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tutoring in a mathematics support centre

a guide for postgraduate students

National HE STEM Programme

Authors
A.C.Croft, J.W.Gillard, M.J.Grove, J.Kyle, A.Owen, P.C.Samuels, R.H.Wilson

Editors
Tony Croft (a.c.croft@lboro.ac.uk)
Michael Grove (m.j.grove@bham.ac.uk)

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B15 2TT

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Handouts for use within a postgraduate training workshop for mathematics support

Section 1:

Foreword

Welcome to the world of mathematics and statistics support!

This is a *Guide* written for postgraduate students who are working in, or who want to work in, mathematics support centres. It distils the wisdom of seven people, who have many years' experience in mathematics education and in the work of support centres, into a practical resource for postgraduate students. In addition, it contains activities which can be used during training sessions to simulate working in a mathematics support centre.

Working in a support centre can be demanding and stressful, but also very rewarding. We hope this Guide will encourage you to prepare yourself well in order that the support you can offer to students is of the very best.

Good luck!

Section 2:

About the Authors

Tony Croft

Tony Croft is Professor of Mathematics Education at Loughborough University and has developed mathematics support there for many years. He is a Director of the sigma mathematics support network and a Director of **math**centre – the UK's virtual mathematics learning support centre.

Contact: A.C.Croft@lboro.ac.uk

Jonathan Gillard

Jonathan Gillard is a lecturer in statistics based at Cardiff School of Mathematics at Cardiff University. As well as engaging in research into statistical methodology and participating in many interdisciplinary studies, he is interested in the pedagogy and analysis of mathematics support services. He is a member of sigma-sw, a regional hub of sigma mathematics support network.

Contact: GillardJW@cardiff.ac.uk

Michael Grove

Michael Grove is Director of the National HE STEM Programme at the University of Birmingham. He teaches mathematics at university level, and has delivered an annual national series of workshops to support postgraduate students new to teaching mathematics within higher education for over five years.

Contact: M.J.Grove@bham.ac.uk

Joe Kyle

Joe Kyle is former Director of Undergraduate Studies within the School of Mathematics at the University of Birmingham, and continues to teach mathematics at the Open University. He is a nationally recognised mathematics educationalist, and the co-editor of 'Effective Learning and Teaching in Mathematics & its Applications'.

Contact: J.Kyle@bham.ac.uk

Alun Owen

Alun Owen manages the Statistics Advisory Service at Loughborough University and has many years' experience of providing statistics support to students at both undergraduate and postgraduate levels. Alun also currently teaches statistics to students from the Civil Engineering and Mathematics undergraduate programmes.

Contact: A.J.Owen@lboro.ac.uk

Peter Samuels

Peter Samuels is an Academic Skills Tutor at Birmingham City University. He has a background in mathematics education research and training postgraduate students, with a particular interest in tutoring students with specific learning differences.

Contact: Peter.Samuels@bcu.ac.uk

Robert Wilson

Robert Wilson is the Director of Learning and Teaching at Cardiff School of Mathematics and Coordinator of the Cardiff University Maths Support Service. His particular research interests relate to mathematical education and include the use of new technology in learning and teaching, and the development of effective mathematical support systems. He is a member of sigma-sw, a regional hub of the sigma mathematics support network.

Contact: WilsonRH@cardiff.ac.uk

Section 3:
Introduction

This is a *Guide* written especially for you, a postgraduate student, who wants to know more about working in a mathematics support centre. It aims to ensure that your time in the centre is well-spent and that it proves a worthwhile experience both for yourself and for the students you are trying to help.

This purpose of this *Guide* is to explain the purpose of mathematics support provision and discuss the ways in which working in a support centre is different from module tutoring. It aims to offer practical advice and plenty of helpful hints. The authoring team have many years' experience of establishing and working in support centres, offering specialist help to a wide range of students, some very gifted mathematically, and others who are struggling with the most basic problems in numeracy. The team have tutored struggling and vulnerable students, including those with additional needs. They have developed statistical advisory services, resources to support teaching and learning, and have carried out extensive evaluation of these activities. Their collective thoughts have been distilled into this Guide for the benefit of postgraduate tutors so that in turn they may go on to help and support many more undergraduate students with their mathematics and statistics.

Provision of additional *mathematics support* for undergraduate students is now common practice in the majority of UK higher education institutions, and *mathematics support centres* are frequently the means of delivering such support. The extent, purpose and practices of mathematics support centres are described more fully in Section 4. Increasingly, support centres are employing postgraduate students to offer one-to-one and small group help to undergraduate students who drop in for assistance. In some important ways, the nature of this help is different from that provided in traditional tutorials for which you may well have had some training provided from either within your university, your department or sometimes by external bodies such as the Higher Education Academy. In Section 5 we discuss some of the potential pitfalls to be aware of whilst tutoring, we discuss ways in which you can best prepare yourself for a tutoring session, and we provide advice on how to conduct yourself whilst in a support centre.

One of the common activities you will undertake within a mathematics support centre is helping students tackle mathematical problems and exercises. You won't typically know in advance what these are, but Section 6 will hopefully provide you with strategies to help you tackle these with students. Offering support with statistics can be quite different from offering mathematics support. Section 7 looks at these differences and offers practical advice for those tutoring in statistics support sessions.

Many of the students who visit your support centre may not have had very good experiences with mathematics in the past. They may dislike the subject intensely and be very anxious. In the extreme, a small number of students will be maths-phobic. All of us are different and bring with us a range of learning styles. Sometimes the way in which mathematics is taught at university does not suit an individual's way of working. This may because they prefer a different learning style, and it may be because of specific learning differences such as dyslexia, dyscalculia, Asperger's syndrome etc. Section 8 will discuss students' different learning styles and how to best offer support when helping the diverse range of students who present themselves in a support centre.

A variety of scenarios will be explored in Section 9 each based on real situations that have occurred in mathematics support centres. What to do and what not to do to help learners will be discussed. Often, there is no right and wrong answer – but you will want to ensure that you do your best for the students you are trying to help without doing all the hard work for them!

When working in mathematics support it is important to realise that you are not alone but that you are a member of growing community of mathematics support practitioners. There is now a wealth of freely available and easily accessible resources to help you to help other students. Section 10 will provide details of many of these.

Working in a mathematics support centre can be very demanding and stressful – at the same time it can be very rewarding, and you as a tutor have the power to change people' lives for the better. You have the opportunity to work with students who perhaps hold very negative views about mathematics and statistics, and to give them the chance to succeed. You may even succeed in changing their long-held negative views! On the other hand you might offer such insight into a mathematical problem, or succeed in encouraging and motivating a student sufficiently that they go on to achieve a first-class degree! We hope this *Guide* goes some way to helping you to achieve all these things!

Tony Croft, Jonathan Gillard, Michael Grove, Joe Kyle, Alun Owen, Peter Samuels, Rob Wilson
September 2011

Section 4:

What is mathematics support?

The term 'mathematics support[1]' means activities, facilities and/or resources provided to support and enhance students' learning of mathematics or statistics whilst the student is enrolled on a programme of study at undergraduate or postgraduate level. Such learning support is extra, optional, and non-compulsory and is designed to assist students in developing mathematical and/or statistical confidence and skills. Usually, no module credit is associated with a student's engagement with a learning support activity. Sometimes such learning support can be aligned with specific components of their degree course, but its assistance is optional and supplementary.

This is support for students who have been granted entry to a university course, and are, by and large, considered by the university to meet the formal entry requirements for the course, even if teaching staff may require or assume levels of knowledge and skills beyond these, or if the university sector places the responsibility for assumed knowledge on students. It is important that you as a mathematics support tutor recognise that some of the students you will work with will not have the required pre-requisite knowledge, and may find it very difficult to rectify their problems on their own.

In general, note that:

- the students can be studying (almost) any discipline, at any level of higher education;
- mathematics support is usually taken to mean activities, facilities and resources which are provided *separately* and *in addition* to traditional lectures, tutorials, examples classes, personal tutorial sessions.

Practice differs from university to university; this *Guide* can only talk in general terms. Once you have read this overview of what is happening in the sector generally, you should find out about how mathematics support is implemented locally in your institution. You might wonder why we say that the students can be studying almost *any* discipline. To give a couple of examples: students about to graduate who decide they want a career in school teaching will be required to pass a mathematics test whatever their own subject. This hurdle can be very intimidating for those who never liked mathematics at school and stopped studying it when they completed their GCSEs several years earlier. Increasingly, potential employers of new graduates use numeracy tests as part of their selection process. In some universities, mathematics learning support tutors offer help in preparation for such tests.

These additional activities, facilities and resources can be offered in a variety of ways, for example via the internet or a virtual learning environment. A good overview of a wide range of support mechanisms in different universities can be found in the book *Maths Support for Students* that is available on-line[2]. However, this Guide focuses on one particular mechanism for providing additional support – the 'Mathematics Support Centre'.

What is a mathematics support centre?

The term 'mathematics support centre' is usually taken to mean a dedicated, physical space in which to offer mathematics support. Tutors are available in the centre at specified times. The centre may be used to house a bank of learning resources so that students are encouraged to help themselves and not rely solely on the intervention of a tutor. Many centres offer students workspace to encourage learning communities. There is often access to computing and other facilities such as video.

There is some variation in where support centres are located. They may be in a mathematics (or other) department or in a central service such as a library or skills centre. There are pros and cons whichever location is used. Some centres may employ staff dedicated to offering mathematics support whereas others may make use of mathematics and statistics lecturers and postgraduate tutors.

Figure 4.1: A mathematics support centre showing student workspace and resources

[1] Throughout this *Guide* the term 'mathematics support' should be taken to mean both mathematics and/or statistics support. Where there are differences these will be highlighted (especially in Section 7).

[2] http://www.mathcentre.ac.uk/resources/mathsteam/student_support.pdf

Increasingly, support centres are the focus of related initiatives, for example offering diagnostic mathematics testing of new students, supporting students who have additional needs, and as noted above, preparing students for employers' numeracy tests. Many centres have successfully sought funding for other teaching and learning projects and so they can very usefully provide a focus for those staff who are interested in mathematics education.

