Good Practice in the Provision of Mathematics Support Centres

Second edition of a guide for those interested in the establishment and development of Mathematics Support Centres in institutes of higher education

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Second edition of a guide for those interested in the establishment and development of Mathematics Support Centres in institutes of higher education.

This guide distils the findings of the LTSN funded teaching and learning project *Evaluating and Enhancing the Effectiveness of Mathematics Support Centres* which investigated the extent to which universities have made additional provision, in the form of Mathematics Support Centres, to support students who are struggling with the mathematical and statistical components of their undergraduate studies.

Data have been gathered by an email and an on-line questionnaire, by telephone interviews and by visits to several Centres, during 2000/2001. During the visits interviews were conducted with staff, students who use the Centres and, where possible, with a number of students who had not used the Centres.

The project aimed to determine how widespread is provision of this nature, how effective it is, and to identify and disseminate good practice.

This guide presents a brief rationale for Support Centres and also for alternative forms of provision. It goes on to provide guidelines on establishing and running a Support Centre. The handbook does not claim that having such a Centre is the best way of supporting students. Rather it offers advice, the experiences of those who have already developed or who work in Support Centres, and good practice for anyone intending to develop such a Centre in their own institution.

The authors would like to acknowledge the financial support provided by the LTSN Maths, Stats & OR Network. Without this support this project would never have started.

In addition the authors would like to thank all those staff from higher education institutions who completed the questionnaires. Special thanks are due to those colleagues who allowed us to visit their support centres and willingly gave of their precious time to explain the way they operated. Without the co-operation of all of these people this project would never have finished.

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Preface to the Second Edition

Good Practice in the Provision of Mathematics Support Centres was published in November 2001. Since then there have been a number of developments which merit description in such a *good practice* guide. It is for this reason that the authors, in conjunction with the Network, have decided to publish a new edition.

The LTSN MathsTEAM project has carried out an in-depth survey examining
- mathematics support programmes and resources
- current practices for teaching mathematics to engineering and science students
- diagnostic testing

A chapter in this new edition provides an overview of this project and gives information on how to access the many sources it cites.

Another LTSN funded project is **math**centre. This is a UK-wide on-line mathematics support centre which will use a mix of modern and traditional techniques to allow students and university professionals free access to high quality learning materials aimed at alleviating the school/university interface problem. A new chapter in this guide gives further details of this project.

There has been a growing awareness in higher education of the particular needs of dyslexic students. Most institutions of higher education provide dyslexia support, but this is traditionally language, rather than mathematics, support. In many institutions mathematics support is provided in support centres but it is usually the case that there is no specialist expertise for dealing with students who have dyslexia. A recent development has been the provision of specialist mathematics support specifically for dyslexic and dyscalculic students, bringing together both these areas of support. There has been little or no previous work done on this although it is clear there is a growing interest. In this new edition, Clare Trott, a mathematics tutor specialising in this field, writes about her experiences, and gives very practical suggestions for mathematics support. She also provides information about a regional network that has been established to share information and resources. Readers are welcome to access and/or contribute to these resources.

The last two or three years have seen major advances in mathematics support with resources and expertise now being coordinated locally and nationally. We hope that practitioners old and new, and policymakers will find material of use in this new edition.

Duncan Lawson & Tony Croft (July 2003)

Chapter 1 – Rationale for supporting mathematics

A very high proportion of students entering higher education is required to study components of a mathematical or statistical nature. These are not just the obvious groups such as mathematicians, physicists and engineers. Increasingly, students of chemistry, biology, geology, psychology, health sciences, nursing, economics, business studies and many other subjects find that they need to master mathematical and statistical tools and their applications if they are to succeed in their chosen discipline. Furthermore, many large companies now set numeracy tests as part of their selection process for management trainees, and those students intending to obtain Qualified Teacher Status must also pass mathematics tests.

However, the increasingly quantitative nature of many degree programmes comes at a time when, for a variety of reasons, there is a significant mismatch between the confidence, manipulative skills and knowledge of many students upon entry, and the expectations of those teaching in universities.

This mismatch arises through:

- inadequate preparation in school (itself due to a variety of causes including curriculum shortcomings, emphasis on assessment and league tables, shortage of mathematically qualified teachers, and social influences),

- widening of access to higher education with the acceptance of students with much more diverse backgrounds and experiences of mathematics than previously,

- a lack of understanding in universities of the true meaning of any particular grade at both GCSE and at A-level mathematics.

- reluctance of university departments to reduce the volume and level of mathematics required in an attempt to maintain academic standards,

- university lecturing staff who, by and large, are recruited and rewarded not for their teaching abilities, innovations and commitments, but for their success in research activities and income generation.

The school mathematics curriculum does not adequately prepare many students for the mathematical components of degree courses. There has been a reduced emphasis on algebraic manipulation, a reduction in the requirement to solve multi-stage problems within which students themselves are required to select the appropriate mathematical tools, and less emphasis on formal mathematics, rigour and proof. These issues have been researched and reported at length by Sutherland and Dewhurst [1] who studied the problems faced by a very wide range of disciplines and in a range of universities. They concluded that *'both schools and universities are straight-jacketed by a mathematics curriculum and examination system which does not adequately prepare students for Higher Education'*. Ignorance within universities exacerbates this situation. They write *'GCSE grade C in mathematics is accepted by some departments as an entrance requirement. There was genuine surprise about how little mathematics undergraduates with this qualification are familiar with. It would appear that universities have not taken on board the difference between GCSE and O-level mathematics.'*

More specifically, the report by Sutherland and Pozzi [2] reported the particular problems faced by engineering undergraduates. It noted that the increase in the number of students entering higher education means that students are now accepted on engineering degree courses with relatively low mathematics qualifications in comparison with the situation in the 1980's. Engineering has been affected more than other disciplines because of a general decline in the number of well-qualified students wanting to study it at university.

