A Civic University's Approach to the "Mathematics Problem" in Society

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Abstract

This article highlights the ways in which one institution is seeking to address the issue of declining mathematical ability amongst students and the knock-on effects this has to wider society through a range of initiatives stemming from its mission as a civic university.

A review of the current literature illustrates the range of interpretations of the role of a civic university and a number of common factors are identified. In addition, literature on the state of mathematics in society indicates that the changing nature of the student population and attitudes of professionals towards teaching and learning has led to the identification of a key set of issues which are in the process of being addressed. These include the dramatic fall in the number of students who were studying A-level and Further Mathematics; the declining number and quality of students entering degree programmes with a strong mathematical element; the lack of qualified mathematics teachers and the need for changes to the mathematics curriculum.

This report outlines the specific ways in which one institution is tackling the issues through the development of a university course for non mathematics graduates aiming to become teachers; the provision of Further Mathematics courses for students pre-entry; and the addition of mathematics education and teaching options to the final year modules for students studying mathematics at the university. It demonstrates how the university as an institution, its

students and the local community in particular are benefiting from this civic university approach.

Introduction

The lower levels of participation in higher education of some groups in society is said to have a important implications both for the individuals concerned in terms of financial prospects (DfES, 2006); and for wider society in terms of social justice and the meeting the skills development necessary to remain competitive in changing global economy (Leitch, 2006). The recognition, by Kingston University, of widening participation as “part of its core business” (Kingston University, 2005, p10) seeks to address this in line with its civic commitment to make an effective contribution to the local community.

In its drive to prepare the British economy to compete on a changing world stage there will, according to Leitch be an increasing demand for skills at all levels, but as the Lambert Review (2003, p 107) reported “Companies that specialise in some areas of science, engineering and technology are finding it difficult to recruit graduates of a suitable quality”. The Roberts Review (2002) found while scientists and engineers in the UK are in demand from a wide range of sectors increasingly demanding highly numerate graduates, there was a downward trend in the numbers of studying mathematics, engineering and the physical sciences.

The response of HEFCE has be to “support subjects – such as science and mathematics – that are of strategic importance to the nation, but where there is a mismatch between supply and demand” (HEFCE 2006, para 26).

Recent studies highlight the range and extent of the “mathematics problem in society”. Hawkes & Savage (2000) in their report Measuring the Mathematics Problem present evidence of a serious decline in students’ mastery of basic mathematical skills; and Pyle (2002) that of the unsuitable preparation of some secondary students for undertaking university degrees in numerate subjects. Tackling the “mathematics problem” can be seen as important to the future of mathematics as an academic subject (UK Mathematics Foundation 2005) and to maintaining mathematics as a skill set in society (Smith 2004).

By raising awareness of maths issues and adding to the number of well trained maths teachers KU is playing a part in both widening access through raising the number of students eligible for HE courses and contributing to tackling the wider issue of maths in society through its focus on raising standards of students in that area. This article examines critically the literature concerning the “mathematics problem” in society and the issues it raises and goes on to discuss the civic responsibility of universities in tacking it. Finally, an overview is offered of how one such civic university is taking action to address the findings through a number of projects.

The civic university

The broad meaning of “civic” as connected with duties and obligations of belonging to a community has been at the heart of the mission of many

universities since their inception; but national and local communities, and thus the interpretation of the term, have necessarily changed with changing times.

The movement away from the restrictions of university education to men who were members of the Church of England, provided by the ancient English universities of Oxford and Cambridge, to a more secular and egalitarian type of institution that admitted men and women of any race, class or religion was arguably begun with the founding of London University in 1826, becoming University College London in 1836 with the acquisition of degree awarding powers (University College London 2007). The early English “civic universities” were founded soon after this to support the growing needs of an industrial age. The first was Owens College Manchester (later renamed the University of Manchester) in 1851 followed by the universities of Birmingham, Sheffield, Leeds, Liverpool and Bristol. These were distinguished by being non-collegiate institutions that admitted men without reference to religion or background and concentrated on imparting to their students 'real-world' skills, often linked to engineering. The colleges from which these universities emerged were initially governed almost entirely by non academics who solicited and managed endowments, selected sites and employed academic staff, the notion of these as civic institutions arose from the subsequent development of bottom-up faculty staff dominated governance through a senate which made the vast majority of decisions concerning curriculum, examination, admissions and appointments. This transfer of power to academics recognised for their knowledge and expertise engaged and brought status to the local community through appearance of professors on

