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e-Uptake Deliverable WP2.1.3

Gap Analysis Report

Abstract

A primary goal of the JISC e-Uptake Project has been to review current e-Infrastructure education and training provision and identify gaps in that provision, considering the expressed needs of the user community. The Training Requirements Report provides analyses based on surveys of the user and trainer communities to determine demand for training, while the Education and Training Sustainability Report details the present provision of e-Infrastructure education and training in the UK, with focus on JISC services. This report brings together findings from these two reports in order to address the supply side, explicitly pointing out gaps in provision and providing suggestions for the ways in which these gaps can be filled and education and training in this area can be sustained over the long-term.

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1 Introduction

One of the JISC e-Uptake Project's goals is to identify gaps in the current provision of education and training in e-Infrastructure, so that these gaps can be filled to increase the adoption of e-Research methods and lead to greater use of JISC services and resources in the UK. JISC, in keeping with the EU's promotion of ICT, has presented a solid argument describing the importance of e-Research methods to the current academic environment (across disciplines). In many fields, research already relies on computer-enabled methods and researchers that do not yet employ such methods would reap great benefits from their uptake. The vast amounts of data researchers across disciplines must manage and analyse require the use of e-Research methods. These assertions prove the value of increasing the adoption of e-Infrastructure through various means, one being adequate provision of education and training.

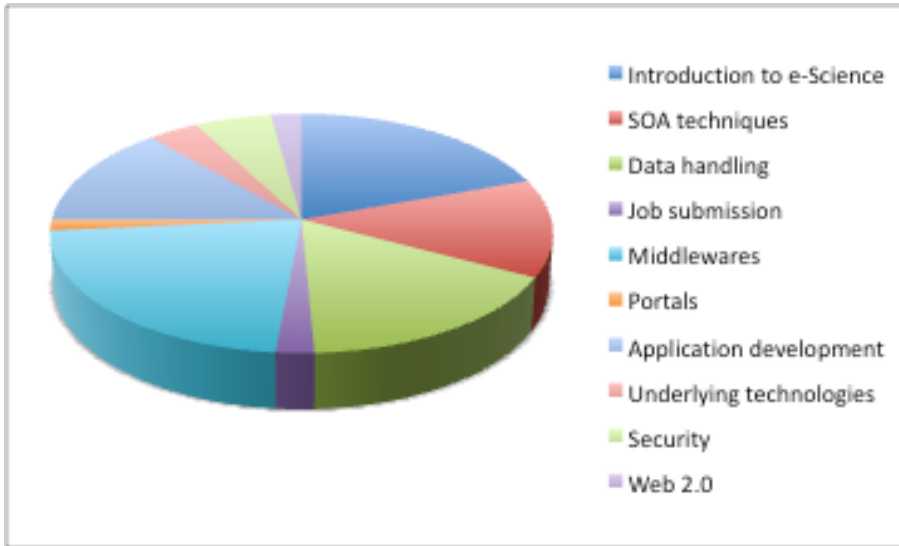
In order to identify gaps in education and training in the UK, we have conducted surveys, interviews, workshops and desk research. Based on the information gathered through these methods, we have produced the Training Requirements Report (D2.1.1) and the Education and Training Sustainability Report (D2.1.2), which will be summarised below. This Gap Analysis Report (D2.1.3) brings together findings from both previous reports to present a list of apparent gaps and related recommendations. When considering the training landscape we have mapped here, we must also keep in mind the changes that will be introduced by NGS3 and the connectivity between National Grid Initiatives facilitated by the European Grid Initiative (EGI).

2 Training Requirements Report

The Training Requirements Report presented training requirements for e-Science based on responses from researchers who were already using or thought that they could benefit from e-Science tools. Data included in the report was collected between 2004 and 2009 from 455 respondents. We gathered training requirements at e-Science events using simple structured face to face interviews and surveys, and then followed up with emailed and online questionnaires (Zoomerang survey). A second component of the report explored the bigger picture, detailing general requirements identified by trainers and educators in EU and international contexts. We drew conclusions from work carried out by the e-Infrastructure Reflection Group (e-IRG) Education and Training Task Force (ETTF) and the Open Grid Forum (OGF) Education and Training Community Group (ET-CG).