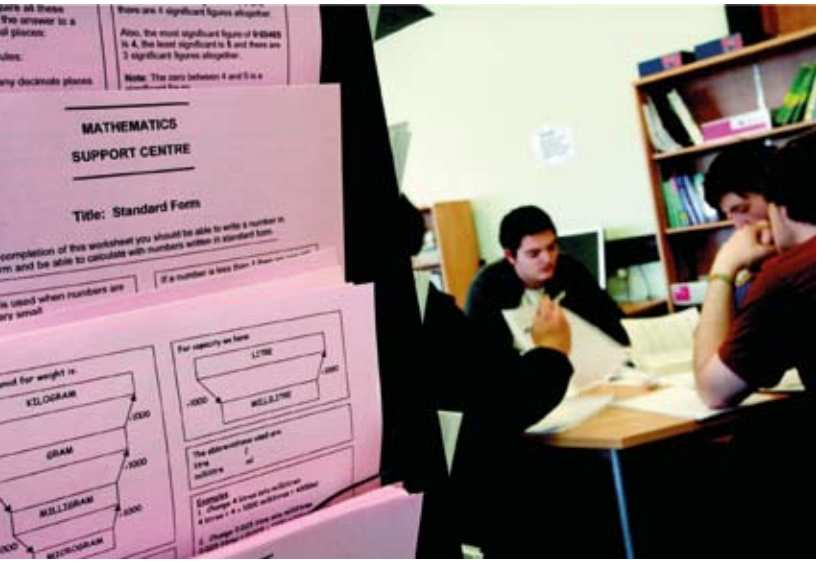

Figure 4.2: Students working together in a mathematics support centre

Figure 4.3: Influential reports in mathematics education

Much has been written in the last decade or so about support centres and in 2003 Lawson et al published the guide *Good Practice in the Provision of Mathematics Support Centres* which is available on line[3].

Why have mathematics support centres been set up?

It is useful to know a little of the background to the establishment of support centres for mathematics. They are a relatively new phenomenon – if you were to go back to the eighties it would be rare, though not impossible, to find a mathematics support centre in a British university. In the UK, in the early 1990s, serious problems were emerging in mathematics, engineering and other departments. There were many reports from professional bodies and research papers which highlighted students' lack of basic skills, lack of preparedness, high failure rates, and low numbers of students wanting to study mathematically-based subjects (for example, see *Measuring the Mathematics Problem*[4]). It was in response to these problems that universities began to look into ways of better supporting students with their mathematics. At the time, it became particularly urgent to support students in engineering.

In 2005 an influential government report, *Making Mathematics Count*, by Professor Adrian Smith, reinforced the concerns and stated that until problems associated with mathematics teaching in schools had been sorted higher education would have to accommodate students who were inadequately prepared.

In the period up to 2004 there was a rapid growth in the number of centres indicating that universities were already proactive. A thorough survey was carried out by Perkin & Croft[5]; this showed that over 60% of UK universities had support centres. Since then many more centres have opened, some supported with funding from the sigma-CETL and the National HE STEM Programme (Leeds, Sheffield, Bath, York, Lincoln, Kent, Central Lancashire, London Metropolitan). Networks of mathematics support professionals have been established in Scotland and in different regions of England and Wales.

[3] http://www.mathcentre.ac.uk/resources/Good%20Practice%20Guide/goodpractice2E.pdf
[4] http://www.engc.org.uk/ecukdocuments/internet/document%20library/Measuring%20the%20Mathematic%20Problems.pdf
[5] Mathematics Support Centres – the extent of current provision, MSOR Connections 4(2), 20040, http://mathstore.ac.uk/headocs/42supportcentres.pdf
[6] An audit of mathematics support provision in Irish third level institutions (http://www.ul.ie/cemtl/pdf%20files/FullAudit.pdf)
[7] Learning support in mathematics and statistics in Australian universities (http://www.altc.edu.au/resource-learning-support-mathematics-guide-qut-2008)
[8] Newton's Mechanics – who needs it? (http://www.mathstore.ac.uk/repository/NewtonMechReportFinal.pdf)
[9] National Audit Office (2007). Staying the course: The retention of students in higher education (see http://www.nao.org.uk/publications/nao_reports/06-07/0607616.pdf) [accessed 15 May 2008]

In other parts of the world there has been rapid growth too. Surveys have been undertaken in Ireland[6] and in Australia[7]. A more recent report highlights the need for support in mechanics[8] because fewer and fewer students studying engineering and physics have studied mechanics as part of A-level mathematics. A report[9] by the National Audit Office in 2007 recommended that support should not be seen merely as 'remedial' but as a way of enhancing the quality and experience of even the best students.

In 2010 Dr Martin Greenhow and Dr Inna Namestnikova (Brunel University) wrote *"given the changing face of the student population and the views of the various stakeholders in Higher Education (students, parents, government, employers and university staff) that eventually get reflected in league tables and NSS scores, we propose that financially secure, long lasting and fully-embedded mathematics support will relatively quickly form an unquestioned part of the provision of any well-found university".* (CETL MSOR Conference, University of Birmingham 2010).

And now in 2011, it is true to say that mathematics support centres are part of the landscape of higher education. They assist in addressing such institution-wide priorities as retention, recruitment, quality enhancement, employability and skills, the first year experience, flexible delivery, inclusivity, support for postgraduate students, the national STEM agenda and the student learning experience. You, as a postgraduate tutor, have an important role to play.

Evaluation of the Work of Mathematics Support Centres

With the rapid growth in mathematics support provision in many parts of the world it is not surprising that questions are being asked about how effective are the various interventions and initiatives. There is a growing body of research evidence that supports the view that our efforts are worthwhile, whilst acknowledging that getting hard evidence is challenging. This is because there are so many factors that can affect the performance of students at university and whilst mathematics support professionals have a key role to play, there are many other influences.

Rigorous data collection and analysis is necessary not only in order to justify the cost of providing a service, but also so that effort can be put into those activities that are most effective. The case for systematic data collection and analysis has been made in MacGillivray & Croft (2011)[10] and an archive of research papers has been established in a dedicated area of the **math**centre website[11].

As a tutor you may well have a role to play in data collection. Many centres have feedback forms or surveys/ questionnaires by which students can report upon how useful they find the service, how it might be improved and so on. You should check out whether such data is collected in your centre, and if so, ensure that as far as possible this data is gathered.

In evaluating your centre, your observations and views are very important too and can lead to improvements. Your critical reflections may turn out to be very important for the future development of your centre, so we would encourage you to take some time to think about this element of your work and provide feedback to those responsible for running it.

[10] MacGillivray, H., & Croft, T., (2011) Understanding evaluation of learning support in mathematics and statistics, International Journal of Mathematical Education in Science and Technology 42(2), pp 189-212.
[11] http://www.mathcentre.ac.uk/staff/types/staff-resources/measuring-the-effectiveness-of-support-centres/

Section 5:

Top tips and DOs and DON'Ts

In this section we give some practical advice aimed to help you to prepare for and work in a mathematics support centre.

Prior to working in the Centre

Take an interest in your Centre! Get to know which academic or academic-related member of staff is responsible for the Centre in which you are working. Don't hesitate to alert the person responsible to any concerns or suggestions you have for improvement of the service, but bear in mind that in the current financial climate resources will be limited.

Get to know the Centre in which you will be tutoring. Are there resources (help leaflets, books etc) that you can use? Is there a computer for your use? Is there a computer for students to use in the event they wish to show you some of their work?

Get to know which students are entitled to use the Centre (for example, only engineers, only first years, postgraduates on taught courses, research students, even staff!). Of those that are entitled to use the Centre, which should have priority?

Establish boundaries – some of you will be asked to offer support with statistics, some of you with mathematics. Perhaps some of you might be asked to offer mechanics help. We are all stronger in some areas than others. Make clear your strengths when you join the Centre and don't be afraid to declare areas in which you have less expertise. Get to know the other tutors, staff or postgraduates, and their particular interests and strengths. Some support centres use timetables to flag when tutors with particular expertise are available.

Ensure you are aware of emergency evacuation procedures for the building you are in. Ensure that you have information about who to call in case of emergency (for example a security office number, local first aiders). If in doubt, ask!

Equip yourself with tools which will be useful: scrap paper and pens; calculator; formula books; perhaps a laptop if you have one with useful software such as Maple, GeoGebra, Excel, a graph plotter, other specialist software if necessary.

During a drop-in session or during a student appointment – general points

Do introduce yourself to the student(s) and let them know that you are there to try to help them.

Be very sensitive to the fact that for some students just entering the Centre can be very daunting. There are lots of university students who are extremely anxious about mathematics and if they have taken the first steps in overcoming their anxiety by coming to see you, then you must do all you can to avoid undermining their initiative.

Ensure that the student is sitting comfortably and able to get out their folders of work and other things they might require. It is often helpful to sit next to the student so you can both work on a piece of mathematics. However be careful not to invade their space – keep a reasonable distance!

Ask the student for the following important information: which course they are studying and what year they are in. This will help you get a feel for the background of the student (students studying engineering will expect to have to solve lots of mathematical problems; students of chemistry, design, perhaps less so; students of social sciences may not have expected to meet any mathematics (or statistics) at all.

Don't spend all your time with one student if there are others waiting. Perhaps give a struggling student a small task to be usefully doing whilst you see others. Ensure there is an equitable system in place so that students who ought to have a higher priority are seen.

Do not feel that you need to know everything – you will never know all the mathematics or statistics that the students in your university are required to know.

Do not feel embarrassed about letting the student know that you don't know – such a situation can be turned into a learning opportunity for the student. How?

Never demean the student. Even inadvertent remarks can be very humiliating – "you should have covered this in school", or even worse "you shouldn't be in a university if you are asking questions like this" are way out of order. Equally, be careful if trying to use humour because not everyone will see the funny side!

On rare occasions you may become aware that a student is particularly distressed or behaving abnormally. Your university will have in place specialist staff to deal with counselling issues, students with additional needs, mental health problems etc. It is not your job to deal with these things. If in doubt refer to the academic member of staff responsible. See also the useful tips in Section 8.

Try to ensure you do not offer direct help with a student's assessed coursework. If in doubt, ask if the work is assessed coursework. It is good practice to have notices in the Centre telling the students that if they do not make clear that they are asking about assessed work, they may find themselves reported to their department and risk losing all marks.

On rare occasions a student may ask you for private tuition and offer to pay for this. Most Centres would discourage you from accepting this invitation as it may give the impression that a free service provided by the university is actually being charged for, and during normal working hours this might put the tutor in a difficult situation should the student come in demanding additional help.

After you have helped a student, and especially before they leave, ask them whether they feel they have made some progress, and whether there is anything else you can do to help. Encourage them to keep coming – maths support is not just remedial – it can be used to help the better students perform even better.

