Global Access to Research Software: The Forgotten Pillar of Open Science Implementation

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Executive Summary

Research software is central to modern science. Virtually all researchers today use a variety of software for many purposes including steering complex apparatuses, modelling hypotheses, collecting data and analysing findings. Therefore, access to appropriate research software is crucial for researchers to be able to produce, disseminate and re-use outputs, and it is equally key to participating in the global trend towards Open Science.

There are often good reasons for using proprietary software and open source software, respectively, but in all cases a first important requirement is that the *software is widely accessible and compatible with other software, so that data and results can easily be retrieved*. A second important requirement is the *adaptability of the software to fulfil specific and sometimes idiosyncratic needs*. Additionally, *scientific research needs to be reproducible*, which means that not only the data but also the methodology and the processes of analysis are to be shared, and this works most effectively with open source software. Finally, *science needs to be scrutinised by peers and there is an increasing demand for science to become more transparent*, which makes the use of open source software particularly appealing. The existence of a dynamic open source community in general software (cf. Linux, Mozilla, Wikimedia) should not blind researchers to the limited uptake of open software in the sciences. The reasons for this, as well as the specific problems and needs of the sciences with regard to open software, need to be identified and empirically explored. The authors believe that software is the new frontier in the successful implementation of Open Science. Open Research Software is crucial to the uptake and analysis of Open Data and the accomplishment of transparent and reproducible research.

The Global Young Academy (GYA), in collaboration with the Oxford-based organisation INASP, carried out a pilot survey to assess the quantity and quality of access to proprietary and open source software among researchers from all disciplines. Survey data were collected between July and December 2015, and data analysis took place from January to December 2016. Emphasis was placed on gathering data from researchers based in Bangladesh, Ghana and Nigeria, whose access to and use of research software had not yet been extensively documented. These results provide the foundation for more detailed research in different countries and can serve as a preliminary guide for new private initiatives and policy decisions with regard to improving access to software for scientists all over the world.

Preliminary findings from this research include the following:

- Researchers in low-income countries overwhelmingly rely on proprietary software.
- The desired research software is highly field-specific and diverse.
- Lack of access to software significantly affects research content and networks.
- There is a significant gap in the uptake and even awareness of Free and Open Source Software (FOSS) alternatives between low-income and high-income countries[1].
- There is an interest in adopting and developing FOSS, but for this interest to bear fruit, there is a strong need for increased FOSS awareness, knowledge, training and support.

In Open Science debates and policy-making in high-income countries, it may sometimes be assumed that researchers in low-income countries, in the absence of funds to purchase or access proprietary software, would naturally lean towards open software. In fact, the collected data clearly shows that researchers in Bangladesh, Ghana and Nigeria have only limited knowledge about and experience with FOSS. There also seems to be little interaction between the Open Research Software communities in high-income and low-income countries. Even if FOSS is free to use for everyone, the lack of active promotion and training specifically targeted to FOSS means that it remains inaccessible to most researchers.

[1] Free and Open Source Software (FOSS) or Free/Libre and Open Source Software (FLOSS) are overarching terms making a compromise between Free/Libre Software and Open Source Software, two movements that stand for different values and political goals. In short, FOSS is software that is free to use, copy and change, and of which the programming source code is openly shared.

Based on the results of the survey as well as contextual information and discussions among GYA members, the report issues the following recommendations:

1. All stakeholders should widely encourage the use of FOSS globally, in high-, middle- and low-income countries, for instance by promoting local champions and role models.

For the research community, including research-performing organisations and learned societies:

2. There is a need for field-specific discussion and information events around software access and use by scientists (either at a national or regional level), particularly FOSS.

3. There is a need for empirical research on which proprietary software is needed in different research areas, and why many researchers prefer proprietary software over FOSS alternatives.

4. Research institutions need to enhance researchers' access to software and related training opportunities.

5. FOSS developers should aim for easy interface and access to their tools, and major packages or operating systems should be available in offline versions for use in the absence of reliable broadband internet access.

For for-profit stakeholders such as computer manufacturers and software producers:

6. Researchers' access to proprietary software of relevance to academic work needs to be improved.

7. Software producers should consider sponsoring discounted licenses to individual researchers/groups, particularly those working in low-resourced environments, and these discounts should be clearly advertised.

8. Computer dealers should offer a choice of software options to potential buyers, specifying related costs over time (including subscription costs, helpdesk, etc.). There is a need for cross-national collaboration around software acquisition and training.

For stakeholders from science governance:

9. Funders and charities that support instrument acquisition in low-resource environments should also provide related software and training.