User interviews and surveys revealed a clear pattern for training requirements. In the first wave (2006 and 2007 results), a large proportion of respondents stated a need for general introductions to e-Science and available middleware products.

Figure 1: 2006-2007 Training Requirements



In 2008 - 2009 surveys and interviews, researchers also expressed significant requirements for introductory e-Science courses, along with application development (Figure 2) and the new categories of data management and Access Grid (Figure 3).

Figure 2: 2008 -2009 Training Requirements

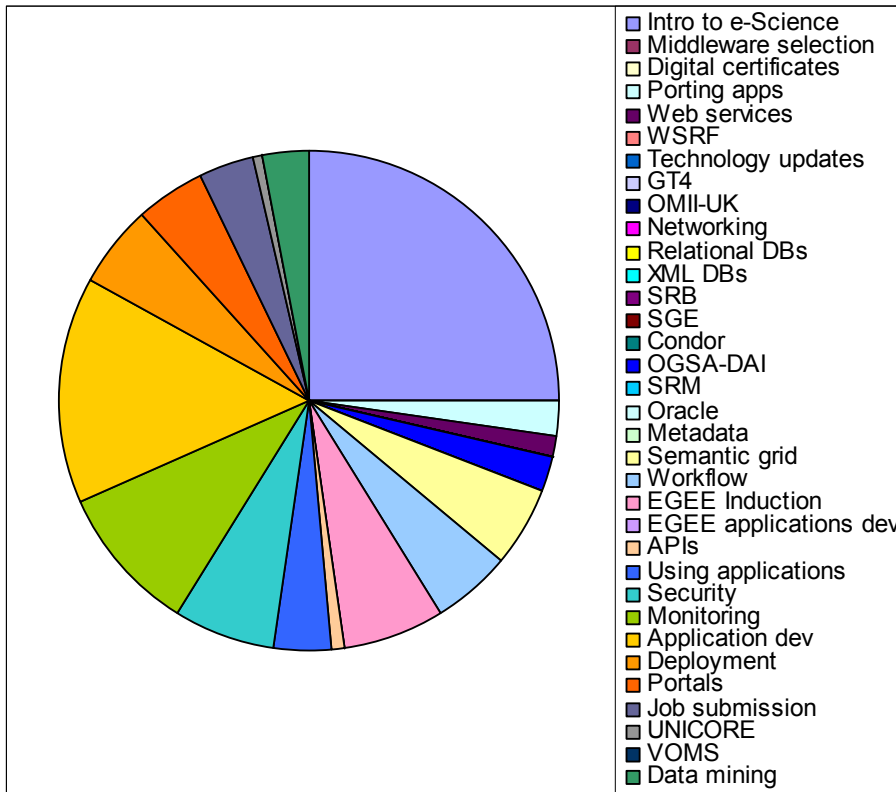
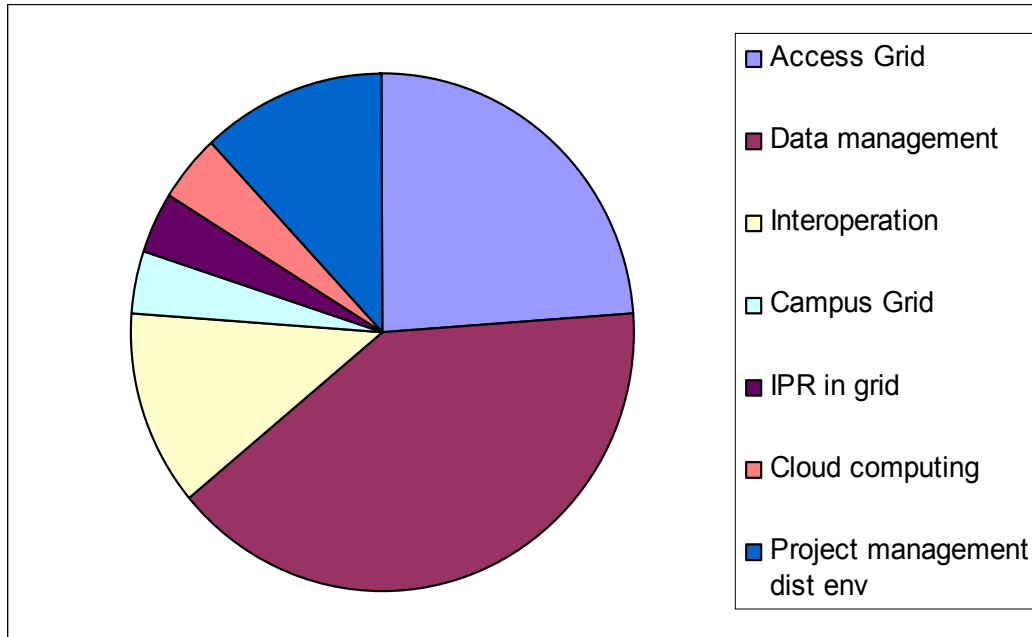