Always try to maintain a professional relationship with the students - you are their tutor, not one of their friends. Behave accordingly.

During a drop-in session or during a student appointment – mathematical points

Try to avoid 'telling' the student the 'answer' to their problem. Instead try to get them to explain their problem to you – often this helps them clarify and even solve their problem. From this information you may or may not be able to identify the cause of the difficulty.

If you identify a particular sort of mathematical problem ask yourself what sort is it? – is it a method problem? a proof? an open-ended problem? a puzzle-type problem? an application? Refer to Section 6 for strategies on helping students solve problems.

Have in your mind Ausubel's[12] dictum: "Ascertain what the student knows, and teach accordingly."

It is generally better to engage in a two-way dialogue, rather than telling the student how to solve a problem. Ask them what they think they should do next? What techniques do they know? Do they know the definition of *{particular term}*? What does this symbol *{symbol}* mean? Even if you know the answer, it is often better to try to help the student locate the appropriate parts of their notes in order to develop their own study skills.

If a student has an isolated difficulty you may be able to help them resolve it, and they can leave quite satisfied. On the other hand if a student has serious difficulties (perhaps lacking basic skills in important areas, e.g. algebra) it is very important that you impress upon them the need to develop a long-term strategy for overcoming their problems. Try to identify areas that it will be fruitful for them to work on and help them to draw up a schedule of work. Direct them to appropriate resources (See Section 10). Encourage them to start some work in the Centre whilst you are still around and invite them to come again after a few days to tell you how they are getting along, and to take the support further.

If the query is concerned with an assessed piece of work (and the student has made this clear) what is quite appropriate is for you to help the student find appropriate sections in their notes. If the problem is one of applying a standard technique (e.g. integration by parts) then it would be quite appropriate to assist the student in working through a different but similar problem. Usually you should not tell them whether an assessed piece of work is right or wrong.

[12] David Ausubel – American educational psychologist

Section 6:

Supporting Students with Mathematical Problem Solving

What exactly is meant by 'Problem Solving' is not well-defined: different authors use the term to mean quite different things. In fact, given the multiplicity of definitions already in use, a common definition of mathematical problem-solving may not even be possible.

A definition accepted by many in the mathematical community is that a problem must force the solver to seek a solution to a mathematical situation for which they have no immediately accessible or obvious process or method.

A problem is subjective in nature: a task or question can be a problem for one student, but merely a routine exercise for another. But very few acknowledge the subjective nature of what constitutes a problem and the implications this might have for curriculum design.

Finally, there is the essential "unseen" nature of a problem: once someone solves a problem, it ceases to be a problem for that individual. In short, a problem is only a problem for as long as it is a problem!

Problem-Solving within Mathematics Support

You may already have experience of problem-solving or exercise classes. These are typically classes where there are a large group of students tackling a series of questions or exercises. In a structured problem-solving class:

1. You, the tutor, will have typically seen the problem sheets in advance and may even have a solution sheet.
2. It will be in an area of mathematics that you either know about, or you are given enough advance notice so that you can familiarise yourself with the topic.
3. There will be other participants within the room, and you can work with multiple individuals to tackle a particular question, discussing the ideas and thinking as they emerge.

In a mathematics support environment, typical sessions will involve one-to-one work with a student. Although there may be others present in the room, you alone will need to guide the student. It is likely that you will not know in advance which area of mathematics the student requires support with. Once the area of mathematics is identified it is quite possible that it is one with which you are not entirely familiar.

This may at first sound daunting, but helping a student tackle a mathematical problem so that they ultimately gain understanding is a very rewarding experience. We offer below, some advice and guidance, based upon our experiences, that you may find useful.

Setting the Scene

Within a mathematics support environment, although we talk about problem-solving, many of the 'problems' that we refer to are actually 'exercises'. However, while they may be routine exercises to you, to the students, they will be real problems with which they are struggling and are seeking your assistance. When students seek advice, it is often for them a significant step, and they may well have had to summon the courage to do so. Regardless of how easy or difficult you perceive the question to be, you need to treat the student in an equal manner, and try to avoid using phrases such as 'easy', 'trivial' or 'basic' when talking about the material. Setting the tone at the outset is vital: if a student feels patronised or if you create the impression they are 'wasting your time' they may never engage with you again.

Of course, we talk about student problems, but it is possible that the question a student arrives with is one you may struggle to solve. In this instance, you too have to engage in the problem-solving process!

Some Ground 'Rules'

Just as rules are important in mathematics, there are a few fundamental principles underpinning mathematics support. The overarching principle in helping students tackle mathematical problems is that you should **never** tell the student the answer; it is vital that they find this for themselves. Your role is to help them through this process.

To help you do this, always keep the following statement in your mind: "listen, question and only then explain". This means that when working with a student, one should listen to their own words, question them about the underlying mathematics and try to discover what they know, and, perhaps more importantly, what they don't know. It may be that you have to extrapolate back to earlier mathematical topics (remember, mathematics is an extremely linear discipline where understanding a particular topic can depend upon understanding an earlier one); for example a student may be struggling with a first order differential equation because they have a problem manipulating algebraic expressions. Once you identify where the difficulty lies, you can start to help them by beginning to explain.

Beginning to explain does not mean that you must give the student the 'answer'. Indeed you may not even tackle the problem they have brought along. You may identify a particular issue and it would be perfectly reasonable to suggest they look at this within their notes, or a text book, or using some of the many online resources. If you do this,

you have provided assistance, and the student has a way of moving forward. Mathematics support is not about providing answers; it is about helping students learn.

When tackling a mathematical problem, there may be multiple ways of solving it. For example, take problems involving energy or momentum. If two objects collide in an elastic collision, for example two atoms, both momentum and kinetic energy are conserved, and either an energy or momentum approach towards say determining one of their velocities can be utilised. You may have a preferred method, but it is important that you use techniques with which the student is familiar. Ask them if they have seen or heard of a particular approach before you start to use it, or ask to look at their notes. If a student is seeking help, it is appropriate for you to ask them to bring their notes with them.

The final 'rule' to remember is that there will be competing demands on your time. This means you have to distribute your time accordingly and move around the students who attend. You can always set a student a task, for example, ask them to look something up, find a similar problem, or tackle a component task related to the question, leave them to work on this and then return to them some time later. Knowing when to leave a student so that they can work on their own is also an important part of mathematics support.

Helping Others Solve Problems

The seminal book by Polya entitled How to solve it, provides guidance on tackling mathematical problems. Much of what follows is based upon our interpretation and experience of how the problem solving process applies when working with undergraduate students.

Students may arrive at different points within this process, and the individual support you provide needs to reflect this. Equally, you need to monitor students as they progress through the problem-solving process; it will not benefit anyone if you let them get to the end knowing that the method they have used or an interim step (which you have checked) is incorrect. It is your role to guide and support students through this process using your expertise and knowledge. To re-iterate this does not mean you should tell or solve the problem for the students.

First Steps

When a student seeks help, you need to first check that they (and indeed you) understand the problem. Mathematical problem-solving is as much about understanding the question as it is tackling it. In particular, you need to check they understand any mathematical language that is included within the question. You may wish to:

- Ask them to identify what the question is asking. Is it to construct a proof, draw upon a theorem, find a solution, or create a geometric construction? Get them to read it carefully and, if helpful, underline any key words or information;
- Ask them if they understand the mathematical terminology;
- Ask them if they have seen a similar example elsewhere.

Planning for a solution

Planning for problem-solving may seem like a strange concept, but this is often vital. It is at this stage that you help the student to identify and collect together the mathematical information, tools and techniques needed to tackle the question. For example, you may wish to:

- Ask the student to draw a diagram: a good diagram can often set the information in context;
- Help the student break the problem down into smaller tasks. Almost all mathematical problems consist of a series of steps, and while the student may not be able to tackle the problem in one go, they may be able to tackle a part of it. If so, they will still leave with a sense of achievement even if they tackle nothing further;
- Ask the students to find a similar example, in their notes or elsewhere. You can then have a discussion about how the two are related;
- Ask the students to identify the mathematical ideas involved and think of ways in which they might apply these to the problem in question. For example, does the problem involve differentiating, if so, is there a rule they can use. You can then discuss whether or not this is the right approach;
- Ask the student to review a previous mathematical topic that is vital for solving their particular problem, or tackle a related mathematical question to demonstrate a technique that is essential for this one.

Finding the solution

This is what the student is looking for and why they have attended mathematics support; this doesn't, however, mean they must leave with the full solution. As long as their knowledge of mathematics, even if it is an earlier topic, has advanced, that is a success. Encourage the student to:

- Apply the strategy you have jointly developed to the problem;
- Tackle each stage of the problem 'one step at a time', and at the end of each, check that they feel the approach, and hopefully their answer, is correct;
- Remain calm and be patient; solving mathematical problems takes time.
- Think about what they are doing throughout, and encourage them to keep thinking about why they are approaching it in this way.

Validating the Answer

The student may feel that once they have written down an answer the problem is solved; we however know that this is not always the case. The final stage of the problem-solving process is to validate the solution, checking that the solution makes sense. You may wish to ask the student:

- Does the solution seems reasonable, for example is it realistic and does it make sense? If there are units, are these consistent with the answer?
- Can they use estimation to check, or is there a graphical method?
- Can they explain to you what they did and why they did it?

Hopefully if you have reached this stage of the process, the student will have been successful at either tackling the problem or part of it. Before they leave, you may wish to recommend material they could read (see, for example, Section 10), or identify where they can find similar examples to practice. You have provided support and helped the student with their learning of mathematics: it is now their responsibility to build upon this, and it does no harm to remind them of this providing you do it in a sensitive way.

Mathematical Problems You May Have

While the majority of student mathematical problems you encounter within a support centre will be ones you can tackle, there may be, quite legitimately, occasions when you can't solve the problem either. In this case, there are a number of things you can do:

1. Give the student the task of finding a similar example for you to look at.
2. If, after you have looked at this, you are still unsure, set the student a task and utilise some of the reference material available in the support centre to help you.
3. It is unlikely you will be in the support centre on your own, and so don't be afraid to ask another colleague for help. You could even make an excuse and ask them to work with the student.

Prepare by speaking to more experienced colleagues to find out about the types of students (their backgrounds) who attend, so that you can explore the kinds of mathematical topics they encounter. In summary, try to prepare as much as you can!