public platforms advocating Victorian virtues such as sanitation and charity. This system meant that the curricular decisions including recommendations for enlargement and introduction of new subjects demanded by the changes in society were in the hands of experts best equipped to make them (Jones 1985). This mechanism has largely continued at Universities throughout the twentieth and into the twenty first century and has provided a basis for continuing civic engagement and one in which higher education has become a significant element in the nation's overall educational provision and its political concerns (Ives 2000).

The current governance of the traditional UK civic university is described by Bell (2000) as to set a broad framework and to enable local policies and processes to emerge, and as having academic policy determined predominantly by discipline areas, in Faculties and Departments which allow for a bottom-up approach and, equally important at University level, the provision of a parallel 'top down' structure. Their civil role has continued to adjust with credentials and missions stated both in terms of the needs of the communities they serve and of providing trained professionals, and through the teaching of civic responsibility. As Sir Howard Newby stated in 2002

"I think, part of the civic tradition of the universities in this country is a determination to ensure that the benefits of the knowledge that is created in our institutions is passed on as effectively as possible to all those who can make use of it - whether in the business community in the voluntary sector in the health service and elsewhere"

(Newby 2002)

The emphasis in providing graduates who engage with civic issues, is mirrored particularly in United States, because, as Cantor (2004, p1) puts it

"Universities have a rare and critical role to play as a public good. We educate the next generation of leaders. We address important societal issues with discoveries that change our world. We preserve our cultural past while laying the groundwork for the future. And we experiment with new ways of building community…. the task of universities is urgent: to build on themes of diversity, not only in admissions and in recruiting, but also in creating living and learning communities that will produce a citizenry that is both engaged and informed."

The University of Chicago is described as the first civic university in that country (Benson & Harkavy 2000a), and is described as such because when it opened its doors at the turn of the 20th century, its strategy was to advance university and community development and to develop a sense of civic responsibility in its students, especially with regard to fostering close ties between the university and local secondary schools (University of Chicago 1992). Its vision was to create a civic university whose mission was to educate young people so that they function as active, informed, intelligent and moral citizens, and to do this by fostering links between universities and secondary schools to work together to achieve this mission (Benson & Harkavy 2000a). Other universities in the US have taken this same approach (Sommerfeld 1994; Benson & Harkavy 2000b).

However, as Crowther et al (2002) point out we live in a world hostile to the educating notion of the civic mission, with the increased marketisation of higher education and an emphasis on performance indicators and intensified public scrutiny. The performative university has according to Blackmore (2001) responded by intensifying internal pressure for quality assurance and improved outcomes, largely measured through the capacity to attract and retain students.

Universities such as Kingston have continued the civic tradition particularly through focusing on community engagement as encouraged by the higher education funding council for England (HEFCE); which, in its current strategic plan states that it wants to support HEIs in their "contributions to the wider social agenda – in terms of civic engagement and developing democratic values, and in supporting and helping to regenerate communities" (HEFCE 2006, para 15).

