Mathematics support is a broad term now widely interpreted within higher education as embracing facilities offered to students that are provided in addition to those which may traditionally have been available such as lectures, tutorials, and problem classes. Mathematics support is often provided outside of academic departments and perhaps by staff who are not formally teaching the students. Historically, such provision has been focussed upon non-specialist students, for example those on engineering programmes especially as they enter university and throughout their first year. In 2005, sigma – the Centre for Excellence in Mathematics and Statistics Support was established as part of HEFCE’s initiative to establish Centres for Excellence in Teaching and Learning (CETLs). It aims to develop provision not only for students who are struggling with basic mathematics at the transition to university, but also for other groups for whom a need can be identified, or for whom existing provision can be enhanced. Thus we are in the process of redefining mathematics support, to move beyond a remedial model to one of enhancement.

A particular group that is now benefiting from such provision has been single and joint honours mathematics students, studying at Loughborough University, and who are beyond their year of transition into higher education. Sigma funding has enabled the development of a resource and activity centre for these students. This article explains the rationale for the centre in terms of both local need and research findings nationally which suggest such a development might be a useful enhancement to the student learning experience. We provide an outline of underlying theoretical considerations, a research methodology which has, and is, being used to inform developments, together with practical information about the centre’s creation, and its early evaluation.

Rationale and theoretical considerations

There is a substantial body of research in the socio-cultural literature which suggests that mathematics teaching to undergraduates is ‘excluding’, and that it treats students as unimportant outsiders with the effect that many are marginalised [1,2,3]. A relevant contribution in this area is the ESRC-funded project, Student Experiences of Undergraduate Mathematics (SEUM) led by Wiliam [4] (elements of which have also been reported in [5,6]) which examined single honours mathematics students in two large research-led universities. The project report noted that “for many of those staying [on the course] the problems of coping with the work were accompanied by growing disillusionment with mathematics.” This work sought to identify factors which engender positive attitudes both to students’ own competence and to mathematics
as a discipline. A major finding in relation to student experiences related to the extent to which students felt part of a mathematical community. In one of the two universities, students had their own mathematics study areas close to staff offices, and students could thereby interact readily with lecturers as well as make appointments to discuss their concerns. In the second institution, a large number of the students lived at home and problems with time-consuming commuting, combined with very limited social space for mathematics students resulted in a sense of isolation. Students in that institution also reported making less use of lecturers and tutors outside teaching sessions, and there was sometimes a low attendance at lectures.

Solomon [7] in her study of undergraduate mathematicians in another research-led university reported a pervasive identity of ‘not belonging’. In order to understand how these students can develop negative relationships with mathematics, it is useful to explore their identities in terms of their membership of a community of practice [8] and the extent to which they experience studying mathematics in terms of “legitimate peripheral participation” [9] – that is, as a novice who nevertheless feels guided and supported by experts. This socio-cultural perspective characterises identity as the experience of a common enterprise, with shared values, assumptions, purpose and rules of engagement and communication: “we know who we are by what is familiar, understandable, usable, negotiable; we know who we are not by what is foreign, opaque, unwieldy, unproductive” [8]. The research literature reports that many students in fact tend to describe themselves as outsiders, as lacking control over their mathematical knowledge and its learning; many follow rules without understanding, and consequently they are vulnerable to failure – staying with the subject is possible only as long as they can do it, and this ability can fail at any time.

Wiliam [4] reports that many students choose to study mathematics at university because they find it easy at A-level. Thus they risk losing motivation when the work becomes more difficult and success is no longer guaranteed. Of particular relevance here is their finding that students who had more positive attitudes to studying mathematics were those who shared their ideas and problems with other students. Feeling part of a mathematical community emerged as a crucial factor in the student experience, and in the SEUM project, this community focused on a particular physical space within one of the participating universities.