Finally, you may find yourself dealing with material with which you are totally unfamiliar, which you think may be explained poorly (or even incorrectly) in the student's lecture notes or handouts. You may be unable to make progress, perhaps because you don't understand the notation being used or you cannot understand what the question is asking for. A useful strategy is to try to write down, with the student, a small number of questions that the student can take back to the lecturer concerned. Often a student is reluctant to approach his or her lecturer because he or she does not know which questions to ask. Put the responsibility back on the student to ask the lecturer questions like: what does this symbol mean? Is there a similar problem in the lecture notes? Can you explain the working from this line to the next ? and so on.

References

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Section 7:

Providing Support with Statistics

You might be wondering why statistics has its own dedicated section when discussing support centres. Surely the hints and tips within Section 6 also apply to supporting students with the learning of statistics? Well the answer is yes they do, but there are other challenges you might face if you are asked, formally or otherwise, to provide statistics support.

So what are the differences? In statistics support, students may arrive seeking help with introductory exercises to calculate measures of central tendency (mean, median, and mode), or measures of spread (for example, variance or standard deviation). In this instance, you would work with the student to tackle the exercise in a similar manner to that described within Section 6. However, they might equally arrive seeking help with a particular statistical software package that they are using to analyse data, or may be seeking more complex advice and guidance on how to design and analyse a survey or an experiment, or how to analyse data for a PhD thesis. In this case helping the student may demand more time than usual and/or may demand a broader range of skills to help them. The important thing is to be realistic about what can be achieved during the time available and with the skills that you have.

Not only will the level of the material you encounter vary (its depth if you will), but also so will its breadth. This isn't only in the range of statistical topics but also the contexts within which they are applied. Many examples of statistics support move beyond tackling a single problem or exercise, to tackling a more substantial package of work where it is essential you understand the wider, and often disciplinary, context. This could involve working with a single student for several hours; however, as someone new to providing mathematics support, or if you are not a statistics specialist, this is unlikely to be a scenario you will face.

Now consider the students you are working with; many may be non-specialists who haven't studied statistics previously, or if they have, it hasn't been for a long time. They could be from physics or mathematical sciences programmes, but equally they could be from the health or social science disciplines encountering a particular application of statistics. Such students may not have a desire to understand the statistical concept at a deep level; they may just want a solution to the problem. Statistics can mean very different things to different people.

As you can see, this all has the potential to add up to a challenging activity for a support centre tutor!

Providing Statistics Support

If a student arrives at the Centre seeking statistics support, you may wish to prepare yourself in advance by checking if a statistics advisory service is available within the university. Statistics advisory services are similar to mathematics support centres; however, students typically make an appointment with a dedicated statistics tutor to tackle a particular package of work over an allocated time period. Further details of statistics advisory services are available[13]. If your university offers such a service, and the student problem extends beyond something with which you are comfortable or can tackle within a reasonable timeframe, then it is perfectly reasonable to suggest the student makes contact with them.

It is quite possible a student may arrive at the centre without knowing what they want help with. Even if your only input is to help them identify the area where they are seeking assistance, then you have provided support! Equally, a student might arrive knowing the statistical technique they would like assistance with, but it may be that this is not the most suitable. Judging this probably requires years of experience! You will need to work with them to not only identify the most appropriate technique, but also explain, and possibly convince them, of why their proposed method is incorrect or inappropriate. Again, even if you do only this, you have provided students with support as their knowledge, or understanding, has advanced.

How much support you can reasonably provide is also dependent upon the level of your own knowledge and the potential ability of the student. If they are a PhD student, they will have the time to invest in learning new techniques from scratch, and advising them of a statistical method or technique and suggesting they begin to explore this for themselves is quite appropriate. Taught students, undergraduate or postgraduate, typically won't have the same amount of time available to invest, and so an acceptable analysis for their project should suffice. However it is important that you ask the student to check with their module tutor that the analysis or approach you may have suggested meets the intended learning outcomes of the module the student is studying.

For statistical problems or queries that may involve experimental or survey work, you may wish to provide an initial level of advice, for example recommending a statistical method, technique or resource. You can suggest they explore the relevant material and come back at another (agreed) time, where you will have then read-up on the subject yourself, or identified a more appropriate colleague who will be present to support them. There is nothing wrong with admitting that statistics is not your area of expertise, as long as you work to either assist them, or identify someone who can help.

There is a range of material to assist students with the learning of statistics that you might find helpful, either for your students or for yourself. A number of useful examples are described in Section 10.

[13] http://www.sigma-cetl.ac.uk/index.php?section=18

Section 8:

Individual differences and needs in mathematics support

This section of the Guide aims to provide you with an awareness of some of the implications of the non-academic differences between students in the context of tutoring in the mathematics support centre. Included are some activities, focused around scenarios, which you may wish to ask the lead of your Centre to use within a training session for those new to providing mathematics support.

These non-academic differences are important because they can affect students' ability to gain from the way we try to help them – especially if we adopt the same approach to every student based only on their presented academic, as opposed to non-academic, needs. As members of staff we also have a duty of care towards students, so awareness of individual differences or needs might mean we are better informed to refer a student to another university professional who can assist them better.

The five areas of differences and needs that are covered in this section are:

- Thinking styles;
- Learning styles;
- Maths anxiety;
- Specific learning differences;
- Counselling.

Thinking Styles

We start this Section with an Activity to get you thinking about the way you and others think!

Activity (3 minutes)
On a blank sheet of A4 paper, using four differently-coloured pens, copy Figure 8.1, changing pens in sequence approximately every 45 seconds. When you have finished, provide a key of the order you used the pens, e.g. 1. red, 2. green, etc.

This activity will help demonstrate how people have different thinking styles: if several people independently attempt this task, some will work from the outline to the detail whilst others will work through different areas of detail in turn. Sharma (1989) applied this idea to simple mathematical thinking and has characterised these two opposite thinking styles as 'grasshoppers' and 'inchworms' which can be differentiated as shown in Table 8.1.

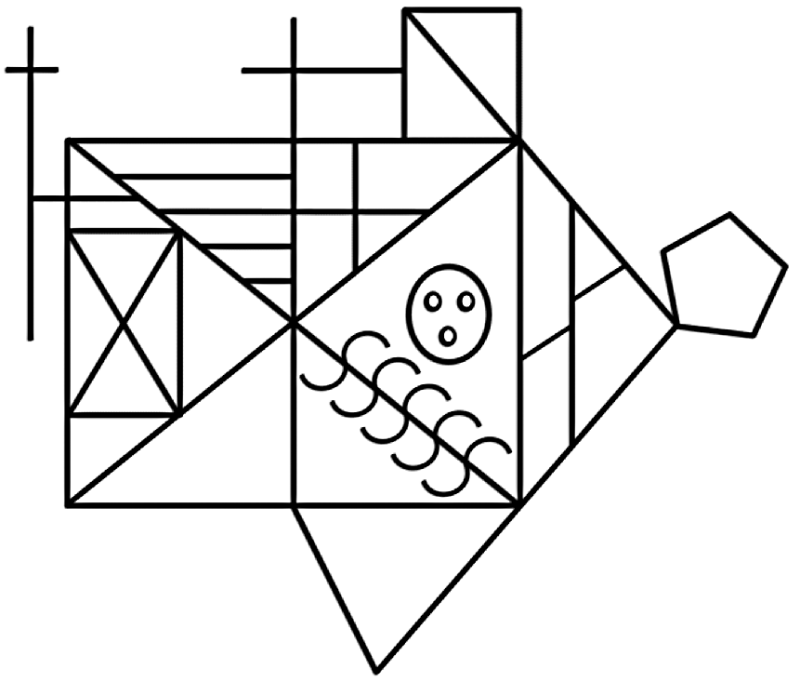

Figure 8.1: Diagram adapted from Rey-Osterrieth Complex Figure

	Inchworm	Grasshopper
I. Analysing and identifying the problem	1. Focuses on the parts and details; separates 2. Looks at the numbers and facts to select a relevant formula or procedure	1. Tends to overview; holistic; puts together 2. Looks at the numbers and facts to estimate an answer or restrict the range of the answer; controlled exploration
II. Solving the problem	3. Formula, procedure orientated 4. Constrained focus; uses a single method 5. Works in serially ordered steps, usually forward ('rifle') 6. Uses numbers exactly as given 7. More comfortable with paper and pen; documents the method	3. Answer orientated 4. Flexible focusing; methods change 5. Often works back from a trial answer; multi-method ('shot gun') 6. Adjusts, breaks down/builds up numbers to make an easier calculation 7. Rarely documents the method; performs calculation mentally
III. Checking and evaluating	8. Unlikely to check or evaluate the answer; if check is done, uses the same procedure or method 9. Often does not understand procedure or values of numbers; works mechanically	8. Likely to appraise and evaluate answer against original estimate; checks by an alternate method 9. Has good understanding of the numbers, methods and relationships

Table 8.1: Cognitive styles of the inchworm and grasshopper *(Chinn, S. and Ashcroft, R. (2007) Mathematics for Dyslexics, 3rd Edition, Chichester: John Wiley & Sons)*

An example of its application to more advanced mathematical thinking is the solution of ordinary differential equations (ODEs), such as:

$$\frac{dy}{dx} = 3x + 2y, \quad y(0) = 1$$

A characterisation of their possible approaches is given in Table 8.2. Whilst the inchworm may get more questions correct more quickly they may not have as good a holistic understanding as the grasshopper.

Another consequence of this theory is that students may not have the same cognitive style as their tutors. Tutors need to be careful that they do not judge students' work incorrectly by only seeing it from their own preferred thinking style.

Inchworm	Grasshopper
Recognises the equation as a coming from particular class of ODE	Plays around with the equation, e.g. tries differentiating e^{2x} and ye^{2x}
Rearranges the equation into standard form	Eventually realises that the terms involving y must be considered as the derivative of the product ye^{-2x}
Finds for the integrating factor	Rearranges the equation appropriately and multiplies both sides by e^{-2x}
Writes the solution down using the standard form without really understanding the process	Integrates both sides and applies the boundary condition to obtain the solution

Table 8.2 Characterisation of the approaches of inchworms and grasshoppers

Learning Styles

Students adopt different learning styles when studying mathematics. A summary of current research into learning styles in mathematics and numerate subjects is shown in Table 8.3:

One implication of these styles is that the proportion of students with different styles attending the drop-in centre will change at different times in the academic year. For example, additional drop-in centre hours close to examination periods would be more suitable for strategic and procedural surface learners.