10. National governments should support institutions, infrastructures and tax regimes appropriate to the acquisition and effective use of research software.

11. Academies of Science should work closely with national governments and funding agencies to organise IT support for individual researchers at the national or regional level.

12. There is a need for dedicated international programmes to look at access to software, to work towards discounted licensing of proprietary software as well as greater promotion of FOSS alternatives in low-income countries. Existing international programmes for access to e-journals and e-books (e. g. INASP, EIFL, TEEAL, Research4Life) can be used as a model and a foundation for setting up a similar programme in relation to access to software. However, the demand for research software is found to be much more diverse and dispersed compared to the more homogeneous demand for research literature, and this calls for ingenious adaptations of the licensing models.

Global Young Academy Report: Global Access to Research Software

Introduction

The promotion of Open Science is widely viewed as a priority for funding agencies, businesses and governments globally. However, big differences remain in how Open Science is fostered across countries depending on disciplinary and regional research norms and practices, institutional set-ups and diverse degrees of access to relevant infrastructures, resources and funding in different locations.

The variability in conditions under which Open Science can flourish is particularly relevant in the case of research software. Access to software and related computing facilities is crucial to conducting research, collecting and disseminating data, analysing those data and producing knowledge. However, very little is known about the levels of access to and usage of software by researchers working in different disciplines and locations around the world. Moreover, few studies so far have documented conditions for uptake (or lack thereof) of Open Software by research communities across the world, and particularly in the Global South. This report aims to start filling this gap, through analysis of survey results that document conditions under which researchers access and use both proprietary software and FOSS, with a particular emphasis on Bangladesh, Ghana and Nigeria.

This report focuses on Open Software because of its crucial role in, and alignment with, the aims, values and methods of Open Science. Recent attention to Open Data and Open Access initiatives has taken attention away from the fact that data are often analysed via proprietary software, which is only available through often expensive licensing agreements. Various alternatives to this model are being developed, which go under the general heading of Open Software. Open Software is a broad category encompassing a variety of types of software and licensing agreements. This report is particularly interested in the use of Free and Open Source Software [FOSS], defined by the Open Source Initiative criteria as free, shareable and open source (https://opensource.org/osd-annotated).[2] At the same time, the hybridisation of proprietary and Open Source software is steadily increasing, and software producers often offer a diverse range of functionalities matched with a variety of pricing plans, making it hard to distinguish software that is freely available from that which is in some ways proprietary (Androutsellis-Theotokis 2010, Shemtov and Walden 2014).

The standards, accessibility and use of research software varies depending on institutional, geographical and disciplinary contexts, creating confusion among researchers needing to negotiate proliferating software options and models of access. This report investigates this variability and its impact on the flourishing of Open Science initiatives by documenting researchers' perceptions of their own software needs, their existing levels of access and their future priorities, as well as their understanding of existing FOSS models and their usefulness. This study thus has four goals:

- Identify patterns and characteristics of software access and usage among researchers, particularly within three countries about which little is known in that respect (Nigeria, Ghana and Bangladesh).

- Assess to what extent FOSS represents a useful alternative to expensive proprietary software, and to what extent and by which mechanisms uptake can be fostered.

[2] See the websites of Electronic Information for Libraries (http://www.eifl.net/resources) and the Software Sustainability Institute (https://www.software.ac.uk/) for a list of resources and references on the use of FOSS for libraries and scholarly use.

- Provide suggestions on how to overcome gaps in access to and expertise about research software by building evidence-based recommendations.

- Provide a preliminary set of findings to provoke more extensive and better-resourced empirical studies of access to research software and its implications for science across different countries.

Method

This study took the form of a survey targeted to researchers in the natural, life, health, and social sciences, as well as in business schools and in the humanities, between July and December 2015. The survey consisted of 23 questions formulated in 2015 by members of the working groups Global Access to Open Software and Open Science of the Global Young Academy. Respondents were also given the option to provide personal information relating to gender, discipline, occupation, location, age and publication history, so as to enrich understanding of their background and motivations. Answers to the questions were provided in a variety of formats, including multiple-choice answers, free-text answers and ranking exercises (see Appendix for the full questionnaire and answer formats).

The survey was made accessible through the internet via SurveyMonkey, and was widely publicised by members of the Global Young Academy and related networks. Reported connectivity issues in Bangladesh, Ghana and Nigeria also led to an amended dissemination methodology in which data collectors were employed to distribute paper copies of the questionnaire and to enter the results manually into SurveyMonkey. This procedure facilitated participation by researchers who would not have been reached otherwise, and whose voices are more rarely heard in global discussions about Open Science and software access.