In July 2007, the National Audit Office (NAO) published a report [10] on the retention of students within Higher Education. Although the report was not specifically targeted at the mathematical sciences, there are several areas where it recommends that an institution can target its work in order to make a difference to student retention. In particular, the report describes that the approach to retention should be a positive one, and that it should provide students with opportunities to improve their grades rather than simply addressing any gaps within their knowledge. Thus our intended shift of mathematics support from a remedial to an enhancement model aligns well the NAO recommendation.

Loughborough University, which was not one of the three universities researched in the studies cited above, has an undergraduate population of around 600 students based in the School of Mathematics studying on single and joint honours mathematics programmes. Whilst areas for private and group study can be found in the University Library and in smaller social learning spaces incorporating cafeterias at locations around the campus, the School of Mathematics itself consists largely of staff offices with little teaching space and no social or learning spaces for student use. Though a significant number of students live in halls located conveniently on campus, and though these are appropriate for individual study, the majority of students move off-campus and out into the town for their second year. Thus opportunities for students to work together within the School confines are rare and the scope for students being isolated from the rest of the mathematics academic community is great.

There is a mathematics learning support centre within the School and this is well-used by students from many departments. This was established in 1996 to offer one-to-one help, primarily to engineering students, and to first year mathematics specialists. Prior to 2005/6 students entering year 2 continued to use the centre as social learning space, although first year students were prioritised as far as one-to-one help was concerned. In 2005/6 the Centre had become so busy that use was restricted to first year mathematicians so removing entirely any learning space for those in year 2 and beyond. This step, albeit taken reluctantly, was pragmatic. With the opportunity of CETL funding we sought to address this. At the same time, we set out in this project to try to overcome some of the factors which generate identities of non-participation or marginalisation. We were interested in ways in which support for undergraduate mathematicians beyond the transition might be enhanced through the provision of dedicated, well-resourced social learning space within the heart of the School of Mathematics, and also through new activities designed to take place therein. The intention is that this space is used not only to encourage students to work independently and together, but also for staff-student interaction.

An expectation of the CETL initiative is that developments will be research informed and research-based, and so not only are we engaged in the practical aspects of delivering a resource centre, we also seek to ensure that we develop a research programme to guide its development and evaluation, and to contribute to the knowledge base in our field. The overall aims of the project are to improve the engagement of second year undergraduates, to improve their resource base, to develop a more positive relationship
with mathematics, and to mitigate against the development of identities of not-belonging. The methodology adopted is described next.

**Methodology**

The methodological basis of the research is Lewin’s model of Action Research (e.g. McNiff [11]), appropriate because it provides a structure for the identification of strategies to make informed changes to practice. This involves fact-finding to obtain a fuller description of the issues being faced, literature review and pre-action prior to implementation of the Action itself. The resulting Action, in this case development of additional support structures, is evaluated in conjunction with the students themselves. Amendments and refinements are made before the Action Research cycle begins again. We intend to implement at least two cycles. This methodology is shown schematically in Figure 1.

**Pre-action and Data Gathering**

In November 2006 two focus groups were held with second year undergraduate mathematicians. These students were chosen from a second year cohort of approximately 150 students, of which 58 were single honours. A decision was made to constitute the focus groups from those identified as being overall first class or upper second class honours students at the end of their first year, of which there were 22. This was a deliberate decision because, historically, mathematics support has primarily concentrated upon those students with mathematical deficiencies and this new programme of activity intends to shift the balance to in order enhance performance and learning experience for even the best of students. The two groups each comprised five students.

Students were asked about their learning of mathematics at University generally, and particularly about their use of the existing Mathematics Learning Support Centre. Not all students had used it, but those that had described how they were using it both to seek help from staff and as social learning space.

**V** - I used to go and sit up there, and you’d have quite a few people doing the same coursework, throw ideas about how to answer the questions.

**B** - .... I think it’s just handy if you work in there, and you come across something difficult, if the lecturer happens to be in there they can help. I mean I have been in there before, just worked, never had any help.

A repeated opinion was that in the second year, the stakes are higher, but the support on offer is reduced:

**B** - ... I normally use it when, to be honest I normally go in when the lecturer’s on duty ... but it’s just a bit annoying that if you turn up before a 1st year, they get help, especially when it doesn’t count with them.