More specifically one of its strategic aims is that of "enhancing HE's contribution to the economy and society" through taking "the benefits of excellent teaching and research directly into the economic, cultural, community and civic life of the nation" while prompting the HE sector to "remember the market, and social and community needs, in shaping the future agendas for research and teaching; and through this interchange, supporting vibrant communities of practice" (HEFCE 2006, para 121)

Kingston University as a civic university

As a broad-based Higher Education institution in Kingston-upon-Thames and the neighbouring areas of south west London and Surrey, Kingston University willingly accepts its responsibilities as a public institution and as a civic university, and is aware of the significant contribution it makes to the local community and economy, not least as one of the largest employers in the area (Kingston University 2005). The University is also aware that its development plans will impact on the region, that there will be increasing mutual dependency between the University and local public institutions, and that a shared vision is required. It has adopted the definition of a civic university as one that has intellectual and economic links to the local community, and its approach to this role is underpinned by the concepts of the public good and civic engagement. As such, it takes the view that universities are public institutions serving the public good regardless of the particular sources of their funding and, while rightly guarding their institutional autonomy and academic freedom, they have special responsibilities to the public (Kingston University 2005). This has manifested itself in a number of ways including: contributing to fundamental debates, acting as a focus for cultural exchanges, satisfying aspirations for access to higher education, providing facilities and resources for community renewal, and meeting national and regional skills needs; in doing so has shaped the way the university has embarked on a series of projects to address the "mathematics problem" in society.

Literature review – The "mathematics problem" in society

Two major reports into the problem of mathematics teaching and mathematics skills for work have been undertaken. Roberts (2002) was commissioned by the Chancellor of the Exchequer as part of the government's strategy for improving innovation and productivity in the UK and the concern about the decreasing numbers of high quality scientists and engineers, the issues it raised led to the commissioning by the DFES of the Smith Report into post 14 maths education (Smith 2004).

Roberts (2002) was invited to undertake a review of the supply of science and engineering skills and focused on biological, physical and computer sciences and on engineering and mathematics. He found that there was a downward trend in the numbers of students studying mathematics, engineering and the physical sciences despite the fact that graduates within these strongly numerical skill areas are in increasing demand. This discrepancy is, he concludes, resulting in a skills shortage and the report also raised a number of issues about the development of science and engineering skills in schools, colleges and universities.

In his report *Making Mathematics Count* Smith (2004) suggests that mathematics in society is important for a number of reasons: as an intellectual discipline, for the knowledge economy, for science, technology and engineering, for the workplace and for individuals. He described mathematics as a "powerful universal language" and as the language of science and technology. Not only are mathematical skills highly regarded, but

mathematical training helps to improve cognitive ability in terms of mental discipline, logical thinking, critical reasoning, analytical thinking and problem-solving. He also reminds us that mathematics is of central importance to modern society in terms of the knowledge economy, providing the underpinning for many parts of the economy such as the technological industries and ICT, financial services, scientific research and business.

He goes on to deduce that advanced economies need increasing numbers of people who have more than the minimum qualifications in mathematics in order to maintain competitiveness in a global economy. Therefore, mathematical skills in the workplace are essential for the future prosperity of the country. Hoyles et al (2002) found in their review of the requirements for mathematical skills in the workplace that although IT in all sectors of the economy has changed the nature of mathematics skills that were required in the workplace, it had not reduced the need for mathematics. Hoyles used the term *mathematical literacy* to reflect the particular mathematical skills that are required by individuals to contribute to business goals and to communicate mathematically-based decisions to others. They concluded was that there is an increased need for workers at all levels of the workplace to hold an appropriate level of mathematical literacy.

At the individual level, possessing a certain degree of basic mathematical skills (e.g. basic numeracy) creates life and work opportunities for people and enables them to succeed. Smith (2004) suggests that the evidence shows that when individuals have a deficit in basic skills, this has an adverse effect

on their lives. Individuals with poor basic numeracy skills are greatly disadvantaged in the labour market, are less likely to be employed, to be promoted and to receive further training. What is clear is that from an economic, workplace and individual perspective, the UK needs more young people with greater mastery of higher levels of appropriate mathematical skills. Despite this, Smith found that, apart from in Scotland, there has been long-term decline in the numbers of young people in the UK who continue to study mathematics after aged 16. Two of the key issues that emerged are:

- The shortage of specialist mathematics teachers in England and Wales
- Failure of the mathematics curriculum to meet the needs of learners and the requirements of employers