In 1999 a two-day seminar funded by the Gatsby Foundation focussed on the mathematical attainment of young people entering higher education to study subjects that call for a good grasp of mathematics (e.g. Physics, Engineering, Mathematics itself.) The resulting report *Measuring the Mathematics Problem* [3] drew attention to the significant and measurable decline over the last decade in students' basic mathematical skills even amongst those with good A-level grades in mathematics. Evidence is provided from several independent sources that even when universities recruit students who are well-qualified, many do not possess the necessary manipulative skills in algebra and calculus. It would appear that universities are not only faced with the difficulties arising through widening participation and changes in the school curriculum, but also must grapple with an A-level mathematics regime in which it is very difficult to determine what it is that any particular student can do having achieved any particular grade.

In addition to the declining achievement of entrants with A-level qualifications, the situation is complicated because a significant proportion of entrants to engineering degree courses have undertaken vocational qualifications leading to BTEC and Advanced GNVQ. Although these qualifications are widely treated as equivalent to A-level they are not the same. There is evidence from diagnostic testing upon entry to university that students with Advanced GNVQ perform worse than those with A-level grade E (See [4]).

Clearly universities are faced with major difficulties. In a climate of widening participation, a government agenda to increase the numbers entering higher education and a competitive need to attract and retain students, the majority of universities are not in a position to require the highest level entry requirements in mathematics. As a consequence they must take what they can find and put mechanisms in place to do the best possible job with the students they have. Universities and individual departments have not been unaware of these problems and are developing ways to deal with them. Some of these are described in the next Chapter.

Chapter 2 – Possible forms of support

Although this handbook concentrates primarily on Mathematics Support Centres, this is not an assertion that provision of such a facility is the best way of responding to the situation described in Chapter 1. Rather it is an acknowledgement that this is an approach that has already been adopted by many universities. Before giving, in Chapter 3, detailed consideration to the operation of a Mathematics Support Centre, this chapter presents a short review of other forms of support for students. It should be noted that these are not mutually exclusive and many institutions have adopted a range of support mechanisms rather than a single one.

Amongst the range of strategies for coping with the difficulties outlined in Chapter 1, one option is to reduce syllabus content or to replace some of the harder material with more revision of lower level work. This may help the weaker students. However, if more advanced material is removed to make space for this revision, it disadvantages the more able making them less well prepared for the mathematical demands of the more advanced and more analytical parts of their studies. It has a longer-term effect of making these students less able to compete for jobs in the rest of Europe and beyond.

Some universities have developed additional units of study (sometimes called bridging courses) for their weaker students. However this option is not universally adopted and may not be an option for some departments constrained by modular schemes which do not have sufficient flexibility to require (or even permit) students to attend more than a specified number of modules. Furthermore, it is not sensible for students to be learning basic mathematical techniques at the same time as they are supposed to be using more advanced techniques in applications and in problem solving in their other studies.

Some universities attempt to cope with diversity by streaming their students and teaching the weaker group separately, sometimes using the services of experienced school teachers rather than university lecturers. In order to cover the same syllabus as the stronger group it may be necessary to increase contact hours for the weaker group.

Many departments now routinely carry out some form of mathematics diagnostic testing upon their new students at entry. The report *Measuring the Mathematics Problem* [3] recorded that over 60 departments (of Physics, Engineering or Mathematics) carried out such testing, although the figure now is likely to be much higher than this, particularly if a wider range of disciplines were to be included. There are several reasons why diagnostic testing is useful:

- it can provide information about the cohort as a whole and enable curriculum developers to take account of the changing nature of the intake;
- it can provide individual teaching staff with information about gaps in the prior knowledge of the group and so enable them to take particular care when introducing new topics;
- it can help to identify students who are significantly weaker than the rest of the group and thus be targeted with individual help and attention;
- it can inform the development or acquisition of remedial materials in Support Centres.

Furthermore, by testing over an extended period of time, trends can be observed (see, for example, [5]). Some departments use diagnostic testing as a basis for streaming students into two or more groups, in an attempt to cope with diversity. However, there are many other departments where this does not happen. A shortcoming of the whole process of diagnostic testing is the provision of adequate follow-up support. In situations where students are simply told their test result and advised to revise certain topics on their own, there is little evidence that this happens.

Mathematics Support Centres are one way of providing follow-up support to diagnostic testing and indeed to offer support more generally. The remainder of this handbook will present those findings of the project relevant to good practice in establishing and developing Mathematics Support Centres.

Chapter 3 – Good practice in running a Mathematics Support Centre

3.1 Introduction

The provision of Mathematics Support Centres in higher education is already extensive. The survey carried out as part of this project revealed that of the 95 higher education institutions replying 46 (48%) had some kind of Mathematics Support Centre provision. In replying to the survey respondents were asked to interpret the term 'mathematics support centre' broadly, as outlined below.

The term 'Mathematics Support Centre' should be interpreted to mean a facility offered to students (not necessarily of mathematics) which is in addition to their regular programme of teaching through lectures, tutorials, seminars, problems classes, personal tutorials, etc. The term should be regarded as an umbrella term encompassing a wide range of provision (known in different institutions by various names including Maths Workshop, Maths Help, Maths Drop-In).

The provision at these 46 institutions varies greatly, although there are a significant number of common themes. 42 of these institutions completed a questionnaire, outlining in some detail the operation of their provision. In addition site visits were made to 8 institutions to gain first hand insight into the support provision at these universities.

In the following sections many of the key areas of consideration in the operation of a Mathematics Support Centre are discussed. The experiences, and particularly the good practice, of institutions as revealed from the questionnaires and visits are recorded as advice for those intending to operate such a provision or who wish to enhance an existing centre. Further material can also be found in [6].