Not surprisingly, when asked whether an area dedicated for their use would be welcome there was enthusiasm. But some of the reasons for that enthusiasm were illuminating:

**V** - I think that when it comes to exam time you do need to be out, because sometimes you don’t want to be in the house revising, you just want to go somewhere and the library round exams is so full and there’s really nowhere else for you to go.

**D** - when you go to work, the people in there are going to be doing the same stuff as you anyway, so you get help with each other.

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![Fig 1 – The Action Research cycle – adapted from Lewin (McNiff, 1988).](image-url)
V - there will be more people who know what you’re on about when you try to ask a question.

B - if it was just close to the maths [learning support] centre as well that would be pretty good.

As it turned out, the new centre was eventually located adjacent to the existing centre and this has proved helpful as we detail below.

It is interesting to note that the views described above echo some of the emerging findings from a related, simultaneously undertaken, programme of activity which explores the prior mathematical experiences of postgraduate students. It seeks to better understand progression patterns and motivating factors for continued study within the mathematical sciences, and although this work is still at an early stage, some interesting findings have emerged. The students themselves comment that:

- mathematics support for mathematics undergraduates is needed more at the transition into year two, as new and more abstract topics are introduced;
- informal peer support is the first choice of many for mathematics support;
- many students welcome the opportunity to both give and receive formal peer support;
- postgraduate communities of practice within the department are important in order to encourage a sense of belonging.

Both these programmes of activity - our work with postgraduate students and with second-year undergraduates - indicate that many, though not all, students value opportunities to interact with each other on learning activities as much as they value direct one-on-one support from an academic member of staff. There is a greater emphasis on the development of student learning communities throughout undergraduate programmes than may have first been realised, and these views validate similar findings in [4].

Implementation

Fortuitously, space became available adjacent to the existing Centre, and within the School of Mathematics, and a successful case was made to house the new facility there. The room, 46 square metres, was refurbished to include whiteboard, tables around which up to 20 students can work, five computer workstations, 7 low chairs and tables, fixed data projector, DVD player and video player. All recommended textbooks for second and third year mathematics modules were bought to provide a core of resources. These were supplemented by user guides on various computer packages. Students are able, independently, to connect their own laptops to the data projector in order to practice the individual and group presentations required as part of their modules. Such a facility has not hitherto been available. A laptop is also available for short-term loan.

At the beginning of the academic year 2007/8 the new centre was promoted to second and third year students via personal invitation, via email and via an advertising flyer. An initiative, Second Year Success (SYS) was developed by two members of academic staff, one from within the Mathematics Education Centre at Loughborough and one from a nearby University who was engaged as a consultant. In the first term (2007/8) this initiative consisted of two workshops which were formally scheduled into students’ timetables. The first focussed on a review of year 1 modules, information on how the year 2 programme follows on from year 1 and how this will lead into year 3. Part of the workshop was concerned with accessing resources students have available to them electronically. Finally, there was a timetabling exercise intended to help students organise their time better. The second workshop focussed on reading theorems and proofs. Discussion of the SYS initiative will form the basis of a future article.

Some preliminary evaluation findings

At the time of writing, the centre has been open to students for one term, and so the evaluation of its use and impact is still very much in the early stages. However, a number of interesting findings are already beginning to emerge from the data collected. Evaluation has been carried out using a mix of quantitative and qualitative methodologies. Usage data have been gathered which show which students are
using the facilities, how often and when. Interview data have been gathered to elicit students’ views. A series of observations have been undertaken to study the ways in which the centre is being used, and how students interact with each other.

Table 1 shows the number of visits made to the centre each week of the Autumn term of 2007/2008 [Week 10 data are not shown due to a system malfunction]. At the end of term, a total of 125 student visits had been made by a total of 48 different students. This information is collected by a swipe-card system upon entry to the centre. The centre is not staffed and we are aware that not all students swipe-in. Consequently actual usage is known to be higher than indicated in the table. As is to be expected, the number of student visits increased as the term progressed as more students became aware of the existence of the centre.