The government White Paper (2005), "*14 – 19 Education and Skills",* was the government's response to both Roberts (2002) and Smith (2004). However, mathematicians in the UK have expressed concern that the White Paper did not represent a proper analysis of the two reports (UK Mathematics Foundation 2005), and concluded that the UK mathematics community is now falling far short of being able to reproduce itself, as evidenced by the decline in students undertaking A-level and further mathematics study. They also concluded that the most urgent short-term action, as outlined by Smith (2004), which was to increase the number of students studying A-level mathematics, will not be achieved by making A-level mathematics less demanding. They suggest that any effective strategy for recovery of mathematics must focus on two elements. The first is to strengthen the foundations laid at key skills (KS)

levels 3 and 4 and to nurture the interest and raise the aspirations of more able students; the second is to create a programme of professional development to ensure that current mathematics teachers appreciate why the strong foundations of KS3 and KS4 matter (UK Mathematics Foundation 2005). This resonates with Foster (2001) who suggests that the syllabus for GCSE-level mathematics has undergone change over the past 10 years which has led to an erosion of standards in mathematics learning and teaching and that the knock on effect, for universities who provide undergraduate programmes in subjects that include data handing and mathematics, has led to the perception that standards of mathematical requirements for entry into university programmes that require data handling skills have fallen.

On the one hand, the government's widening participation agenda has led to an increase in the number of students entering these programme with non traditional qualifications and may therefore not have covered the mathematical areas once taken for granted in those with A levels. Nationally and internationally, there is evidence to suggest that in general, students are increasingly less well-equipped at the time of entry to university in quantitative skills and knowledge (Croft 2003, Lawson et al 2003; Hall 2002), affecting a range of undergraduate programmes in university (Hawkes & Savage 2000; Tariq 2002; Hutton 1998). Hawkes & Savage (2000) provided detailed evidence of the serious decline in students' basic mathematical skills upon entry to undergraduate mathematically-based degree programmes such as engineering and proposed the use of diagnostic testing on entry and the

establishment of a National Centre for Diagnostic Testing; they also recommended the continued provision of remedial support for students who are undertaking degree courses that require mathematics and data handling skills such as that now available in many universities (Atkins et al 2005). On the other hand is the proposal from the UK Mathematics Foundation (2005) who seem to suggest a return to former approaches of targeting and nurturing more able students through a curriculum and assessment framework that rewards excellence and removes disincentives.

What emerges from the literature is twofold. Firstly, mathematics plays, and will continue to play, a major role in society. Secondly, there is a key set of problems and issues for mathematics in UK society. These include the dramatic fall in the number of students who are studying A-level and Further Mathematics; the declining number and quality of students entering degree programmes with a strong mathematical element; the lack of qualified mathematics teachers; and the need for changes to the mathematics curriculum.

How one civic university is tackling the "mathematics problem"

Kingston University is tackling the "mathematics problem" in line with its position and role as a civic university through adopting a multi faceted strategic approach as shown schematically in Figure 1

(Insert Figure 1 here)

Figure 1 depicts the Higher Education establishment and other agents in the strategy together with primary influences indicated directionally by the arrows, although the lengths of these arrows have no significance. It shows that advantage can be taken of recent national initiatives in mathematics provision which, when combined with particular curriculum offerings within the university form a coherent modus operandi for addressing the skills shortage, and does so within a longer timescale. The sphere of influence encompasses teachers already in schools, through to undergraduates in mathematics plus postgraduates in other subjects who want to become mathematics teachers, to pupils in years 12 and 13 who want to study more mathematics.

The remainder of this paper outlines work in progress related to the three main components of the approach outlined in Figure 1 – provision of a Mathematics Enhancement Course, hosting a Centre for the Further Mathematics Network and introducing mathematics education modules into the undergraduate curriculum. More evaluative research of each of these aspects is planned in the near future.