Figure 3: 2008 New Categories for Training



General requirements gleaned from e-IRG and OGF meetings and related reports included provision of training infrastructure to meet special teaching requirements, curricula development, training certification programmes and an intellectual property rights framework to facilitate the sharing of training material.

Suggestions for t-Infrastructure originated from the review of GILDA (Grid INFN Laboratory for Dissemination Activities), with inputs from industry and academic sectors through the OGF groups. This provided information about best practice and flagged the need to consider the role of National Grid Initiatives (NGIs) and the European Grid Initiative (EGI) in providing and coordinating a shared infrastructure to support training. Conclusions on curricula content for e-Science education can be found in the Training Requirements Report, which extends the e-IRG ETTF and OGF ET-CG work and is based on discussions that took place at the Curricula Development Workshop in Brussels (February 2008). Digital systems thinking was stressed as a necessary foundation, at undergraduate level, for further e-Science education at higher levels. The OGF ET-CG informational document on professional grid certification spelled out ways in which certification enables grid computing uptake, listing the benefits of “standard” measures and these were included in our requirements report. Intellectual Property Rights were also discussed, as they relate to digital repositories, and specifically concerning digital libraries for e-Science education. The OGF ET-CG recommendations on copyright, supporting use of Creative Commons licences in the context of digital libraries containing education and training materials are included in the Training Requirements Report as a solid guide for requirements in this area.

These general training requirements, and the user requirements introduced above, are relevant not only in the UK. They have international scope and value.

3 Training and Education Sustainability Report

In the Education and Training Sustainability Report, we summarised the UK provision of training and education relating to e-Infrastructure, with particular focus on JISC services. This work led us to conclusions about the sustainability of existing training programmes.

The report serves as a valuable reference due to its comprehensive list of services and associated training on offer in the UK. It details those training and educational activities provided by training teams, academic institutions, campus grids, e-Infrastructure services at national level, regional grid initiatives, component creators and research communities.

The NeSC Training, Outreach and Education (TOE) team leads UK training activities and supports EGEE (Enabling Grids for E-Science) and the NGS through training events. Academic institutions primarily offer MSc level courses in e-Science, distributed computing and advanced computing. Universities providing such educational opportunities are listed in the sustainability report. Many campus grids also offer some level of training on use of grids, including Cambridge, Cardiff University, Oxford, Plymouth and University of Reading. National infrastructure services, which encompass JISC services, give users and potential users opportunities for training in their use. JANET, the NGS, Access Grid, data centres such as EDINA, MIMAS and AHDS, the DCC (Digital Curation Centre) and ReDReSS do already address training needs through online courses and guides, workshops, tutorials and other training events. National Centres and institutions such as NCeSS, NIEEs and AHeSSC provide some limited training options or refer to other training events run by e-Infrastructure providers. The sustainability report goes on to catalogue training offered by regional grid initiatives such as North West Grid, White Rose Grid and UK e-Science Centres. Research community support concludes the catalogue of existing training and includes Research Council-based e-Science training courses or events (overlapping with some of the National Centre offerings).

Final sections consider the impact of international initiatives, which serve as support for and influence training and education programmes. These initiatives include EGEE, the ICEAGE (International Collaboration to Extend and Advance Grid Education) Project, OGF ET-CG, e-IRG ETTF and summer schools.