It is acknowledged that there are inevitably constraints on the operation of every Mathematics Support Centre and these constraints will differ from institution to institution. For example, locating the Centre in a dedicated room is much to be preferred to only having the use, for a few hours a week, of a general purpose teaching room. However, economic and space constraints may mean that the former is not an option. Where the 'ideal' cannot be attained this does not mean that an institution should abandon the idea of a Mathematics Support Centre. However, it may mean that the support may not be as effective as otherwise or that the staff may have to work harder or more imaginatively to achieve the same effect.

3.2 Aims

If an institution is considering establishing a Mathematics Support Centre, or if it is reviewing an existing provision, it should ask the question "What is the purpose of the Centre?" The evidence from the detailed questionnaires shows that almost all centres have aims which are variations on the same theme, as illustrated in the examples below.

- *'To provide non-judgmental support for students outside their teaching departments'*
- *'To ease the transition of all students to HE courses with a significant numerate component'*
- *'To provide one-to-one support for any member of the University with mathematics difficulties no matter how small'*

There was only one institution that reported an aim significantly different to those listed above. This aim was

- *'To provide a pleasant environment where students can work, study and support each other'*

Although the method of operation of this centre is similar to that of many other centres this different aim does lead to some important variations. In particular, as is discussed in Section 3.7, this was one of the few institutions that did not report any barriers to the effectiveness of its operation. It should be noted that, although this did not feature explicitly in the stated aims of any centre, there is an implicit aim that the provision should be used.

In determining the aims for the centre one controversial area which must be addressed is "Who precisely will be allowed to use the facility?" At the most extreme, the answer to this might be only mathematics students. However, this approach is not common. A more common situation is that any student taking a mathematics or statistics module is allowed to use the centre. The most common view is that any member of the university is welcome. Whilst it is desirable to reach this decision solely on educational and academic grounds it is sometimes the case that internal politics and funding issues are a factor in deciding this question. For example, if a department takes back its service teaching and, in the opinion of the mathematics department, does it badly then there may be pressure not to allow these students to use the centre.

If the decision is to support anyone in the university then the full implications of this need to be considered. For example, will this lead to significant numbers of

PhD students from non-numerate disciplines seeking help with relatively advanced data analysis and, if so, is this going to be a disproportionate drain on the centre's resources. There are some institutions where the help is limited to foundation and first year students. Alternatively, help may be offered to anyone in the university but limitations put on the help that is provided so that advanced topics are not covered.

The overall ethos of the centre is a key factor in its effectiveness. The intention of the majority of centres is to create a non-threatening, positively supportive atmosphere. The interviews with student users revealed that they valued the informal nature of the support. Typical comments included *'you can ask anything', 'it is informal and less embarrassing than asking things in lectures'* and *'the help is not patronising'*. The imposition of limitations about who can use the centre (and, in particular, the enforcing of these restrictions) can undermine such a supportive and non-threatening atmosphere.

3.3 Nature of Support

Once the aims of the centre have been established the next things to decide is what support will be offered to students so that the aims are achieved. In virtually all institutions surveyed a key component of the support is access to one-to-one help. This included the institution whose stated aim was *'to provide a pleasant environment where students can work, study and support each other'*. Bearing in mind the point made earlier that the aim cannot be deemed to have been achieved unless the provision is used, this provision of one-to-one help is seen as an incentive to attract students to use the centre as a place to study.

There are two ways of providing one-to-one support: by pre-booked appointments or on a drop-in basis. There are advantages and disadvantages to both alternatives. Using an appointments system means that students know that they will get help at a particular time, and staff know when they are needed and when they are not. However, there are administrative overheads in that someone must manage the appointments schedule and students may have to wait some time to receive help. On the other hand, using a drop-in centre can lead to peaks and troughs. During peaks there are so many students in the centre seeking help from the tutor that some give up after they have been waiting for a long time without being seen. During the troughs the tutor may be left with nothing to do, waiting for someone to come and ask for help.

At the one institution where one-to-one help was not provided, what is offered is a series of workshops on fundamental topics. The timetable of these workshops (including topics to be covered as well as times) is published in advance so that students can attend those which are relevant to their particular weaknesses.

Many institutions offer a mixture of support, providing two or more of drop-in one-to-one help, pre-booked appointments and workshops. Inevitably, the range of what can be offered is limited by the available funding.

It was clear from the interviews with student users that the one-to-one help was the most highly valued part of every support centre. At one well-resourced centre which offers a wide range of learning aids (as well as one-to-one support) students commented that the handouts available were very good, but one-to-one support is better. When asked what should be changed about their centres some students replied “more one-to-one help is needed”.

3.4 Location

There are two primary issues relating to location:

- where the centre is situated
- whether or not the room used is dedicated to the centre.

Although at many institutions there may be little choice in either of these it is worth outlining the advantages of the different alternatives for the benefit of those who do have a choice.

The locations of existing centres are split broadly evenly between, on the one hand, being in a central building such as the library, general student support centre or central teaching room and, on the other hand, being in the mathematics, computing or engineering department. If the aims of a centre only target a limited clientele (for example, only engineering students) then it makes sense to be sited somewhere which will be convenient for the targeted students. On the other hand, if the aim is to offer support to anyone in the university then being situated in a well-used central building such as the library has obvious advantages; most particularly students do not have to make a special journey to get to the centre. However, the interviews with students revealed that neither the users nor non-users regarded the location as a major issue.

Whether or not the room is dedicated to the Mathematics Support Centre can have an impact on the effectiveness of the centre and the range of support it can offer. If the centre only operates for a few hours per week then it is unlikely that a dedicated room will be made available for it. But without a dedicated room (or at least secure storage) it is unlikely that resources other than a tutor will be made available. At some institutions which have a dedicated room the centre is open for study for considerably longer hours than a tutor is present. This fosters the idea that the centre is a place to come and work where, at certain times, personal help is available.

3.5 Staffing

The people who staff a centre are undoubtedly the key resource and are highly influential in the success (or otherwise) of the centre. A number of questionnaire respondents made the point quite forcefully that it is important to have high quality staff with particular skills. Not all members of academic staff are well-suited to working in a Mathematics Support Centre. The key point made was that building students' confidence is of huge importance. This requires staff who are patient and accepting. If a student visits the Mathematics Support Centre and goes away with the impression that their questions were regarded as stupid or trivial then they are unlikely to return for further help.