Approach to studying	Strategy	Intention
Deep	To transform knowledge and integrate ideas	To understand and integrate to prior knowledge
Surface	To reproduce information	To simply reproduce contents
Strategic	To combine approaches to suit need	To pass assessments
Procedural deep	To relate knowledge to other knowledge	To understand through problem solving procedures
Procedural surface	To memorise processes	To pass assessments

Table 8.3: Learning styles in mathematics and numerate subjects (Patel & Samuels, 2009)

Maths Anxiety

We introduce maths anxiety by asking you first to consider and discuss the following scenario:

Scenario 1

Two female final year nursing students come to the drop-in centre. They appear nervous and defensive. When it's their turn they tell you that they have failed their nursing numeracy test twice and if they fail it once more they will be thrown off their course.

Discuss:

- *Their possible mathematical needs*
- *Their possible other needs*
- *How would you change your approach?*

Maths anxiety is tension, apprehension or fear that interferes with maths performance. It is a 'non-intellectual' factor that nonetheless interferes with educational and career choices. It is only weakly related to general intelligence. It can also result in physical signs, such as sweating, rashes or an increased heart rate. It is reliably elicited by asking the simple question: *"On a scale from 1 to 10 how maths anxious are you?"*

Maths anxiety is particularly relevant to subjects such as nursing as nursing students may have a weaker maths background, have spent many years without doing maths, be less confident and less interested in maths, and feel socially intimidated by the drop-in centre environment. Nevertheless, they are forced to pass a maths test in order to become professionally qualified.

Maths anxiety may also create a vicious circle of short-term memory overload as shown in Figure 8.2. Given a mathematical problem, a student will approach it with a certain level of knowledge. However, at the same time that they identify the problem they may also trigger a negative emotional reaction to it (for example, simply thinking about the word 'fractions' can cause anxiety in some students). Then instead of thinking about how to solve the problem they are distracted by these negative thoughts and their performance may not be as successful at it could be. This poor performance then strengthens their negative attitude towards the subject (for example, "I can never do fractions") making a vicious circle. This can then lead to a sudden drop in performance above a certain level of difficulty as their working memory simply cannot cope with both the complexity of the problem and the anxiety reaction to the problem at the same time.

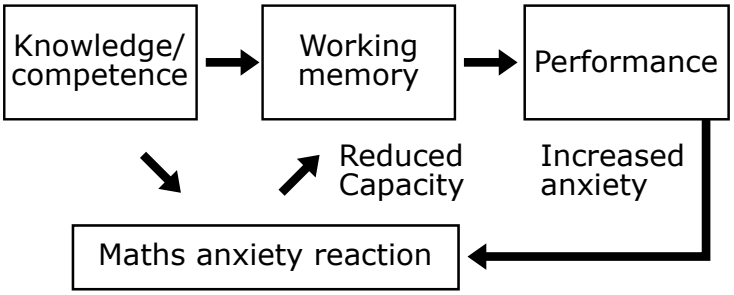

Figure 8.2: The maths anxiety reaction cycle

Tips for Overcoming Maths Anxiety

The following are some suggestions of ways in which you can help a student to overcome their maths anxiety:

- Concentrate on small successes in order to build confidence and self-belief;
- Fill knowledge gaps;
- Consider using physical techniques, such as breathing exercises;
- Consider receiving counselling for negative past experiences of learning or doing mathematics;
- Encourage the student to improve their test-taking strategies:
- There's no need to be a perfectionist – use a strategic approach based on your strengths, not anxiety about your weaknesses;
- Practice without a clock and slowly build up to timed practice;
- Try making learning enjoyable, for example use maths gaming sites[14];
- Don't over prepare the night before a test.

Sources: (Arem, 2009; Hembree, 1990; Sabin, 2002).

Specific Learning Differences

We introduce specific learning differences by asking you first to consider and discuss the following scenario:

Scenario 2

A male first year student comes to the drop-in centre and asks for help with matrix multiplication. His work is untidy and disorganised. You try to help him but he finds it hard to follow your written explanation. He also appears distracted by the noise in the centre and doesn't give you eye contact. He eventually leaves complaining of a headache from the bright lights.

Discuss:

- *What do you think is going on?*
- *How might you change your approach?*

Specific learning differences (SpLDs) are different ways of processing information. They are not a sign of a lack of intelligence but they can interfere with higher level academic tasks. They cover a spectrum of inter-related difficulties. Individuals with SpLDs may have an associated identity problem (e.g. they may 'feel' stupid). Common examples are:

Dyslexia – Difficulty in processing the mechanical aspects of language; also related to visual stress[15].

Dyscalculia – An inability to connect with numbers and basic maths concepts[16].

Dyspraxia – Difficulty with motor skills and sequencing multiple step tasks[17].

Autism (including Asperger's syndrome) – Difficulty relating to the physical word socially, in communicating and behaviour – appears like 'watching a film'[18].

Tips for tutoring students with Specific Learning Differences

- Treat all students normally, with warmth and respect;
- If a student tells you that they have a SpLD:
  - If they've been identified by an educational psychologist they may be able to receive free equipment and extra support from a specialist under Disability Support Allowance funding;
  - If they haven't you could refer them to your Disabilities Office for screening.
- Consider changing the environment:
  - Adjust the light and reduce background noise (if they are a problem);
  - Offer to use coloured paper;
  - Cover up distracting information;
  - Leave gaps between lines / use short sentences (dyslexics).
- Don't be over offended by students' body language – they may not be aware of normal social rules (autistics).
- Finally, if you suspect that a student may have a specific learning difference but they have not disclosed this to you, DO NOT suggest to them that they may have one. Identification of specific learning difficulties can be a sensitive process requiring the professional expertise of educational psychologists, SpLD advisors and counsellors. However, it may be possible to gently refer a student to a SpLD advisor without offending them or causing unnecessary anxiety. If in doubt, seek the advice of your Centre Manager.

Source: (Pollak, 2009)

[14] See for example: www.mangahigh.com
[15] See http://ddig.lboro.ac.uk/self_check_list.html for a checklist
[16] See http://www.sussexpatoss.org/documents/Helen_Arkell/CawseGillian_DyscalculiaChecklist.doc for a checklist
[17] See http://www.civilservice.gov.uk/about/resources/diversity/toolkits/dyspraxia.aspx for a checklist
[18] See http://www.educational-psychologist.co.uk/autismcklist.htm for a checklist

Counselling

We introduce counselling by asking you first to consider and discuss the following scenario:

Scenario 3

A female postgraduate student comes to the drop-in centre in a quiet period asking for help with her quantitative analysis.

When you begin to explain a statistical technique to her she suddenly bursts into tears and explains that she has just split up with her long standing boyfriend, has only 2 weeks to finish her dissertations and has major financial problems.

Discuss:

- *What would you do?*
- *What issues do you need to be aware of?*

McGahey and Szumko (2006) promote Rogers' (1979) Person-Centered Approach (PCA) to counselling in the context of personal tutoring. PCA has three basic elements (adapted from Rogers, 1979):

- **Congruence** – Genuineness, realness, authenticity: The more the tutor is him or herself in the relationship, putting up no professional front or personal facade, the greater is the likelihood that the tutee will change and grow in a constructive manner. It means that the tutor is openly being the feelings and attitudes that are flowing within at the moment. The term transparent catches the flavour of this condition – the tutor makes himself or herself transparent to the tutee; the tutee can see right through what the tutor is in the relationship; the tutee experiences no holding back on the part of the tutor.
- **Unconditional Positive Regard** – An attitude of accepting, caring or prizing: When the tutor is experiencing a positive, acceptant attitude toward whatever the tutee is at that moment, therapeutic movement or change is more likely. It involves the tutor's willingness for the tutee to be whatever immediate feeling is going on – confusion, resentment, fear, anger, courage, love, or pride. It is a non-possessive caring. The tutor prizes the tutee in a total rather than a conditional way.
- **Empathy** – Understanding the person from their internal 'frame of reference': This means that the tutor senses accurately the feelings and personal meanings that are being experienced by the tutee and communicates this understanding to the tutee. When functioning best the tutor is so much inside the private world of the other that he or she can clarify not only the meanings of which the tutee is aware but even those just below the level of awareness. This kind of sensitive, active listening is exceedingly rare: very rarely do we listen with real understanding, true empathy.

McGahey and Szumko (2006) assert that the use of these techniques in tutoring can lead to effective learning as they break down the power relationship between the tutor and the tutee and enable the tutee to be treated more as a whole person whilst still maintaining a professional relationship.

Consider your attitude and approach towards students in your drop-in centre: how might they be improved by adopting these principles?

Counselling techniques are also relevant to tutoring in the drop-in centre in other ways:

- It is important to be aware of your own safety and professional boundaries in a drop-in centre;
- It may sometimes be appropriate for your Centre Manager to refer a student to another professional service, such as counselling, finance or mental health (most commonly for anxiety and depression). If in doubt, discuss this with your Manager.

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Section 9:

Scenarios You Might Encounter

Providing Mathematics support in Higher Education is potentially a very challenging experience. A range of student motivational factors and learning styles are constantly observed and this should not be underestimated. Given the range of approaches to learning adopted by students, it is vitally important for tutors to consider how they might respond to the variety of situations that occur. Support which would be excellent for one student might be futile for another.

To this end four typical student profiles have been created to help tutors reflect upon the range of strategies that might be employed when dealing with students. Following each profile described below there are some additional questions and comments to provoke further debate and self-reflection. There will not necessarily be a correct way of dealing with any of these scenarios.

Note that this is not an exhaustive list of scenarios and questions. Indeed you are encouraged to raise further questions and explore a wider variety of situations with your colleagues in the Support Centre.

Scenario A: "I can't do maths"

David is currently on a Chemistry degree scheme with a high numeracy content. As the main focus of the degree scheme is Chemistry, and not numeracy, the numeric part of the course is taught very quickly with multiple question sheets set. He has never felt particularly confident with maths, and the high turnover of work that he has to do makes him feel less and less secure about his ability.

David attends a mathematics support centre with a file full of jumbled notes, half attempted question sheets and an uncompleted coursework that is due in the next few days. When he is approached by a support tutor, and asked what the problem is, he replies "I can't do maths".

Question A-1: How can a tutor encourage a student to engage with mathematics if they have already convinced themselves that they 'can't do it'?

Phrases such as "I can't do maths" or "I'm not mathematically minded" are heard all too often when providing Mathematics Support. In these cases reassurance that the student is not 'just stupid' is vital. It is very likely that it has taken the student a great deal of deliberation to simply attend the support session and therefore it is important to try and establish what the student can do and build on those experiences. It can help to take time to discuss what the student enjoys studying, the level of their mathematical background, how they tend to approach mathematics. Creating the right environment for the individual is essential before diving in to any technical problems.