EGEE is supportive and influential because it provides grid infrastructure across disciplines for Europe and beyond. EGEE holds training events in Europe and also hosts a digital library of educational and training materials. The EU FP6 ICEAGE Project focused solely on developing grid and e-Science education. It did this by organising and supporting the International Summer Schools on Grid Computing (ISSGC) series, creating the first online International Winter School in Grid Computing (IWSGC) in 2008 and developing the ICEAGE Digital Library so that students and educators could access (and share) quality educational resources. At the same time, the ICEAGE Project spent considerable effort defining strategies and policies that would progress e-Science education in the EU. This policy work was advanced through forums such as OGF and the e-IRG. Within the OGF, the Education and Training Community Group refined recommendations on policy and practice in areas such as curricula development, t-Infrastructure provision, IPR in the context of digital repositories and professional grid certification. The e-IRG provided

a means to discuss high level strategy and policy suggestions relating to education and training via the Education and Training Task Force. These recommendations have been adopted by the e-IRG and published in the Education and Training Task Force Report. The ICEAGE Project, OGF and e-IRG also collaborated to organise the Curricula Development Workshop in Brussels (February 2008), which resulted in an influential and foundational report that can be used as a reference for further work in this area.

We conclude in this sustainability report that while there may be adequate support for the continuation of JISC services and other services due to long-term funding, there needs to be support in place for the continuation of short-term project-based training, after projects come to an end. For instance, the ICEAGE Project was fundamental in advancing policy recommendations regarding e-Science education and in organising the Curricula Development Workshop, which was meant to be the first in a series of workshops. But since the project ended, this work has not been adequately continued. In the case of academic courses, we can predict that provision may change based on the market, but there should be enough of a range of options for sustainability in this area.

4 Identified Gaps

The Training Requirements Report and Training and Education Sustainability Report revealed what training, education and other related support exists for individuals wishing to apply e-Science methods to their work. In certain areas, provision is more than adequate and both users and educators/trainers voice satisfaction. But, after reviewing all of the data gathered in these reports, we have been able to identify the following gaps in training and education provision:

- 1) **Courses (training)** - Introduction to e-Science, application development, and the new requests: data management, Access Grid; NCeSS and AHeSSC offering formal, accredited training for social scientists and in the arts and humanities respectively
- 2) **Academic courses** - A lack of well-developed undergraduate and postgraduate curricula (and textbooks) across the UK and so a lack of (foundational) courses
- 3) **Support for continuation of training as a project output** – to allow this provision to continue beyond the life of the project
- 4) **Campus grids** - supporting training for widely used components like Condor
- 5) **Web services** - training in these is outside the domain of most Grid training initiatives
- 6) **Targeted advertisement of JISC services** – there seems to be a lack of adequate advertisement in terms of the training offered/available targeting different disciplines, so that researchers across fields know what services and resources are relevant and useful to them (to take the step to get trained).

- 7) **General gaps** - lack of shared t-Infrastructure for running training and educational exercises, etc., and lack of an IPR framework to allow for sharing of educational/training materials

These gaps are significant and need to be addressed if we are to successfully increase uptake of e-Science across disciplines. The lack of appropriate courses and continuation of successful courses or users' lack of knowledge about existing courses will limit the spread of e-Research methods. This along with weaknesses in the provision of infrastructure necessary to support training will inevitably cause problems for widening adoption of e-Infrastructure. In most cases, we see that gaps in the context of training and education can be remedied through the actions of various existing organisations or groups. The next sections will provide further details on each issue and then suggest possible solutions.

4.1 Training courses

In forums such as the All Hands Meetings, EGEE Conferences and Oxford e-Research Conference, a significant number of attendees highlighted the need for the following courses: Introduction to e-Science, application development, data management and Access Grid training. Either these courses were not already available to individuals responding to our surveys, or respondents were unaware of the training opportunities that currently exist.

4.1.1 Introductory Training and Education

In the case of an Introduction to e-Science course, we find that training provision is scant. Few training opportunities exist for individuals who want to gain a broad understanding of basic concepts and applications of e-Science. This kind of course seems best suited to academic realms, but could be delivered as a short course laying the foundation for use of e-Infrastructure services. It would stimulate and develop interest, showing the general relevance of e-Science methods to research in most, if not all, fields by providing an over-arching context. In this way, users can see how technologies fit into a wider picture, so they are not using services piecemeal and have the chance to become more ardent users of a range of e-Infrastructure services relevant to their work.