Mathematics Enhancement Courses

The pre-initial teacher training Enhancement Courses operating out of the Training and Development Agency for Schools (TDA) are designed for

graduates who want to become teachers in one of a few selected subjects, but who do not have the necessary academic knowledge to embark directly on their initial training course, such as a PGCE, for which they must also be registered. Mathematics is one of the five areas currently on offer for these six month long intensive courses, which provide the missing depth of subject knowledge, and students on this usually have studied some years in the past to A level standard or have some equivalent occupational experience.

At present there are just 20 Mathematics Enhancement Courses (MEC) registered around England with the South West London one being the only such course in the capital during its first time of operation in 2005-06. The resulting catchment area was large and the intake of 27 was above the maximum target number, but some of the students were known to be commuting considerable distances four days a week on TDA funding which at the time was below that awarded to PGCE students. In the next year the TDA funding will be increased and another London course is due to open which should assist in students being successful with less hardship.

For HE this is an excellent opportunity for collaboration not only between local institutions but also across mathematics departments; in this case it comprises one subject specialist and three education departments. The experience of the Southwest London contributors has been that a real synergy has developed and the mathematics specialists in particular have had the opportunity to better understand the Further Education sector which is by far the largest feeder to its undergraduate programmes.

The initial indications of the students' experience on the MEC are that overall it has been very positive. Before the course began it was clear that this was a dedicated cohort of individuals who were prepared to undergo considerable personal hardship to fulfil their teaching ambitions. What proved to be something of a surprise to the provider institutions was that in spite of this and quite a wide range of mathematical ability within the group, every individual completed the course and early indications are that all but one passed. This success was truly the outcome of a cooperative effort on behalf of all concerned and not least because of an unexpectedly supportive environment amongst the students themselves. For a vocational profession like teaching this must surely be just as encouraging for the future of these individuals as their enhanced subject knowledge.

What appears to be emerging from the MEC is twofold. Firstly the students place a high value on the collaborative learning ethos of the programme and secondly, that the MEC contributed to both students' personal learning of mathematics as well as pedagogic learning – learning how to explain maths to others.

A more detailed critical analysis of the MEC findings will be available when the evaluative research study has been completed.

The Further Mathematics Network

Further mathematics (FM) is important in ensuring the wellbeing of mathematics as a subject, both at Further and Higher Education levels. In addition to reinforcing the topics being covered in A2 it also bridges the academic gap between GCE and university mathematics. However the uptake of further mathematics in schools has undergone a serious decline in recent decades; for example the LMS reported that in 1960 over 35% of pupils taking A level also studied further mathematics, but that this figure had dropped to below 10% by 1994 (LMS 1995). To address this a project from Mathematics in Education and Industry (MEI) and funded through the Gatsby Technology Education Projects, called Enabling Further Mathematics, ran from 2000 to 2003 and was essentially a pilot for the national Further Mathematics Network (FMN) which was launched in February 2005.

The School of Mathematics at Kingston University recognised the merits in the pilot project, but decided that it was better to delay contributing until the FMN was constructed. This has proved to be a wise choice because the MEI now has a robust infrastructure for the network and each Centre has its own manager. The original idea of Centres being assembled in many different ways such as being coordinated from universities, schools, colleges and LEAs remains as one of the FMN's most attractive features because it allows a huge amount of flexibility which allows a Centre to conform to the needs of its surrounding region. London was treated as something of a special case with five Centres being assigned to cover the boroughs around the capital and all of these being created at the same time through the coordinating influence of the London Mathematics Centre at the Institute of Education.

Kingston University has been hosting the London SW Centre and its manager since June 2006, but it must be stressed that it operates through strong collaboration with the surrounding stakeholders. The essential idea of a FMC is that it allows access to the subject for all school pupils, especially where it would otherwise not be run either because of small numbers or due to lack of suitable qualified staff. Yet it is not only the pupils who are able to benefit, the further mathematics qualifications are still registered with the school and there is strong evidence that studying further mathematics will also enhance the A2 results, whilst the Centre receives the majority of the DfES funding for the further mathematics modules. This income to the FMC encourages it to recruit so that when the initial funding ceases after 3 years, the Centre is self sufficient. The FMC manager's role at Kingston in the first year involves advertising its presence, recruiting a relatively small cohort and providing tuition in a convenient cluster location to supplement the highly valued MEI on line resources.