Question A-2: How can a tutor be expected to assist a student who himself doesn't know where to start?

This question is not meant to imply that the students query should simply be dismissed until he sorts himself out. Moreover it is about establishing clear student/tutor expectations to emphasise the process of support as a two-way experience with input required from both student and tutor. For example, it could be suggested that before discussing any mathematical problems the student is given the responsibility of organising and reviewing his work to determine where the problem areas might be. The tutor can then make suggestions on how appropriate (and realistic) assistance might be provided in relation to the specific topics raised by the student. All the time, it is important to maintain a positive atmosphere during such discussions.

Scenario B: – "Here is my data, what statistical test do I use?"

Afia is a postgraduate student in Optometry, and has been collecting data for her thesis over the past three years. She has little experience of statistics, and has only picked up some key terms and concepts from browsing the internet. When it comes to finally analyse the data, her supervisor, who knows very little about statistics, recommends that she attends the Maths Support Service.

Afia attends Maths Support, with a laptop and a spreadsheet full of data. After explaining to a tutor the story behind the data, she asks "What statistical test do I use?"

Question B-1: What exactly is the research trying to show? i.e. Is there a clearly defined hypothesis?

The first point to note is that queries of this nature can be very time consuming, but it is vitally important before even looking at the data, to get the student to clearly explain what they are trying to establish. It may be that no consideration to the statistical testing has been given until after all the data has been collected, and as a result the recommendation of a specific statistical technique may be difficult without some additional analysis of the data. It is very important to be clear to manage expectations during the session. It is not the responsibility of the tutor to carry out the analysis, but merely steer the student to the appropriate resources so they may carry out the analyses themselves.

Question B-2: Is it appropriate for a postgraduate tutor to be responsible for advice given to another postgraduate research student?

This is possibly more of a strategic consideration for those coordinating the support service. However, in particularly busy support sessions, a tutor can very easily get involved in a query before establishing the level of the work under

consideration. In all such cases (not just when considering statistical work) it can be difficult to inform a student that you are not the most appropriate tutor to discuss such queries. Nevertheless if at any point a tutor is not comfortable dealing with a particular query (for any reason) it should be referred to a more experienced tutor.

Scenario C: "How do I integrate – my exam is later this afternoon"

Sachin has an exam later this afternoon and so runs into Maths Support with just a few pens and pencils. He always leaves things until the last minute, and is still unsure how to integrate some simple functions, but he wants to be quickly taught the basics so that he might do better in the exam this afternoon. He can stay for twenty minutes only, and so asks a tutor "How do I integrate?"

Question C-1: Should support actually be offered to the student in this situation?

It might be argued that providing support in this situation would be unproductive given the lack of time available for the student to reflect on the ideas discussed. However, if it is possible to provide support to students (within any time/resource constraints) then support should be made available. Simply reviewing techniques that the student may/may not know will help reinforce ideas and hopefully provide the student with enough confidence to at least attempt similar problems. It is important in such circumstances for the tutor to remain calm and positive so as not to further agitate the student. It may also be helpful to enquire if the student has all the necessary equipment for the examination.

Question C-2: Is it the responsibility of a Maths Support Tutor to try and avoid this situation from happening in the future?

Ultimately it is the responsibility of the student to be prepared for an examination. However, as well as informing students on specific mathematical queries, tutors should be constantly encouraging generic study skills such as time-management, reading mathematical texts, mathematical writing, problem solving etc. In this situation, it would be appropriate to discuss honestly the importance of exam preparation, so that the support available can be fully utilised in the future to discuss any queries that may arise well in advance of the actual exam.

Scenario D:"How do I do question 4?"

Poppy is a Maths student, who has been working on a coursework assignment in the library. She manages questions 1 to 3 fine, but comes to a halt as soon as she sees question 4. She looks at the time, and notices that a Maths Support session is happening down the corridor.

Poppy walks into Maths Support with the coursework sheet, and asks the tutor "How do I do question 4?" Afterwards, she calls into Maths Support again, and asks "Is my answer correct for question 2?"

Question D-1: Should a tutor encourage a student to consider more generic ideas instead of focussing on the answer to a specific question? If so, how might this be achieved?

It should be noted that a tutor is not expected to know the answer to all the problems posed in a support session. Indeed it can be a positive situation not to know the answer as it allows the tutor to demonstrate the problem solving techniques they would adopt to attempt to solve the problem. This might include some simple ideas such as exploring resources for more information (texts, internet etc.), or solving a simplified but similar problem. Again, emphasis on such skills will hopefully encourage the student to become more independent when faced with similar barriers in the future.

Even if the required method is known, instead of demonstrating the solution, a tutor could encourage the student to engage with the problem by posing suitably related questions. For example, a tutor might ask the student, "What techniques do you think are appropriate for this example, and why", "Have you seen/attempted any similar or related examples? What techniques were used there?" Students should also be encouraged to check their own work and reflect upon the answers they obtain; this should also include a discussion about methods students can use to check their answer. For example, could the answer be checked numerically? Could it be checked using a computer package?

Question D-2: Given their mathematical background, should a Mathematics Undergraduate be treated differently to a student from another discipline?

All students should be treated as individuals, and just because a student studies a particular degree scheme it does not mean that they should receive a different level of support or understanding. However, if through discussions it is established that a student has a more detailed mathematical background and has more confidence with their mathematical ability, then some of the techniques outlined above could be further emphasised. For example, asking the student to search for additional information, asking the student to attempt the problem before discussing it further, maybe asking the student to join a group of her peers to discuss the problem, would all be valuable techniques that would benefit the student's learning.

Clearly, many of the suggestions above have applications to a number of scenarios. All can and should be adjusted according to the individual query and student. Having the mathematical knowledge is important, but it could be argued that it is equally important to be able to clearly communicate with students in order to develop an environment where students can feel relaxed and are suitably encouraged to discuss and explore ideas. Care must always be taken to not over-burden a student but at the same time get the student involved and engaged in their own learning journey.

All this makes assisting in mathematics support a challenging, yet extremely rewarding experience.

Section 10:

Resources for Mathematics Support Tutors

Being involved in providing mathematics support to a group of students for the first time may feel like a daunting experience. However, the mathematics support community is a large, and growing, one, and as such there is a considerable range of resources and materials available for use by both you, and your students.

Below is a range of resources that you might find useful. This is by no means an exhaustive or exclusive list, but the materials below have two key features: they are all freely available, and most importantly, have undergone an element of academic scrutiny. They have been divided into three categories, and are hyperlinked for convenience. There is not the space here to describe each individual resource in detail, but I encourage you to explore the range of materials that are freely available; if you spot others that are particularly useful; please do let me know.

Subject Specific Learning and Teaching Materials

You may wish to think of the resources in this section as materials that can be used by your students to gain a deeper understanding of a particular mathematical topic. Alternatively, it may be a while since you yourself have studied a particular piece of mathematics, and the material here can be used as a handy 'refresher' for yourself. While it may be tempting to call these materials 'lesson notes', they are much more than this, and many of the resources listed below might be better thought of as 'self study materials'.

mathcentre (www.mathcentre.ac.uk)
mathcentre was developed in 2003 to ease the transition of students from school to university mathematics. It has grown into an on-line mathematics support centre for both students and staff providing access to over 1,000 individual resources across a range of topics. The level of mathematical topics covered ranges from what a student might expect in a GCSE programme to what they might meet as they progress through their first year of university studies.

The resources are available for students to access directly themselves when seeking assistance on a particular mathematical topic, and they include both paper and video based material packaged in many different downloadable formats. For mathematics support tutors, you may wish to download the resources and use as handouts, or link to them directly from an institutional website or virtual learning environment.

The Partner site to **math**centre is **math**tutor (www.mathtutor.ac.uk), which contains the resources grouped into seven mathematical subject areas into an integrated and interactive package.

Loughborough University Mathematics Learning Support Centre Resources on Statistics
(http://mlsc.lboro.ac.uk/statsres.php)
The Mathematics Learning Support Centre, which is home to the sigma initiative and hosts the **math**centre site, has developed a series of student handouts covering a range of statistical topics. These resources are particularly useful for students to use as self-study materials, either within, or outside of the support centre.

MIT OpenCourseWare
(http://ocw.mit.edu/courses/#mathematics)
The MIT OpenCourseWare initiative is a free online publication of course materials across the range of subjects taught at Massachusetts Institute of Technology. The mathematical sciences material covers a range of topics, and while it is usable by undergraduate students at all levels, in the context of this guide, it is included primarily as a resource for mathematics support tutors should you need to re-familiarise yourself with particular mathematical topics.

Computer-Assisted Statistics Textbooks
(http://cast.massey.ac.nz/collection_public.html)
These Computer-Assisted Statistics Textbooks (CAST) have been developed at Massey University in New Zealand. They consist of a series of electronic textbooks covering material ranging from introductory statistical methods to more advanced material such as multiple regression. They are particularly useful for use by students as self-study material as they are interactive, utilise dynamic graphics to explain difficult concepts, and make use of many data sets. For mathematics support tutors, a series of interactive diagrams are available for download as interactive diagrams for use within teaching and demonstrating.

STARS (Creation of STAtistical ResourceS from Real Data Sets)
(http://stars.ac.uk)
This provides data sets from published research and includes worksheets based on SPSS, Excel or Minitab. This is a useful resource for students if they require advice with analysing data as part of a project or research.

Useful Reference Materials

There is a range of other resources available that mathematics support tutors might wish to utilise to enhance their teaching. They range from resources that offer advice and guidance on good teaching practices, to material that provides wider background and historical information on a mathematical topic. Some of these will be useful to help you answer the inevitable question we are always asked by students: 'But when will we ever use this...?'.

A Handbook for Mathematics Teaching Assistants
(http://www.maa.org/programs/tahandbook.html)
Written by Tom Rishel of Cornell University and the Mathematical Association of America, this online resource, offers some very useful advice and guidance for those postgraduate students new to teaching mathematics within higher education.

Study Skills Online
(http://people.brunel.ac.uk/~mastmmg/ssguide/sshome.htm)
Developed by Martin Greenhow from Brunel University, this online resource is aimed at helping undergraduate students enhance their study skills, and understand what is required of them while studying mathematical sciences programmes at university. If you have a student arrive at the support centre who you feel needs guidance in managing their own time or studies, you may wish to direct them towards this resource. It contains a range of material covering topics such as presentations, revision, exams and applying for jobs.