4.1.2 Application Development

Application developer courses are well covered in many cases by the technology developers, at least with respect to those particular implementations. In general the lack for application developers is in the dissemination of best practice or training and education relating to more abstract design or practice issues (eg. software engineering practice). Other topics such as security best practice or the design of testing frameworks are not well covered. Unfortunately much of this type of training/education falls within the remit of Masters courses in software engineering or similar and would not generally be considered appropriate for funding through projects from the EU or UK research councils. The best outcome is therefore likely to come from encouraging the inclusion of these principles where possible in project

based training and to support the provision of appropriate Masters courses or internal institutional training opportunities.

4.1.3 Data Management

Attendees at events in 2008 registered their need for both data management and Access Grid training. These requests had not been made in previous years and thus reflect new requirements. All academic fields now struggle with managing vast amounts of data. This data must be organised and analysed adequately in order to advance research. Computer-enabled methods provide a means to do this and researchers need appropriate training in these methods to make best use of the sea of data surrounding them. So it is no surprise that respondents asked for data management training considering this context. Training is currently available through data centres such as EDINA, MIMAS and DCC, as detailed in the Training Sustainability Report. The training offered relates to specific existing data management services and does not necessarily provide broad understandings in this area, including how a particular discipline can use computer-enabled methods to manage their data (even outside of existing services). The former could be all that a user might want or require – they may just need to be pointed in the direction of existing data management services. But if researchers require more general purpose courses, then we could look to Research Councils to provide data management training tailored to the disciplines they support.

4.1.4 Access Grid Training

An increase in collaboration, both intra- and internationally, has increased the importance of tools such as video conferencing offered by Access Grid. Survey and interview respondents in 2008 requested the need for training specifically in Access Grid. The Access Grid Support Centre does provide training for their services, so here we do not see a gap in provision but possibly, or probably, a gap in terms of outreach.

4.1.5 NCeSS and AHeSSC

The Sustainability Report pinpointed key organisations promoting e-Research methods in the social sciences and arts and humanities. While physics, biomedicine and engineering have integrated computer-enabled methods into their ways of working, disciplines within the social sciences and arts and humanities have been comparatively slow in such uptake, due to differences in cultures and traditional research methods. These domains are specifically targeted by NCeSS and AHeSSC, but both organisations could focus increased effort on developing accredited, formal training for social scientists and arts and humanities graduates.

We have identified a gap in users' knowledge of the training that already exists in the UK and a lack of certain courses that users consistently request at events, such as Introduction to e-Science. Users of e-Infrastructure services and potential users need to be aware of existing courses that provide them with training opportunities, and this means that course organisers must advertise well and devise successful outreach programmes. At the same time, we must listen to users in the development of new courses that will suit their needs.

4.2 Academic education

The review of academic education carried out for the Training Requirements and Sustainability Reports revealed a lack of well-developed undergraduate and postgraduate curricula in the UK, including lack of textbooks to support curricula. The reports referred to the e-IRG ETTF Report and OGF ET-CG documents, which provided ample and up to date detail on this issue. While there certainly are a number of strong UK MSc programmes in distributed computing and e-Science that can provide examples of best practice (these were listed in the Training Sustainability Report), the offerings at undergraduate level are few and in need of development. The EU FP6 ICEAGE Project began work on this problem and organised an international Curricula Development Workshop in Brussels in February 2008. The workshop brought together experts in the area of e-Science and distributed computing education to begin to develop a framework for undergraduate courses and a Masters in e-Science.

Participants at the Brussels workshop successfully addressed many of the challenges for curricula development described by the e-IRG ETTF while also speaking to important educational goals for e-Science. For instance, at undergraduate level, attendees defined three learning stages:

Stage 1 (e-Working): All disciplines – CORE SKILLS

- Digital systems thinking

Stage 2 (Basic Methods): Disciplines applying e-Science – DOMAIN-ORIENTED COMPUTATIONAL THINKING SKILLS based on:

- Numerical models
- Statistical models
- Social theories, conceptual models and narratives in arts and humanities

Stage 3 (Advanced Methods): Computer Science – SPECIALISED KNOWLEDGE of:

- Distributed systems
- Data systems
- Computational systems
- Software engineering