As the number of pupils registered increases, it is envisaged that other tutors will be recruited from within schools and colleges who want to be involved in delivering this interesting material and that other courses run by the FMN will constitute an important CPD strand to the project; thus, it seems that all parties involved benefit from the FMN. Kingston University is pleased not only to be putting into practice its commitments to the local community but also to be raising its own profile as a provider of the subject at HE level, since it will

run occasional study days and master classes for all the registered further mathematics pupils.

Mathematics Education in the Undergraduate Curriculum

The observation from Roberts (2002) that too few mathematics graduates were being produced to meet the needs of industry and business also applies to the supply of new school teachers. One way of addressing this is to build mathematics education into the undergraduate curriculum as an option so that students can obtain exposure to teaching mathematics at a stage when they may still be considering the direction of their career path. Kingston has done this with two final year modules which can be taken as an alternative to an individual final undergraduate project. This is considered to be a comparable choice in terms of the modules' aims of enhancing independent research and learning skills whilst furthering communication skills.

If there is sufficient flexibility in the curriculum then mathematics education can successfully be introduced in two complementary modules; a theoretical one followed by a more practical, placement based one. The theoretical module gives insights into current issues in mathematics education in the 11-16 years age range, such as a critical analysis of the nature of mathematics and different approaches to its acquisition. Knowledge of current documentation for curriculum and assessment has been delivered along with the ability to recognise and differentiate between concepts, skills and process

in learning a mathematical topic. As an alternative to a project students undertaking this module are expected to display understanding of some current research, particularly relating to issues of equality of opportunity in terms of class, culture and gender.

The second module reinforces the fact that this is a vocational elective by sending students out into the school classrooms after they have undergone suitable pre-placement training and Criminal Record Bureau checks. At Kingston the module runs under the auspices of the national Undergraduate Ambassadors Scheme (UAS). The scheme shares the Kingston aims of providing undergraduates with transferable skills and encouragement to consider a career in teaching through a mentoring process with mathematics teachers in local schools. The students spend half of a day per week in schools equivalent to the normal class contact time of a traditional module and there they can observe the teachers as role models, although their main activity is in giving classroom support. A valuable opportunity for the university to liaise with the local secondary education sector is again afforded by this scheme.

Conclusion

Through a review of the literature it is clear that that there is, indeed, a mathematics problem in society (Roberts 2002; Smith 2004). In addition to the FMN other national initiatives are beginning to address the problem by closely following the recommendation of Smith. In June 2006 the National Centre for Excellence in the Teaching of Mathematics (NCTEM) was launched. This is a government funded virtual resource which is becoming a vital tool for the teaching community. In addition a Chief Advisor for Mathematics to the government has recently been appointed and in March 2005 the Qualifications and Curriculum Authority announced a two-tier mathematics GCSE in line with the Smith report. An encouraging outcome of local and national initiatives has been August 2006 announcement of significant increases in the uptake of A-level mathematics and particularly further mathematics (BBC 2006).

Kingston University is fulfilling its role as a civic university through its approaches to participating in solutions to the mathematics problem in society by fostering academic partnerships and intellectual and economic links with the local community in terms of the mathematics initiatives described earlier in this paper. This includes liaising with local schools in the scheme to provide mathematics education modules in the undergraduate curriculum, affording local schools and colleges the opportunity for their pupils to study further mathematics and to impact upon the number of new teachers of mathematics. Any university that claims to be a civic university needs to participate in finding solutions to the social and economic issues in society and the model

presented in figure 1 shows how one such social and economic problem in society is being addressed by a number of very practical projects. Evaluative research studies are being undertaken on each of these with the aim of measuring the extent to which these projects succeed in finding some solutions to the mathematics problem in society.

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Figure 1: Overview of approach