The MacTutor History of Mathematics archive
(http://www-history.mcs.st-and.ac.uk/)

Based at the University of St Andrews, the MacTutor History of Mathematics archive is a searchable resource that contains biographies on many mathematicians, both past and present, as well as information on various topics in the history of mathematics. It is particularly useful as a resource to add contextual or background information to the teaching of a mathematical topic, idea or concept.

Online Mathematics and Statistics Glossaries
One of the reasons why a student may initially be struggling with a problem or exercise might be that they don't understand the mathematical terminology that is used. Rather than simply 'telling' them, you may wish to suggest they use an online glossary to 'look-up' the meanings in the support centre and then ask them to explain these to you. This provides a natural opportunity for you to work with other students (before returning to them), but also, as these glossaries are typically hyperlinked, it provides a mechanism for students to begin to find out more about a mathematical concept for themselves.

There are a number of good glossaries available, but I have found the following to be particularly helpful:

STEPS Statistics Glossary (http://www.stats.gla.ac.uk/steps/glossary/)

Mathematics Glossary (http://www.math.ucdavis.edu/profiles/glossary.html)

Wikipedia

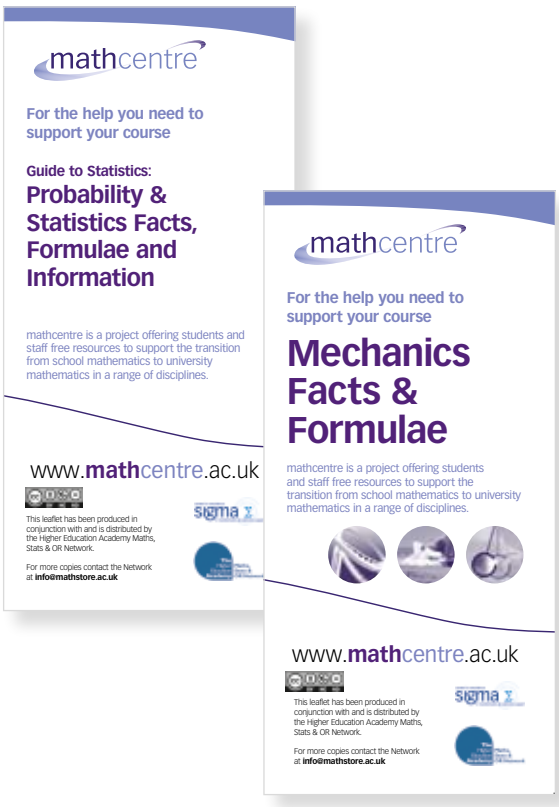
(http://www.wikipedia.org/)

I mentioned earlier that I had decided to include only resources that have undergone an element of academic scrutiny. You may therefore find it surprising that I have chosen to include Wikipedia. However, a 2005 study of Wikipedia by the journal Nature found it is about as accurate on science as the Encyclopaedia Britannica. That said, while there is always a need for caution with material that can be edited freely by others, the fact remains that Wikipedia is a potentially useful resource for mathematics support tutors. For example, in addition to providing a level of mathematical content, it also provides a timeline for the history of mathematical thinking and development in a particular area. In addition, it is also helpful for providing wider context, for example, if you need to know how complex numbers might be used in Physics, Wikipedia may well have some examples you can cite to your students.

Facts & Formulae Leaflets

(http://www.mathcentre.ac.uk/types/facts-and-formulae-leaflets/leaflets/)

Although included as part of the mathcentre website, these facts & formulae leaflets merit separate mention. Developed by those within the university sector, they have been designed to provide common reference material for use by students when tackling mathematical problems, which will be particularly helpful to students using a mathematics support centre. Many support centres already have these freely available, but if not, they can either be accessed online or downloaded and printed; large-print versions are also available.



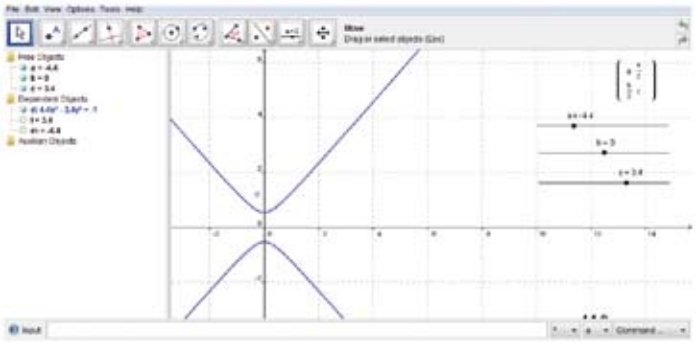
Interactive Resources

While there is a range of reference materials available to students, these can often be static in nature. Interactive resources are particular useful within a mathematics support environment as they allow you to demonstrate mathematical ideas and concepts in real-time and discuss the results with students. For example, they allow you to explore what happens to the mathematical properties of an expression when you change any of the component terms; this provides an ideal starting point for discussing mathematical relationships with a student.

Geogebra

(http://www.geogebra.org)

GeoGebra is an interactive, Java based, (accessible either through download and installation or through a standard web browser) mathematics package that links geometry and algebra through an easy to use interface. It allows users to create mathematical constructions (using, for example, points, vectors, segments, lines, polygons, conic sections, and functions), either geometrically or algebraically and then manipulate these in a dynamic manner. It is particular useful for demonstrating geometric theorems.



WolframAlpha®
(http://www.wolframalpha.com)
At first glance, WolframAlpha® may look like a search engine, however, it is much more than this. Try entering a mathematical expression and it will undertake dynamic computations based on a vast collection of built-in data, algorithms, and methods.

If you need to know, or check, the individual steps, you can even download these as a .pdf document.

WolframAlpha® is a particularly helpful resource if you, as a mathematics support tutor, need to quickly check the solution to a mathematical example a student has attempted. Just be aware, if you can check a solution, along with the intermediate steps, students can also use it to find solutions to a problem!

Mathletics
(http://www.brunel.ac.uk/~mastmmg/Downloads/entry.htm)
Mathletics is a series of assessments that covers many areas of mathematics at the levels of GCSE, AS, A level, and first- and second-year university. Each question uses random parameters so that many thousands of realisations will be generated and each assessment chooses randomly from within the selected topic libraries of questions. This means that if students do the test again they will get related, but not repeated, questions.

The Mathletics assessments are ideally suited for use within a mathematics support context, either within the centre or by students outside it, as they provide the opportunity for students to repeat multiple questions of a particular type to develop fluency in a particular area. They are a valuable learning tool for students as each question comes with full feedback, which seeks to explain where they may have gone wrong.

Sigma Mathematics Support Network
(http://sigma-network.ac.uk/)
In conjunction with the National HE STEM Programme, sigma has established the sigma Mathematics Support Network, which is a free association of staff and institutions providing mathematics and statistics support. The sigma Mathematics Support Network provides those who are delivering mathematics support activities with the opportunity to meet fellow practitioners and to work together to share resources and experiences. If you have a particular question you would like an answer to, then you can post it on the online forum. Alternatively, you may wish to attend one of the free workshops that are offered throughout the UK to meet other support practitioners and find out about new developments, learning and resources.

Section 11:

A Closing Note for Mathematics Support Centre Leads

This *Guide* has been written specifically for postgraduates who tutor in mathematics support centres. However, those with responsibility for leading mathematics support centres and for providing training opportunities for those postgraduate tutors will find herein information which will enable them to structure comprehensive training events.

The format of the *Guide* follows the same structure as several successful workshops run by the authoring team for postgraduates who were tutoring in support centres in 2010/2011.

The format of a typical workshop was as follows:

Welcome and introductions
Mathematics support – what is it?
Problem solving session (Example Handout in Appendix 1)
Principles of maths support – do's and don'ts
Offering statistics support
Tutoring in the mathematics drop-in centre – awareness of individual differences and needs (Example Handout in Appendix 2)
Group activity – exploring various scenarios (Example Handout in Appendix 3)
Resources and networking with others (Example Handout in Appendix 4)
Question and answer session

The *Guide* is intended to contain sufficient information to get whoever is leading the workshop started. In particular, sections 8 and 9 of this *Guide* include suggestions for group activities that are intended to raise awareness of the different types of student who use mathematics support, and the ways in which tutors can respond to their needs.

Section 10 has references to a wealth of freely available mathematics support material of which the tutors should be aware both for their own benefit and that of the students they are trying to help. Appendix 1 of this guide also contains a number of mathematical tasks (but note not the solutions – we leave that up to you!) that you might like to utilise as part of the problem solving session.

During the introductory session at the workshops that were run, postgraduate tutors were asked what they hoped they would get out of the day, and were asked to come up with at least one question they would like answering. A selection of typical comments/questions follows:

How can we backtrack, and unconfuse a student when a first attempt at an explanation is too complex?

How do we advise students about presenting their answers well?

What if I myself am not sure of the problem or I make mistakes?

How do I divide up my time between all the students who need help?

What is the best approach to helping the "here's my page of algebraic manipulation – where have I gone wrong?" type question – when pressed for time this is the hardest type of question!

What type of guidance can you offer someone with a clear difficulty or a disability?

How do we approach helping with coursework?

Suggested approaches to these issues can be found in the Guide; however they could usefully form the basis of group discussions during a training workshop.

Finally, the authors of this Guide are willing and will endeavour to offer answers to any questions you might have as far as is reasonably possible; our email addresses are available within Section 2. Alternatively, you may wish to engage with the sigma Mathematics Support Network detailed within Section 10, and take advantage of the large and growing mathematics support community. There are many individuals across the higher education mathematics support community who have expertise and resources that they are more than willing to share.

Appendix 1:

Handout: Problem Solving in Mathematics Support

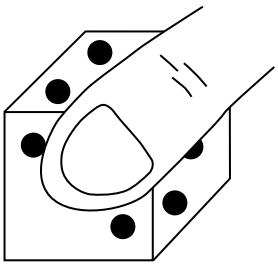
The following is a series of mathematical problems that you might like to attempt during this workshop session.

These may not look like the types of problems students will seek advice on during a mathematics support session, but while you yourselves are tackling these, you are encouraged to think about how you are tackling the problem and how you would advise a student to do the same. Consider these from the perspective of the advice that you would offer to students if they were seeking to tackle these problems for themselves.

The leader of the workshop session will advise which of these problems you should attempt to solve.