The content of these stages was designed to address the challenge of diverse student contexts. Stage 1 provides an e-Working foundation for undergraduate students in *all* disciplines, introducing digital systems thinking which imparts core skills that will then underlie the domain-oriented skills and specialised knowledge of Stages 2 and 3. While Stage 1 teaches general foundational skills, Stage 2 on Basic Methods is carefully planned to meet the needs of students in different disciplines. The strands teased out here are based on the predominant research models used in particular disciplines. For instance, in physics, engineering, earth systems science, chemistry and materials science, numerical models predominate. In contrast, biology, medicine, the social sciences and economics often rely on statistical models, while social theories, conceptual models and narratives dominate in the arts, humanities and languages. Advanced Methods, Stage 3, continues in this vein, providing content in

domain-specific strands, while also going into greater technical detail about distributed systems and other relevant computer science methods. In each stage we also see content addressing educational goals such as the teaching of underlying processes, concepts and critical thinking, use of relevant examples for practical experience and the need for collaboration between computer scientists and application scientists.

This workshop was meant to be the start of a series of workshops to develop curricula, thus addressing the lacks identified by the e-IRG, OGF and ICEAGE Project. Another Curricula Development Workshop is being organised by the DCC for 2009, with support from the JISC e-Uptake Project, but a series of workshops may be difficult to sustain due to problems in finding continued funding. The OGF ET-CG group will push forward work in this area by developing the documents on undergraduate and Masters curricula that resulted from discussion at the Brussels workshop.

The e-Uptake Project will begin to address the lack of introductory textbooks by developing an introduction to e-Science brochure (entitled “Research in a Connected World”). The brochure provides researchers with a broad understanding of ways in which e-Science has been applied in different disciplines through reference to detailed examples in practice. It also presents information on distributed systems, research computation problems, resource sharing issues such as trust and security and virtual research environments. This booklet can be used as the starting point for an expanded version that would satisfy the need for a suitable e-Science textbook. It is important to determine who will take on this task once the JISC e-Uptake project comes to an end.

4.3 Project-based training provision

The absence of secure and continued funding for training and educational programmes leads to predictable gaps in provision. This is evident when examining the training outputs from short-term projects, such as those discussed in the previous section (ICEAGE and the current JISC e-Uptake Project). Training in these cases often does not outlive the life of the project for the obvious reason of discontinued funding. If a project has been successful in providing training, outreach or educational materials of value, there need to be mechanisms in place that allow for the ongoing development of these project outputs so that momentum in these areas is not lost and resources discontinued.

There is a clear need to support training in developing technologies both during the lifetime of projects (through coordination, boot-strapping and supporting shared resources) and where successful technologies persist beyond the founding projects. This coordination and support function needs to be independent, non-partisan and sustainably funded. The formation of a UK NGI may provide an obvious home for such an activity.

There is a clear existing trajectory for the support of emerging important technologies, through the connection which exists between research and teaching in academic institutions. In general, this system has proved effective and flexible enough over the centuries to support the adoption of new technologies. However, it is also clear that

the system itself needs support and development, particularly in the case of rapidly emerging technologies developed in international collaborations. In this case the underlying assumption that societies can gain competitive advantages because they have leading research in a small number of institutions is not correct. The transformative nature of e-Science technologies mean that in order to gain advantage there must be support for rapid perfusion of these methods throughout the science base. In this case the quality of the support arrangements and technology transfer within a society may prove decisive. Given this, it is a clear priority for the UK to take advantage of its hard won lead in this field by supporting the rapid diffusion of these technologies as broadly as possible within disciplines and institutions in the UK.

4.4 Campus grids

Review of current e-Infrastructure training and education in the UK uncovered a need for increased collaboration across campus grids. A number of campus grids, but not all, provide training in the use of these grids. We also discovered a gap when it comes to widespread training in the use of Condor and sharing of training material.

NeSC hosts a wiki for the UK Campus Grids Special Interest Group (SIG), so that individuals involved in setting up and maintaining campus grids across the UK have a forum for exchanging ideas and sharing best practice. Previous meetings of the group have dealt with the issue of middleware and institutional connectivity, considering the role of the NGS. This is a first step towards development of coordinated training programmes and sharing of training material.

It is important that the training support offered acknowledges and supports the needs of institutions to adopt their own infrastructures internally to address their own specific needs. However, mechanisms to facilitate shared experience and support boot-strapping are also crucial.