Two institutions use final year undergraduate students to help first year students and a number of others use post-graduates. The idea here is that this will be less threatening than seeking help from members of academic staff. The disadvantage of such an approach is that most final year under-graduate and post-graduate students have little, if any, experience of teaching and furthermore may not have the breadth of knowledge to offer help in the full range of areas in which it is sought.

Some institutions use dedicated Mathematics Support Centre staff. These are often former teachers or further education lecturers who are employed on a part-time basis. Such staff usually have, as a result of their previous experience, a good grasp of the mathematical backgrounds of the students coming for help.

The interviews with student users provided a slightly mixed response about the staff in Mathematics Support Centres. Some students singled out *'helpful staff'* as among the good points of their centres. However, other students said that there was a need for more good teachers and 9% of all student users interviewed indicated that not all staff were helpful.

In addition to the issue of who should staff the centre there is also the question of how many staff are required. Some students reported that sometimes their centres were very busy and waiting times could be in excess of an hour. However such peaks are rare (usually coming shortly before a test on a module with a large student population) and to double staff at all times simply for these peaks would be wasteful. One student made the imaginative suggestion that the centre should install a ticket machine of the kind often seen at delicatessen counters in supermarkets.

Whatever type of staff are used it is important that they are given a good induction into the ethos of the centre so that they promote, rather than inhibit, the development of a safe, non-threatening atmosphere.

3.6 Resources

The aims of many Mathematics Support Centres make it plain that the primary resource available is the staff. For example, one centre's aim is

'To provide one-to-one support for any member of the University with mathematics difficulties no matter how small'

To achieve such an aim all that is needed is to have staff available for one-to-one consultation. Almost 20% of centres completing the questionnaire indicated that the only resource available was staff. However, when the aim is a little broader, such as

'To ease the transition of all students to HE courses with a significant numerate component'

then the fulfilment of this aim may be achieved using a variety of resources.

The most commonly available resources are printed ones with almost 70% of replies indicating that paper handouts were available in the centre and over half indicating that textbooks were available. Half the centres have some CAL material and a quarter have videos and a quarter have on-line examples.

In addition to specifying which resources were available questionnaire respondents were also asked to identify the most popular resources and also those which were little used. Due to the questionnaire design, it is possible that there was some confusion about whether or not staff were to be counted as a resource in response to this question. Almost half the respondents listed staff as the most popular resource with a further third identifying handouts as most popular.

The statistics relating to little used resources need careful interpretation. Obviously if a centre does not have a particular resource then it will not be selected as little used. Of those institutions which have videos available 70% recorded them as little used. This is a much higher figure than any other resource. The only other resource showing significant unpopularity was CAL material; one in three centres where CAL is available reported it as little used.

In determining what resources should be made available there are a number of factors to be taken into consideration. A major factor is clearly the funding available to purchase them or the internal staff effort available to develop them. Where funding is available it seems that currently the resources most valued by students are contact with staff and paper handouts. There is evidence that the availability of on-line exercises is something which is growing in popularity with students, but not yet at the level of handouts.

Institutions were asked to indicate which topics they were most commonly asked about. Some respondents did not answer this question and others gave a list of a number of topics. However, half the institutions included basic algebra as a response to this question. The other two topics which were frequently mentioned (by about a quarter of respondents) were calculus and basic statistics. To some extent this was dependent on the disciplines of the main student users of the centre. Where the majority were engineers, it was likely that calculus was listed but where the majority were from health studies and nursing, then basic statistics was often mentioned. If there is only a limited budget for acquisition of (non-staff) resources then focusing on these topics is likely to benefit the students.

3.7 Student Engagement

Crucial to the success of any Mathematics Support Centre is student engagement. A Mathematics Support Centre might provide a whole range of high quality resources, but if no students come to use the resources the centre cannot be deemed to be successful. The difficulty of securing student engagement should not be underestimated. Over two thirds of questionnaires listed issues relating to student engagement as a barrier to the success of the centre. Many respondents made comments such as

'The Centre is effective in helping students who come, but many that need help do not attend'

The students themselves confirmed this problem. Comments made during these interviews included *'students don't like to admit they need help'* and the even starker *'students don't like to work'*!

The fact that so many centres reported this as a problem indicates that there are no easy answers to securing student engagement; however a number of pointers can be given. The first is that publicity is essential. Two thirds of the 'student non-users' indicated that they had not heard of the Mathematics Support Centre. Indications are that publicity needs to be repeated. Most Centres have a major initiative during induction week, with some timetabling student visits so that they are aware of the location of the centre. Other ideas include using posters across the campus, with flyers available in chosen locations such as the library, student services, counselling services and chaplaincy. Recommendations from lecturers teaching the mathematical modules students study can be effective, as can recommendations from personal tutors. It may be necessary to address publicity to staff, perhaps in the period just before induction week, as well as to students. One imaginative idea is to have the mathematics centre advertised on the standard PC screen saver.

Particularly when the centre is not in a frequently-used central location it is important to make it clear to students where the centre is. At one institution, some student users complained that the centre was not signposted properly and claimed that this deterred students who were not sure precisely where the centre was located.

It appears that the most effective way of encouraging student engagement with the support offered by the centre is to promote the use of the room as a general study area where sometimes additional help is available. If students develop the habit of working in the room because it is a pleasant, convenient location then they are in the right place to receive extra help when they need it. One institution has a particularly imaginative way of promoting student use of the room - there is a resources shop located at one end of the room. The shop sells paper, floppy disks and other essential stationery. The shop receives several hundred visits a week and each time a student visits the shop they see the existence of the Mathematics Support Centre.