Problem 1

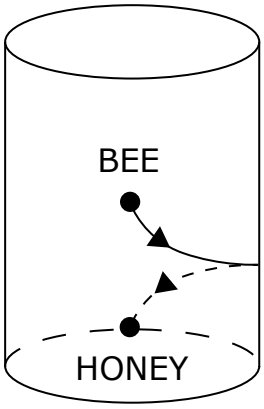
Here we see a conventional die partially obscured by a finger.



Bearing in mind that dice are normally constructed so that opposite faces add up to seven, what is the number on the bottom face?

Problem 2

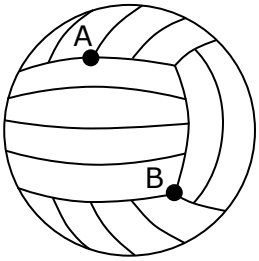
A bee lands on a cylindrical honey pot at a height that is exactly half way up the jar. Diametrically opposite the bee, a drop of honey has slid to the bottom of the pot.



Being mathematically minded and lazy, the bee crawls to this by the shortest route.

The pot is 10 cm high and has a diameter of 24 cm. How far did the bee crawl?

Problem 3

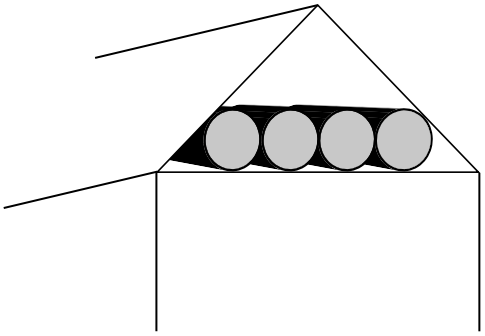


Old-fashioned footballs used to be made out of a number n of equal rectangular strips as shown.

As you can see from the picture, the seams meet either at a "T" shaped junction (e.g. at the point A) of which there are t, or at a "Y" shaped junction (e.g. at B) of which there are y. Calculate: $\frac{n \times t}{y}$

Problem 4

Four identical cylindrical tanks are needed to support my solar heating system. Luckily, they just fit exactly and snugly into the loft space as shown. If the roof space is 3m high and 8m wide, what is the diameter of the cylindrical tanks?



Problem 5

David has only two children and they are called Pat and Alex, which could equally be boys' or girls' names. In fact, Pat is a girl. What is the probability that Alex is a boy?

a) 50%;
b) Slightly less that 50%;
c) Slightly more than 50%;
d) Between 60% and 70%;
e) Between 30% and 40%

Now, explain and justify your answer with colleagues near to you!

Appendix 2:

Handout: Individual Student Differences in Mathematics Support

Activity 1

On a blank sheet of A4 paper, using four differently-coloured pens, copy the figure shown, changing pens in sequence approximately every 45 seconds. When you have finished, provide a key of the order you used the pens, for example:
1. red, 2. green, etc.

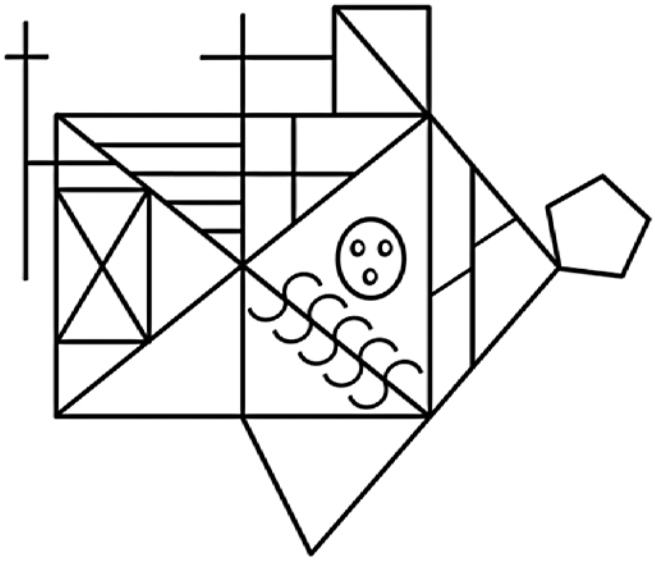


Diagram adapted from Rey-Osterrieth Complex Figure.

Activity 2

Consider the scenarios below. The leader of the workshop will identify which scenario(s) you should consider and discuss within your group. Don't forget to identify someone who will report back to the larger group.

Scenario 1

Two female final year nursing students come to the drop-in centre. They appear nervous and defensive. When it's their turn they tell you that they have failed their nursing numeracy test twice and if they fail it once more they will be thrown off their course.

Discuss:

- *Their possible mathematical needs*
- *Their possible other needs*
- *How would you change your approach?*

Scenario 2

A male first year student comes to the drop-in centre and asks for help with matrix multiplication. His work is untidy and disorganised. You try to help him but he finds it hard to follow your written explanation. He also appears distracted by the noise in the centre and doesn't give you eye contact. He eventually leaves complaining of a headache from the bright lights.

Discuss:

- *What do you think is going on?*
- *How might you change your approach?*

Scenario 3

A female postgraduate student comes to the drop-in centre in a quiet period asking for help with her quantitative analysis.

When you begin to explain a statistical technique to her she suddenly bursts into tears and explains that she has just split up with her long standing boyfriend, has only 2 weeks to finish her dissertations and has major financial problems.

Discuss:

- *What would you do?*
- *What issues do you need to be aware of?*

Appendix 3:

Handout: Scenarios You Might Encounter When Providing Mathematics Support

Consider the scenarios below. The leader of the workshop will identify which scenario(s) you should consider and discuss within your group. In each case you should identify what you would do to support the student and agree as a group on what your actions would be.

Don't forget to identify someone who will report back to the larger group.

Scenario A: "I can't do maths"
David is currently on a Chemistry degree scheme with a high numeracy content. As the main focus of the degree scheme is Chemistry, and not numeracy, the numeric part of the course is taught very quickly with multiple question sheets set. He has never felt particularly confident with maths, and the high turnover of work that he has to do makes him feel less and less secure about his ability.

David attends a mathematics support centre with a file full of jumbled notes, half attempted question sheets and an uncompleted coursework that is due in the next few days. When he is approached by a support tutor, and asked what the problem is, he replies "I can't do maths".

Scenario B: "Here is my data, what statistical test do I use?"
Afia is a postgraduate student in Optometry, and has been collecting data for her thesis over the past three years. She has little experience of statistics, and has only picked up some key terms and concepts from browsing the internet. When it comes to finally analyse the data, her supervisor, who knows very little about statistics, recommends that she attends the Maths Support Service.

Afia attends Maths Support, with a laptop and a spreadsheet full of data. After explaining to a tutor the story behind the data, she asks "What statistical test do I use?"

Scenario C: "How do I integrate – my exam is later this afternoon"
Sachin has an exam later this afternoon and so runs into Maths Support with just a few pens and pencils. He always leaves things until the last minute, and is still unsure how to integrate some simple functions, but he wants to be quickly taught the basics so that he might do better in the exam this afternoon. He can stay for twenty minutes only, and so asks a tutor "How do I integrate?"

Scenario D: "How do I do question 4?"
Poppy is a Maths student, who has been working on a coursework assignment in the library. She manages questions 1 to 3 fine, but comes to a halt as soon as she sees question 4. She looks at the time, and notices that a Maths Support session is happening down the corridor.

Poppy walks into Maths Support with the coursework sheet, and asks the tutor "How do I do question 4?" Afterwards, she calls into Maths Support again, and asks "Is my answer correct for question 2?"

Appendix 4:

Handout: A list of Resources You Might Like to Try

Below is a series of links to a list of resources that may have been discussed during the workshop. All links are correct and working as of September 2011.

mathcentre
(www.mathcentre.ac.uk)

mathtutor
(www.mathtutor.ac.uk)

Loughborough University Mathematics Learning Support Centre Resources on Statistics
(http://mlsc.lboro.ac.uk/statsres.php)

MIT OpenCourseWare
(http://ocw.mit.edu/courses/#mathematics)

Computer-Assisted Statistics Textbooks
(http://cast.massey.ac.nz/collection_public.html)

STARS (Creation of STAtistical ResourceS from Real Data Sets)
(http://stars.ac.uk)

A Handbook for Mathematics Teaching Assistants
(http://www.maa.org/programs/tahandbook.html)

Study Skills Online
(http://people.brunel.ac.uk/~mastmmg/ssguide/sshome.htm)

The MacTutor History of Mathematics archive
(http://www-history.mcs.st-and.ac.uk/)

STEPS Statistics Glossary
(http://www.stats.gla.ac.uk/steps/glossary/)
Mathematics Glossary
(http://www.math.ucdavis.edu/profiles/glossary.html)

Wikipedia
(http://www.wikipedia.org/)

Facts & Formulae Leaflets
(http://www.mathcentre.ac.uk/types/facts-and-formulae-leaflets/leaflets/)

Geogebra
(http://www.geogebra.org)

WolframAlpha®
(http://www.wolframalpha.com)

Mathletics
(http://www.brunel.ac.uk/~mastmmg/Downloads/entry.htm)

Sigma Mathematics Support Network
(http://sigma-network.ac.uk/)

The National HE STEM Programme

Working across the higher education sector with a particular focus upon the disciplines of Chemistry, Engineering, Mathematics and Physics, the National HE STEM Programme supports higher education institutions in encouraging the exploration of new approaches to recruiting students and delivering programmes of study. It enables the transfer of best practice across the higher education STEM sector, facilitates its wider adoption and encourages innovation. Through collaboration and shared working, the Programme focuses upon sustainable activities to achieve long-term impact within the higher education sector. As part of this philosophy The National HE STEM Programme actively disseminates project outcomes and evidence based good practice to HEIs beyond those involved in the project.

The **sigma** Network

sigma was a HEFCE-funded Centre for Excellence in Teaching and Learning (CETL) – a collaborative initiative between Loughborough and Coventry Universities.

At the end of sigma funding in 2010, the **sigma network** was supported by The HE STEM Programme to continue to share and enhance the work of sigma at universities in England and Wales.

National HE STEM Programme
Pritchatt's Road University of Birmingham B15 2TT
T +44 (0)121 414 8518

sigma – Centre for Excellence in Mathematics & Statistics Support
Mathematics Education Centre
Loughborough University Leicestershire LE11 3TU United Kingdom
T +44 (0)1509 227460

sigma – Centre for Excellence in Mathematics & Statistics Support
Mathematics Support Centre
Coventry University Coventry CV1 5FB United Kingdom
T +44 (0)2476 888965