An interesting breakdown of the total number of visits made by individual students can be shown within Table 2. Although more Year 3 students visited the centre than second year students, 61% of these only attended once; this should be compared to the 35% of second year students who only used the centre once. It is worth noting that 41% of second year students used the centre more than three times and clearly these students are finding the provision useful. The reasons for these usage patterns will be investigated further as the year progresses and more evaluation data become available.

The data in Table 1 & 2 simply show patterns of usage by students, but we sought to better understand just how and why the students were making use of this resource. To assist with identifying this, observations of students using the room were carried out to determine how students were using the centre, and, as a follow-up, several structured interviews with student users were conducted. Observations started in the later weeks of the term when more students were using the centre. Seven observation sessions of between two and four hours were undertaken in Weeks 8-11. The results were not entirely surprising given how it was intended the centre should be used:

- many students attend the centre in groups to work informally on coursework problems; peer support within these groups is often clearly evident;
- students make use of the computing facilities to undertake computer-based coursework,
- students make use of the text-based resources available;
- students, in groups, use the projection facilities to prepare and practice their presentations;

The observations also showed that while some students use the centre as a general space, for checking emails and browsing the internet, these are very much in the minority. It was interesting to note that there were also a number of discussions held amongst students regarding aspects of their courses other than assessed work, and these were almost exclusively amongst students in Year 3. For example, there was discussion of aspects of their mathematics lectures, and discussions about their choice of course module and options.

Interviews with four students confirmed the observations of how the room was being used. It appears that the primary motivation for using the centre is to undertake coursework and try to improve their grades. There was little evidence that students were working to develop deeper understanding of mathematical concepts and ideas:

\[ H \cdots \text{for me grades is the main objective. Obviously I'd like to have understanding of it [as] I wouldn't have to do as much revision as I would if I didn't [understand it].} \]
Students were asked whether they tended to use the centre for individual study or for group work, and it appears students are happy to use the facility for both purposes, but the importance of peer support was clearly emphasised echoing the findings of the pre-action phase:

E - …I think if you get stuck on things, it’s nice to have somebody else, people to bounce off ideas, and also you know if you need help and you can’t get anyone in the other [Support Centre] room, then you’ve got someone else to ask….

H - …we often do the same problems at the same time, sort of a competitive thing and then at the end of it see who’s got the right answer and if we get different answers, we discuss them and have a look at each others work and see if we can see if they went wrong somewhere.

When students work in groups in the centre, they often arrive in ‘pre-formed’ groups and know those they work with well. There was no evidence of peer groups being developed solely as a result of using the centre which is perhaps not surprising, but one student realised it was important to move beyond individual study:

E - …I think I was in my room mostly, because I only started venturing out my room last year to do work, when I realised it wasn’t really working…

One emerging finding regarding the fact that no staff are ‘on hand’ to assist students indicates that the students do not mind this:

H - …I don’t think they [a member of staff] should pop in, otherwise people will be dependent on waiting for them to come in…

This validates the idea of using such centres to encourage students to become independent learners. However, it should be noted that the close proximity of appropriate members of staff to the centre means that students are able to approach staff quickly and easily even though they are not directly available within the centre. This is a factor that was identified as being important to student attitudes and motivation within [4].

Conclusions

This article has provided a rationale for extending the model of mathematics support from one of remedial provision to one of enhancement. The rationale has drawn upon research evidence gathered by mathematics educators during several studies of the undergraduate mathematics experience, on recent recommendations from the National Audit Office report on student retention [10] and on data from focus groups conducted within Loughborough University. We have described the establishment of a facility for specialist mathematicians which is intended to improve their resource base, improve their engagement and develop positively their identities as members of a community of mathematicians. While this approach is still in its very early stages, it is clear that its impact upon students is positive. Peer support appears to have a significant role in student motivation and confidence, and its impact upon student achievement and encouraging further study is one that we intend to investigate further as part of a programme of activity in this area. We invite and welcome comments and suggestions that may help shape developments during the next cycle of activity.

References