3.8 Funding

There are primarily three sources of funding for Mathematics Support Centres: central funding, departmental funding or no funding. Central funding is most commonly (although not exclusively) found when the Mathematics Support Centre is located within a general student support facility. Departmental funding is more likely when the centre is located within the mathematics department. Where no funding was reported this was for centres where the only resource was staff. Technically these centres are funded by the mathematics department as this is the source of the staffing. In one instance the funding came from the faculties in the university according to their use of the centre.

Usually there will be no choice about funding source. If the university will not fund the centre centrally then, if a support facility is to exist, it will have to be provided by the mathematics (or other) department. However, the economics of central funding should be persuasive. If the support of a centre means that each year three first year students, who would otherwise be lost either through withdrawal or failure, are retained by the university then the fee income of these students for the next two years will be substantial. In addition, there are less clear benefits in terms of recruitment (the presence of a centre should be attractive to students) and external review (such as QAA subject review and professional body accreditation).

The amount and source of funding is inevitably dependent to some extent on internal politics. The best advice is to maintain a high profile for the Mathematics Support Centre generally and specifically as a means of addressing 'the mathematics problem'. In particular, seek to publicise stories of students who have clearly benefited from the support provided, keep evidence of success and ensure that managers are aware that around 50% of universities have some kind of Mathematics Support Centre.

3.9 Evaluation

A rigorous evaluation of the effectiveness of a Mathematics Support Centre is very difficult. In the previous section the economics of retaining three students per year through the support of the centre were highlighted. However, it is very difficult to establish that the Mathematics Support Centre has been the key reason behind the retention of any particular student.

Some institutions have tried to analyse the performance of regular centre users and compare them to the overall student body or to groups with similar entry qualifications who do not use the centre. Such comparisons usually show that the regular users perform significantly better overall than the non-users. However, even where these data exist it is not conclusive that the centre has made the difference. It can be argued that the regular users are better motivated students who would have found another source of help had the centre not existed.

The most common method of evaluating the effectiveness of the centre is through student questionnaires. Usually these are distributed to students visiting the centre. Although this gives some useful feedback the sample (of the whole student body) is biased to those who already value the centre. Other institutions have questions on their module questionnaires about the usefulness of the centre. These questionnaires reach a wider audience than those who come into the centre and so are probably more useful.

Invariably Mathematics Support Centres are paraded during external reviews such as QAA subject review and professional body accreditation visits. This can give a useful external input to reflecting on the effectiveness of the support provided.

It is common for institutions to keep attendance records. These give a crude indication of the effectiveness of the centre in as much as they give an indication of how students perceive the value of the centre. Counting return visits, rather than just the number of visits, adds a little sophistication to this measure as students who return are demonstrating that they gained enough from their first visit to regard a second visit as worth making.

During the interviews the students were asked if they thought that a Mathematics Support Centre was the right way to help. Amongst the users 76% said yes, with a further 17% saying yes, but more lectures and tutorials were also needed. 5% thought that more lectures and tutorials would be better than the support centre. Amongst the non-users these three percentages were 64%, 23% and 14% respectively. These indicate overwhelming support amongst the students for Mathematics Support Centres.

3.10 Checklist

Listed below are ten key questions which it will be useful to answer if you are intending to set up (or to review the operation of) a Mathematics Support Centre.

1. Why have a centre at all? What problems are you seeking to solve? Are there other ways of solving these problems? Would these other ways be more effective than a centre?

2. What will be the precise aims of the centre? In particular, who will be allowed to use it and what for (pre-university problems, problems with current modules, final year or post-graduate projects, etc.)?

3. In view of the answer to the last question what would be the ideal location for the centre?

4. Who will staff the centre? Will these staff be able to provide help across the range of problems identified in Question 2?

5. Will help be provided on a drop-in basis or will appointments be necessary? If the latter, who will do the administration of arranging appointments?

6. Will resources other than staff (eg handouts, CAL, on-line exercises, textbooks, etc) be made available? If so, how will they be obtained (bought in or self developed)?

7. What will be the best times for the centre to be open and to be staffed? Is it possible to open the centre even when it is not staffed?

8. How will students be encouraged to use the facilities provided by the centre?

9. How will the centre demonstrate its effectiveness? What records will need to be kept in order to do this?

10. Who will pay for the centre?

Chapter 4 – Some caveats

Many students interviewed during this project and many others known to the authors in their roles as managers of Mathematics Support Centres testify to the help they have obtained from such centres. However, it is important to state that Mathematics Support Centres are not panaceas that will solve every difficulty associated with 'the mathematics problem'.

There are a number of difficulties and potential hazards associated with providing a Mathematics Support Centre. The first hazard is the impact on weak students. If a diagnostic test identifies that a student has weakness in a single topic (perhaps because they were ill for a part of their pre-university education and so missed this topic) then support offered by a mathematics centre can be very helpful. However, when the diagnostic test shows that a student has weakness in many areas then a Mathematics Support Centre may not be a very effective solution. Such students are asked to remedy the deficiencies in their mathematical backgrounds through voluntarily attending the centre, whilst at the same time studying the same mathematics module as their colleagues. They are hit with a 'double whammy'. On the one hand, they are expected to spend extra time improving their mathematical background whilst, on the other hand, work for their modules (not just their mathematics module but others which rely on mathematical knowledge) takes them longer because of the weaknesses in their mathematical background. This can often lead to students taking a superficial approach to remedying gaps in their background knowledge. Rather than seeking to construct a coherent mathematical knowledge base, they simply use the centre to deal with isolated problems they are encountering on their current modules. These students often have a blinkered approach, wanting to be able to answer the particular exercise they have in front of them, rather than to acquire sufficient understanding to answer a range of similar exercises.

Another danger is that the provision of a Mathematics Support Centre is used by curriculum designers as an excuse for not developing curricula that are appropriate for the students they are recruiting. The argument goes along the following lines: "if students cannot do topic x then they can always go to the Mathematics Support Centre to learn it".

