring discussions discreetly.



Learning objectives

Learners should be able to:

- demonstrate their understanding of the call processes of the fixed line and mobile phone networks by placing cards in the correct positions on both flow charts
- explain and justify their choices to their peers

Materials required

The resources for this activity are available electronically or as hard copy.

For each group of learners you will need:

- two blank flow charts (one for POTS and one for ISDN)
- one set of shaped coloured cards for each flow chart
- one blank hard copy of each flow chart per learner

Time needed

About 30 minutes for each flow chart plus 20 minutes for summary and questions.

Starting points

Learners should have some basic knowledge of both the fixed line network (POTS) and the mobile phone network (ISDN) together with the call processes of both.

The purpose of the activity is to consolidate and reinforce learners' knowledge of telecommunications networks and to encourage them to discuss information and share knowledge with their peers.

Suggested approach

Allocate your learners to groups of three. Ask each group to lay out on the table one empty telecommunications flowchart and to spread the related cards around it, face up.

Invite learners to share their knowledge of the call process to complete the flow chart. They take turns to position the cards and to explain their decisions to the rest of the group.

When all the cards have been placed in the flowchart, learners review their answers and check them with you.

Repeat the activity with the second board.

To see this in practice, watch the video clip in Developing and sharing practice/Adapting resources on the CD-ROM.

Consolidating and checking learning

Observe the groups closely to ensure that all learners are participating in the activity. At the end of the activity, check that all learners have completed their written record of the two networks.

Check individuals' understanding by using open questions. Try using mini-whiteboards to check individuals' understanding in a non-judgemental and non-threatening way.

Differentiation

For less confident learners, provide a flow chart with some cards already in position.

What learners might do next

Those learners who have completed the activity successfully might be encouraged to use their mobile phones to check the ISDN call process and to record the various screen messages which they receive during the call process.

Glossary

Aims: Clear and concise statements that describe what the tutor, teacher or trainer hopes to achieve in a learning session.

CPD: Continuing professional development, sometimes referred to as staff development. Any activity that helps tutors, teachers and trainers maintain, improve or broaden their knowledge, understanding and skills, and become more effective in their role.

Differentiation: Differentiation is about identifying and addressing the different needs, interests and abilities of all learners to give them the best possible chance of achieving their learning goals.

e-learning: Learning facilitated and supported through the use of information and communication technology (ICT). E-learning includes delivery of courses, online assessment, learner to learner and learner to teacher or tutor or trainer communications, use of Internet resources, and other learning activities involving ICT and the Internet.

ESOL: English for Speakers of Other Languages.

Expert learner: QIA is charged from the FE White Paper with taking forward work to better understand, and define, the characteristics of the expert learner.

ILT: Information and Learning Technology. Supporting and delivering effective learning supported by technology.

Individual review, action planning and target setting: A type of formative assessment that takes place outside the classroom or workshop, where learners review their progress on a one-to-one basis and formulate actions and targets for improvement.

Individualisation: Recognising and responding to individual needs.

Initial assessment: The overall process of assessing individual learners' needs, aptitudes, preferences and prior learning in order to plan and provide an appropriate learning programme to meet their needs.

Learning cycle: The learning process in which the experience of trying something new is followed by reflection and evaluation on what was effective. Reflection is supported by reference to existing theory and then followed by a new plan of action, taking into account what has already been learnt. The learning process is cyclic and can go on indefinitely.

Learning inside and outside the classroom: This phrase is a challenge to the traditional perception that learning takes place only in formal situations such as classrooms or workshops. Effective learning can take place in a wide range of different, challenging situations such as the workplace, community or family, where learners can draw on their own experience and where the learning context adds interest and relevance.

Learning outcomes: Statements indicating what a learner should know/be able to do at the end of a given period.

Learning preferences*: A preferred way of learning, for example, learning through computer technology or learning through visual, auditory, kinaesthetic or practical activities.

Learning programme: Strategic programme for learning, including schemes of work and session plans, that ensure coherence and continuity across the learning experience.

Learning styles inventory*: A diagnostic instrument used to assess learners' preferred learning styles.

Motivational dialogue: Motivational dialogue is a learner-centred approach to influencing a young person's motivation to change behaviours that stand in the way of their progress. It was designed as a non-confrontational way of trying to help individuals recognise and do something about their present or potential problems.

Objectives: Precise and measurable statements describing what learners should learn in the time specified.

Open/closed questions: Open questions cannot be answered with a 'yes' or 'no' response or a one-word answer and encourage higher level thinking skills. Closed questions have only one satisfactory answer, usually very short. These questions can be useful when testing knowledge.

Peer assessment: Learners check each other's work, using clear criteria. This helps them develop and use skills required to check or evaluate their own work.

Reflection: The process whereby a learner takes time to consider an experience they have been involved in or any new learning experience and reflect on how it has been done. It may also refer to teachers', tutors' and trainers' consideration of their own work.

Self-assessment: The type of assessment undertaken by the learner in order to evaluate his or her performance, strengths and weaknesses. It may also refer to teachers', tutors' and trainers' consideration of their own work.

Session plan: A timed plan for a learning session that specifies aims, learning objectives, learning activities, resource and support needs.

Summative assessment: An end test or assessment, usually at the end of a unit, module or programme, to record a learner's attainment for that unit of learning.

SMART: Objectives that are Specific, Measurable, Achievable, Realistic and Time-related.

Team teaching: Working with a colleague to deliver learning sessions that can provide you both with useful feedback on the effectiveness of your strategies.

*If you look up 'learning styles' on the Internet, you will discover dozens of different questionnaires for assessing learning preferences. But beware! A study by the Learning and Skills Research Centre found that some of the most widely used instruments had low reliability and poor validity. The report recommended that 'teachers and trainers should look instead at broader notions of how learners approach learning' (Coffield, F. et al. (2004) *Learning Styles and Pedagogy in Post-16 Learning: a systematic and critical review*, Learning and Skills Research Centre/Learning and Skills Development Agency, http://www.lsda.org.uk/files/PDF/1543.pdf).

Acknowledgements

We wish to thank the learners, teachers, tutors, trainers and managers from the following centres who helped us develop the materials:

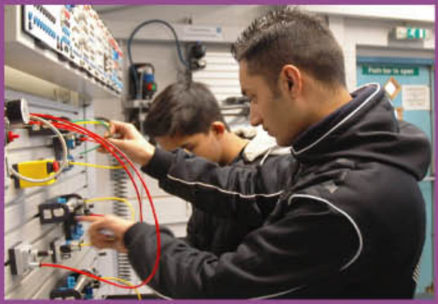
Thames Gateway College at the Centre for Engineering and Manufacturing Excellence (CEME)
Humberside Engineering Training Association (HETA)
Tameside College
College of North West London
Uxbridge College

We would also like to extend our thanks to:

The Engineering Subject Learning Coaches

for their contributions to the research, development and field testing phases of the project.

Finally, we would like to thank members of the Engineering expert group for the advice and guidance provided throughout the project.

The contents of this pack can be downloaded from the Excellence Gateway at http://excellence.qia.org.uk

Quality Improvement Agency
Friars House
Manor House Drive
Coventry
CV1 2TE

Tel: 0870 2113 434
Email: general.info@qia.gsi.gov.uk
www.qia.org.uk

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