Data collection

A total of 748 responses were received, including 217 responses from Bangladesh, 229 responses from Ghana, 201 from Nigeria and 101 from other countries (a total of 34 countries, including Australia, Belgium, Benin, Brazil, Canada, Chile, China, Congo, Cuba, Ethiopia, Germany, Guatemala, India, Indonesia, Iran, Israel, Italy, The Netherlands, Japan, Jordan, Malaysia, Russia, Senegal, South Africa, Sweden, Taiwan, Tanzania, Thailand, Turkey, UK and USA). For the purposes of this report, the analysis will focus on the three countries from which substantial responses were gathered. While aware that findings from other countries are too limited for any generalised analysis or comparison, the authors are keeping this information in the report as a baseline for responses obtained in countries other than the subjects of the study.

The data in Bangladesh were collected by five graduate students of the University of Rajshahi under the supervision of Md. Ashraful Islam Khan and Abdullah Shams Bin Tariq. To have a representation from all sectors, the two largest public universities (University of Dhaka and University of Rajshahi), the largest engineering university in Bangladesh (University of Engineering and Technology), the leading medical research institute ICDDR, B (International Centre for Diarrhoeal Disease Research, Bangladesh), one major private university (BRAC University) and another research institute, Atomic Energy Centre (AEC), were chosen. A few more neighbouring institutes were also explored in the process, such as Rajshahi University of Engineering and Technology (RUET) and East West University, another private university in Bangladesh. The data collectors collected the data over a few days extensively in Dhaka and a little more time in Rajshahi in November and December 2015. A small number of respondents entered their responses directly through web tools.

The data in Ghana were collected with the help of research assistants by administering questionnaires to academic staff in five public universities (University of Ghana, Legon, University of Professional Studies, Accra, University of Cape Coast, University of Education, Winneba and Kwame Nkrumah University of Science and Technology, Kumasi) and two private universities (Wisconsin University College, Accra and Valley View University College, Accra). In all, a total of 350 questionnaires were distributed and 200 were retrieved. In addition, email notifications were sent to the university internal email in the University of Ghana and also to the members of the Ghana Young Academy asking colleagues to visit the data collection website and enter their responses. Out of all 229 respondents from Ghana, 190 responded to the questionnaires and 39 responded to the email notification.

In Nigeria, the sample space included four Federal Universities: University of Ibadan (the country's premier University), University of Lagos, University of Ilorin, Federal University of Agriculture, Abeokuta and a private University; Covenant University (one of the pioneer private universities in the country). A total of 200 paper-based questionnaires were administered in these selected universities with an average of 50 respondents recorded per institution. Respondents included senior and junior academics, technologists, and doctoral students. Aside from these universities, few other respondents from other institutions across the country filled in the online survey.

Quantitative Analysis

Most of the questions were closed-ended and respondents were able to answer by putting tick mark(s). These responses were collated and analysed by dividing responses into country, discipline and gender categories and the data is displayed accordingly. The authors also observed significant differences among participants coming from different countries, though these differences may need to be taken with caution, as there were differences in the distribution of career stage or age among the data from the three countries. The authors constructed univariate and multivariate frequency and percentage distributions with graphical presentations in bar and pie diagrams.[3]

Qualitative Analysis

A number of questions provided respondents with the option to answer in their own words by filling in a free-text box. These responses were collated and analysed thematically. The grouped responses were divided into country categories and the data displayed accordingly. As the responses tended to be very short, no additional analysis was performed.

Limitations of the study

This report provides a preliminary study, executed by a global network of excellent scientists, and it is entirely based on volunteer work. Its core aim is to draw attention to important issues with regards to global access to research software. The authors want to stress the importance of executing detailed follow-up studies, ideally as a fully funded research project that could set up more surveys, expand the study to other countries and take into account more refined methodology and data analysis. This preliminary study was subject to technical limitations. On the one hand, the surveys needed to be short, in order to attract a sizeable amount of responses from volunteer participants. This resulted in some conceptual ambiguities. What is understood as "research software", for instance, is field specific, but at this stage of the research, the authors could not tailor the surveys to different disciplines because they needed to ensure internal comparability between responses from different disciplines. On the other hand, the amount of data garnered through volunteer work is, although significant, still limited, especially given the diversity of information obtained and the differentiations needed for the quantitative and qualitative analysis. For instance, the survey data creates some groups of significantly different sizes (e.g. 251 respondents for engineering and only 31 for business), which increases the danger that some of the statistical comparisons between such groups become less robust. To remedy this, stratification is needed, which would involve more comparisons with more countries. There are similar issues related to sample representativeness, sampling distribution and the simultaneous analysis of multiple demographic variables. Solving these technical constraints would require the infrastructure and human resources of a fully financed research project, as well as complementing quantitative with qualitative methods such as in-depth interviews with researchers. This however goes beyond the scope of the work of the GYA and its members. Such an undertaking would also go beyond the purposes of this report, which specifically aims at presenting preliminary findings based on sampling from three selected countries. It should be noted that, so far, there has been no data related to access to software by scientists in these and many other low-income countries. In this respect, the report shows significant findings that should be refined in future follow-up studies. Furthermore, despite the technical limitations, these findings should also already be taken into account in prospective debates that address the issues and problems highlighted in this report.