A final danger which is worth highlighting is that some institutions have reported that the presence of a Mathematics Support Centre has encouraged certain serviced departments to either remove mathematics from the explicitly required curriculum or to hide it within one of their modules. The students are then told that if they have problems with mathematics then they should go to the Mathematics Support Centre. Both of these approaches are an abuse of the intention of Mathematics Support Centres, which is to provide extra (not replacement) support for students with difficulties in mathematics.

Chapter 5 – The LTSN MathsTEAM project

Reports such as *Measuring the Mathematics Problem* [3] have made recommendations to assist departments enhance the mathematical knowledge of engineering and science students. Academics have responded to the challenge by developing innovative teaching methods, for example streaming and diagnostic testing, which are now part of the curriculum. Support systems have also evolved which provide resources and ongoing assistance.

Funded by the Learning and Teaching Support Network, the LTSN MathsTEAM – a collaborative project between four subject centres (LTSN Maths, Stats & OR Network, LTSN Engineering, LTSN Physical Sciences and the UK Centre for Materials Education) – recently surveyed the growing number of innovative teaching methods throughout the UK.

Three booklets (listed below) have been published each providing a comprehensive collection of case studies which describe the execution of the learning activities, the support needed, the implementation, the difficulties and evidence of success. For those academics considering the implementation of any of the programmes, each case study provides an opportunity to review the learning processes and the tools involved.

Readers can take advantage of this sharing, as pdf versions of the case studies can be found online at the **math**centre website www.mathcentre.ac.uk and copies can be obtained from LTSN Subject Centres.

5.1 Diagnostic Testing for Mathematics

The case studies illustrate two delivery mechanisms: paper-based or computer-based. In theory, computer-based diagnostic testing should be simple – off-the-shelf packages such as DIAGNOSYS or Mathletics can be obtained at little or no cost and installed on the university network. In practice, as some of the case studies point out, life is not quite that simple. Issues such as availability of computer rooms and whether or not students have been given their computer accounts in time can prove to be difficult problems.

5.2 Maths Support for Students

The case studies describe the growing network of support-based activities within institutions. These include maths learning support centres, drop-in centres, summer schools, computer-based and paper-based support and websites. This booklet offers academics a chance to explore the growing diversity of support-based initiatives through examples of good practice found within Higher-Education Institutions throughout the UK.

5.3 Maths for Engineering and Science

From foundation year through to final year, every one of the teaching methods described in the booklet focuses on the needs of the students. Each illustrates that in developing mathematical thinking science and engineering students need to be set meaningful tasks, but tasks that were so structured that they were accessible to both weaker students and the more able. The aim was to create good practice, which would engender mathematical thinking.

The study has provided a valuable insight into the diversity of the methods being developed to tackle the current issues. It indicates the growing need to share knowledge and materials amongst institutions, to develop good practice and to stop re-inventing the wheel.

The LTSN MathsTEAM would like to thank all those who have contributed to the project, including members of the project Action Research on Diagnostic Testing and Student Support (ARDTS), which is ongoing and has a website at www.atm.damtp.cam.ac.uk/people/bh213/ARDTS/index.html

Chapter 6 – Mathematics Support for Dyslexic Students

[Contributed Chapter by Clare Trott, Loughborough University]

6.1 Introduction

Students with dyslexia are characterised by a "marked inefficiency in their working or short term memory" [7]. This means that they may have problems retaining the meaning of text when reading at speed or fail to recall learned facts. Their written work may be disjointed. Dyslexics may have "inadequate phonological processing skills" [7] which can affect reading, spelling and comprehension. They may have difficulties with motor skills or co-ordination and particular difficulty listening and taking notes simultaneously. Dyslexics can also have visual perceptual problems. This can also affect reading, especially when dealing with large amounts of text.

On the other hand, dyscalculia is "the inability to conceptualise numbers, number relationships and the outcomes of numerical operations" [8]. Dyscalculia in adults is described in detail in [9]. These difficulties, in turn, can affect the learning of mathematics in several ways as described in Section 6.2. Most institutions of higher education provide dyslexia support, but this is traditionally language, rather than mathematics, support. In many institutions mathematics support is provided in support centres but it is usually the case that there is no specialist expertise for dealing with students who have dyslexia. A recent development has been the provision of specialist mathematics support specifically for dyslexic and dyscalculic students, bringing together both these areas of support. There has been little or no previous work done in this field although it is clear there is a growing interest.