4.5 Web services

Web Services are an important facilitating set of technologies that provide a widely supported standards-based set of methods for offering services. While there is a need for up-skilling practitioners and providing specialised teaching for Web Services as they relate to e-Science, Web Services training is well served by existing sources. Thus, this gap in relation to the providers we have identified does not require our attention.

4.6 Targeted advertising

A problem that has emerged through research carried out for WP2 is a lack of awareness among researchers of existing training opportunities for e-Infrastructure services. This lack of awareness can mean that researchers turn away from using certain services (once they are aware of them), believing they do not have the learning tools at their disposal to take up a new technology. In the case of JISC services, targeted advertisement of training being offered may need more rigorous implementation, along with advertisement of the services themselves and how they can benefit *particular* disciplines. Arts and Humanities and Social Science

researchers should be targeted specifically. Advertising must present the relevance of the service as well as the opportunity to learn how to use the service through training.

4.7 General gaps - t-Infrastructure provision and an IPR framework

t-Infrastructure provision enables training and education, as does the existence of an IPR framework to manage legal issues associated with the sharing of educational materials. t-Infrastructure is e-Infrastructure adapted to the needs of education, trainers and students, providing easy access to educational exercises. Requirements for t-Infrastructure were defined by the OGF ET-CG and include: convenient provision of authentication and authorisation, provision of directly accessible training material, use of virtual machines and use of web portals to ameliorate interface complexity. In order to provide students with practical experience to ground conceptual and theoretical elements of e-Science courses, educators must develop or acquire the relevant t-Infrastructure. In the UK context, the National Grid Service (NGS) can provide UK-wide t-Infrastructure for e-Science related training exercises.

The OGF ET-CG also made progress on explaining IPR issues that trainers and educators must confront, while also presenting recommendations for an IPR framework in the context of shared training materials housed in digital repositories, or libraries. Lack of coordination on IPR has led to confusion concerning user and depositor rights and responsibilities, which means that some trainers and educators may shy away from contributing to or using digital repositories in teaching. This resource is invaluable, however, for both educator and student.

The following recommendations were put forward by the OGF ET-CG:

- Use of the Creative Commons licences as the recommended licence for education and training focused digital repositories
- Allow depositors to upload their own usage licences
- Facilitate the citation of work by users downloading materials
- All metadata should be based on international standards such as the Dublin Core
- Repositories should allow materials to be searched by licence type
- Depositors should be provided with a short explanation of potential issues that might arise
- In the case of disputes, there should be a mechanism in place for removing or blocking derivative, etc., works

As an international body, the OGF group can continue to develop these recommendations, providing the beginnings of a “universal”, but flexible, framework for IPR in the context of e-Infrastructure education and training.

We can see that in many cases identified above, we can fill gaps by referring to existing programmes or organisations. It should be emphasised that these programmes and organisations can fill gaps but need further resources and know-how in order to do so. The key is to highlight these gaps and then present them to the relevant bodies, suggesting the means by which they could “plug the holes”. The next

section, then, offers conclusions and final recommendations that will lead to enhanced training provision in the UK.

5 Conclusion and Recommendations

It is clear from the preceding sections that there are a number of gaps in the current provision of training and education in the field of e-Science in the UK. Many of these arise due to the rapidly developing and transformational nature of the technologies grouped under the e-Science banner, but also due to the manner in which they change the set of skills that are required for effective researchers in the coming decades.

The resulting recommendations are:

1. Solutions need substantial and sustained funding in order to effect changes of the profundity and on the national scale required. This may mean that support and coordination services will best be hosted under a national independent organisation such as a NGI in order to make their role neutral and credible.
2. To take advantage of the existing knowledge transfer mechanisms, there should be strong support for institutions in making this set of technologies available.
3. Provision is required of specific courses that include teaching on sets of individual technologies which need to be choreographed in order to feed into the activities of researchers.
4. Provision of teaching support beyond that of individual projects to meet 3 (above) and to provide sustainability beyond the end of projects is required.
5. Provision of courses which provide researchers, institutional support services and institutional decision makers with high level (and conceptual) understandings of emerging national and international provision and developments is crucial.

These recommendations present solutions to the problems of provision identified in the Training Requirements Report and the Training and Education Sustainability Report. They provide means by which education and training in e-Infrastructure can develop successfully and become sustainable, so that e-Research methods enhance just about every researchers work experience, no matter what discipline they inhabit.