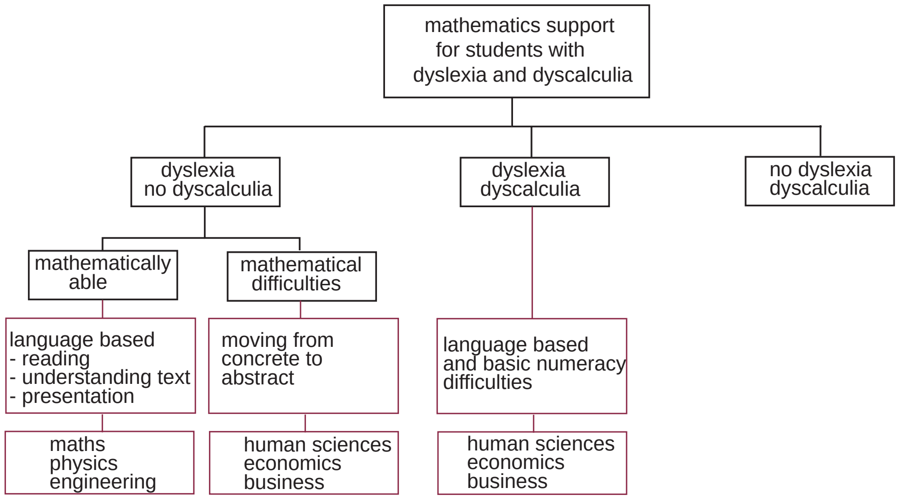
6.2 Dyslexia and mathematics

Dyslexia can affect the learning of mathematics in several ways: dyslexics may have poor arithmetical skills and find that mathematical procedures and sequences of operations are difficult. They may have difficulty recalling the theorems and formulae they need. In multi-step problems, students frequently lose their way or omit sections and fail to hold all the relevant aspects of a problem in mind and combine them to achieve a final solution. They may have problems in sequencing complex instructions, and past/future events. Some students will experience difficulties reading the words that specify the mathematical problem, especially if the problem is embedded in large amounts of text. Dyslexics may be slow at reading, mis-read frequently or not understand what has been read. They often substitute names that begin with the same letter, for example integer/integral, diameter/diagram, classify/calculate, and may have problems remembering and retrieving specialised mathematical vocabulary. Frequent problems occur in associating the word with its symbol or function, for example relating 'integration' to its symbol and knowing what procedure to carry out. There may be visual perception difficulties and reversals, for example 3/E or 2/5 or +/x.

Work is often poorly presented and positioned on the page. Students can make transcription errors when transferring between mediums, for example question paper to computer or calculator, and frequently lose their place. Further copying errors can occur from line to line, for example X+3 becomes X-3. Whilst copying errors are common in many students, the problem appears to arise more frequently amongst dyslexic students. They may have an inadequate documentation of their methods. Slow information processing means that students may have few notes. In a lecture, for example, they may copy down Example 1 and then Example 9, with nothing in between. Dyscalculic students will have difficulty with basic numeracy, in seeing how numbers relate to each other and in the interpretation of data. Overload occurs more frequently, and the student is forced to stop.

It has become clear that dyslexic and dyscalculic students fall, broadly, into three categories. The first category comprises students who are dyslexic but not dyscalculic. The second group consists of students who experience difficulties as a result of both dyslexia and dyscalculia, and the final group are dyscalculic but not dyslexic.

Experience at Loughborough University suggests that the first group is generally the largest, and more students in this group are currently receiving support. This group can be further divided into two sub-groups. The first sub-group could be described as mathematically able and these students tend to choose to study mathematics, physics or engineering, avoiding the subject areas that contain a high language content, since their difficulties are predominantly language based and are entirely as a result of their dyslexia. They may experience difficulty reading and understanding text or inefficiencies in their short-term memory with a resulting inability to retain information. Mathematics plays a central role in their course. The mathematics, for these students, is of a high level. The other sub-group has mathematical difficulties, in addition to the dyslexia based language difficulties. The students who fall into this group would probably never consider studying maths, physics or engineering; instead, they often choose



Human Sciences, Social Science, Economics or Business Studies. The level at which they are able to operate mathematically varies considerably, but this sub-group can not be described as dyscalculic, because their difficulties are not with basic numerical skills. They have difficulty in generalising and in moving from concrete numerical examples to more abstract algebra. They may also have difficulty with remembering and retrieving symbolic material. In particular they may experience problems with equations and rearranging formulae, recognition of like terms and understanding basic calculus.

The second group is both dyslexic and dyscalculic. In addition to the problems that dyslexic students face, they will have fundamental difficulties with basic numeracy. This includes not only poor numerical skills, but also an inability to see how numbers relate to each other. Alongside these difficulties, is usually an acute anxiety about mathematics. The dyscalculic student is likely to be studying social or human sciences or business, avoiding subjects that rely heavily on mathematics. However, many of these students are initially unaware of the important role statistics plays in their course.

Experience of the third group of students is, at present, limited. It is more difficult to diagnose dyscalculia in isolation; although it is believed about 4-6% of people are dyscalculic but not dyslexic [9]. Students in this category would again choose to avoid subject areas containing large amounts of mathematics, but may opt for business studies or human sciences. Their difficulties involve basic numerical skills and an impaired sense of number size, which clearly affects the understanding of number concepts.

6.3 Facilitating mathematics learning for dyslexics

There are several ways in which to facilitate mathematics learning for dyslexics:

- Break up large sections of text with page breaks and bullet points, using sans serif fonts such as Arial, which are easier for dyslexic students to read.

- Avoid justifying text, because this can make it more difficult to read.

- Use coloured overlays to reduce the glare from black type on white paper, which is often a problem for students with visual perceptual problems.

- Reading from the textbook with the student, especially if directed reading is set. As mentioned earlier, maths books can be particularly difficult to read. It is sometimes helpful to photocopy sections and reorder them. Diagrams, tables and charts often intersperse text and require the reader to move backwards and forwards between pages.

- Break down a multi-step problem into small, manageable steps.

- Use various pieces of specialist equipment to help with specific problems, for example a line reader can be used to highlight a specific line. This can reduce copying errors from line to line. It is a horizontal magnifier that will highlight a single line on a page and the other lines fade into the background. The dyslexic student is able to focus clearly on the specific line of work.

- Use coloured pens to highlight various aspects of a question. For example a triple integration can cause dyslexic students difficulties, as they frequently lose their place and miss out an integral. It helps the student if three colours are used, one for each integral, and the integrals are numbered. Three colours can also be used for quadratic equations, one for each term.

- Colour can further facilitate greater clarity and understanding when using software; for example the cells on a spreadsheet can simply be coloured in different colours to aid visual perceptual problems with the rows and columns.

- Edit down the output tables of statistical analysis, so that the student is able to focus on the relevant sections. This is particularly important in reducing the anxiety levels in dyscalculic students.

- Supplement missing or incomplete notes.

- Provide as many "memory hooks" as possible, such as using large wall posters. For example, making a large wall poster for a student who was having difficulties with inequality signs, and another for a student who had problems distinguishing between differentiation and integration. This is particularly important for students with poor short-term memory.

- Use of card indexes and pocket size "card carrying" cases as an aid to memorisation. One theorem or formula can be put on each card. This is particularly relevant to maths students who have many theorems and formulae that they need to be familiar with or to students of any subject where there are large numbers of formulae to learn.

- Provide flow diagrams or tree diagrams for clarifying procedures. For example, a tree diagram can be used for partial differentiation, using one branch for each derivative. The use of different colours will further clarify the problem. Dyslexic students will often lose their way and omit one or more of the derivatives. This provides a structure for the problem.

- Provide mind map diagrams to help with more extended pieces of work such as projects. These can also employ the use of colour, and can clearly show the various aspects of the project that need to be considered as well as the ways in which they interplay.

- Many dyslexic students are very visual learners. They usually find it helpful to 'see' the functions they are considering. It is helpful to take a function from their tutorial sheet or from their notes and to draw its graph on the calculator or computer screen. The student has an immediate visual image. Try to encourage the students to do this on a regular basis, for themselves.

- Provide a "gallery" of graphs to show various functions, transformations or plots. The student can then refer to this and match their function to one in the "gallery". This is again visual and aids short-term memory.

- Go through the work at the student's own pace. This is particularly important for dyslexic students, as overload can occur frequently and this results in an inability to absorb anything.

- Students will frequently need help with general organisational skills, study skills and time management. Focusing on revision techniques prior to exams is useful. Many dyslexic students struggle to learn and recall information for exams, due to their poor short-term memory.

Progress is often slow and frequent revision is necessary. The same ground may need to be covered many times. However, by providing the student with appropriate strategies and a framework they can relate to, it is possible for the dyslexic or dyscalculic student to grow in confidence, become independent in their learning and, above all, to succeed.

Anyone suspecting that dyslexia or dyscalculia might be hindering the progress of a student they are trying to support should consider:

- employing some of the above suggestions,
- talking to the student, in confidence, about the difficulties dyslexia and dyscalculia can cause in the learning of mathematics,
- referring the student for dyslexia assessment which will lead to the student receiving a needs assessment, extra time for examinations if appropriate, and possibly, funding from the Disabled Student's Allowance.

6.4 Resourcing additional support

Clearly, there are resourcing issues associated with the provision of additional support for dyslexic students which need to be resolved locally. However, for students who are registered as dyslexic it may be possible to recover some costs through the Disabled Student's Allowance administered by their local authority. The university's disability unit will be able to offer advice about this. From time to time there are also Government initiatives associated with widening participation, educating students with disabilities, and also the Disability Discrimination Act Part iv (DDA iv).

Readers with additional suggestions for supporting dyslexic or dyscalculic students are invited to send these to Clare Trott, email c.trott@lboro.ac.uk, for incorporation in future editions of this guide and other related publications.

Clare Trott is a mathematics tutor based in the Mathematics Learning Support Centre at Loughborough University. She specialises in helping students with dyslexia and dyscalculia and has been instrumental in the establishment of a Dyscalculia and Dyslexia Interest Group (DDIG) which has a website at http://ddig.lboro.ac.uk

The Group comprises both those involved in dyslexia support and those involved in mathematics support. It aims to exchange information and experiences about the mathematical needs of dyslexic and dyscalculic students in Higher Education, to promote awareness of the difficulties experienced and develop appropriate resources. This will include creating guidelines for identifying and working with these students and developing samples of mathematical resource material, appropriate to the needs of students with dyslexia and dyscalculia. DDIG meets on a regular basis, and would also like to establish contacts with others working in the field of mathematics and dyslexia. It is hoped that the web site will become a focal point for the Group's activities and for it to provide information and support and to act as a point of reference for others interested in this area. There are also plans to run conference workshops and to publish papers relating to its work and to promote exemplar case studies.

Chapter 7 – **math**centre

As we have seen, many universities have introduced Mathematics Support Centres to provide assistance for students experiencing difficulties in making the transition from school to university mathematics. These centres all address broadly the same issues, relating to a lack of mastery of fundamental mathematical skills.

Despite this commonality of purpose, there is much diversity of learning materials with many institutions developing their own handouts, leaflets, etc. which are ultimately very similar. The duplication of effort spent in producing these similar resources is a waste of the most precious resource – staff time. A new LTSN funded project **math**centre aims to reduce this duplication of effort by being an on-line resource centre providing high quality materials free of charge to all university staff and directly to students as well.

The aims of the project are

- To make a positive contribution to the solution of the 'mathematics problem' in the UK.
- To become the primary source of materials and on-line advice concerned with supporting students making the transition from school to university mathematics, whatever their chosen discipline.
- To provide a cost-effective and efficient means by which any university can establish or enhance its own local mathematics support structures.

mathcentre will offer students and university staff supplies of a range of complementary resources including:

- free standing help leaflets on key topics known to cause widespread problems
- more substantial refresher booklets giving opportunities for revision and practice
- on-line exercises to enable students to assess their own competency in specific areas

These materials will enable those university Mathematics Support Centres which receive little funding to make available resources for their students without the need for staff time to develop such resources.

The **math**centre web-site www.mathcentre.ac.uk will also be a place where others can make their resources available to the wider higher education community.

Alongside the **math**centre project there is **math**tutor, a DVD-ROM product being developed and funded under the FDTL4 programme. This project will introduce students to a small number of on-line tutors (not disembodied email correspondents) who students can see and get to know on screen. These tutors will give encouraging, confidence building master classes on basic topics. Information about this developing product is available from Janice Gardner at EBS Trust, email janice@ebst.co.uk. As video streaming technology improves, sections of these master-classes will be made available on the **math**centre web-site where possible.

Conclusion

Set out in this handbook are items of good practice in establishing and running Mathematics Support Centres, which have been identified through the LTSN-funded project *Evaluating and Enhancing the Effectiveness of Mathematics Support Centres*. During the course of this project a large amount of data was gathered from questionnaires, visits and interviews. Full details of this data can be found in the project report *Evaluating and Enhancing the Effectiveness of Mathematics Support Centres* which can be downloaded from the LTSN Maths, Stats & OR Network website http://ltsn.mathstore.ac.uk. A database summarising responses to the questionnaire is also available on this web-site.

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