[3] The authors examined the statistical association between the variables of interest by using the Pearson's Chi-squared test. If the cross tables contained cell count(s) of less than 5, the statistical association was tested by using Fisher's exact test.

Background on Regions of Interest

Bangladesh is the eighth most populous country in the world, following Nigeria, with a population exceeding 160 million. Excluding small city-like states (area less than 500 sq miles, or around 1300 km^2), Bangladesh has the highest density of population in the world with nearly 3000 people per square mile (or 1115 per km^2). Over the last decades the population growth rate has slowed down. However, the population is still relatively young, with 34% aged 15 or younger and 5% aged 65 or older. Despite rapid economic growth, 43% of the country still lives below the international poverty line on less than US$1.25 per day. Bangladesh has 34 public (government owned and subsidised), 64 private (private sector owned) and two international universities. The education system has roots in a British colonial system, but has generally tried to move, often with mixed and confused effects, towards a North American system. The universities are overseen by the University Grants Commission (UGC), which also controls funds and their allocation to public universities. There has been a recent UGC initiative with funds from the World Bank titled Higher Education Quality Enhancement Project (HEQEP) to augment the tertiary education sector. Despite many challenges including natural disasters, insurgency of militants, as well as inherent issues such as corruption, political instability, etc., Bangladesh has made significant macroeconomic progress maintaining a reasonably steady annual GDP growth rate of 5–7%. It has also made significant progress in mobile phone and internet coverage and has become recognised as the 26th best destination in IT outsourcing. In research output, Bangladesh has made some progress and has a 2016 rank of 59th in the world in the Scimago country ranking.

Ghana is one of the five English-speaking West African countries. It has an estimated population of approximately 27 million. Demographically, Ghana is fairly young and growing, with 56% of the population under the age of 24 and an annual growth rate of 2.18%. Currently, there are about 85 degree-awarding institutions in Ghana, which include 10 public universities and 6 public technical universities and 4 polytechnics. Although Ghana is currently a lower middle-income country, between 2012–2017 there have been drastic cuts in public spending. Coupled with a freeze on employment, this has adversely affected many public institutions including the public tertiary education institutions. Research activities in Ghana are hampered by lack of research facilities, poor infrastructure and lack of research grants. They are largely funded by external donor support with very little internal funding. Academics are largely driven by career incentives instead of clear research goals or societal challenges. The country has a dedicated fund called Ghana Education Trust Fund (GETFUND), which provides support for infrastructural development of the tertiary institutions, for training academic/non-academic staff, and for travel grants to attend conferences and workshops.

Nigeria is the most populous country in Africa with an estimated population of approximately 200 million. Demographically, Nigeria is young and growing quickly, with 63% of the population under the age of 24, and a high average relative annual growth rate of 3.24%, half a percentage point higher than the African average. For the Nigerian education system, this means incredible new challenges. Since 2005, the number of universities alone has grown from 51 to 153 (see http://nuc.edu.ng/) comprising 40 Federal Universities, 44 state-owned universities, 69 private universities and a number of other degree-awarding institutions. With an estimated 40% of university positions and 60% of polytechnic positions currently unstaffed, STEM education in the country suffers a serious setback. A sharp decline in crude oil prices from 2014 to early 2016 dragged Nigeria into a recession that added to the country's already long list of challenges: the violent Boko Haram insurgency, endemic corruption, and challenges common to many Sub-Saharan countries: low life expectancy, inadequacies in public health systems, income inequalities, and high illiteracy rates. Between 2015–2017, there have been drastic cuts in public spending following the recession, which have affected government services nationwide. In a recent study on African universities, a number of challenges to collaborative research were highlighted, including lack of access to research articles, lack of functional internet, absence of relevant skills, lack of sincerity and integrity, unfriendly institutional policy on research (Sawyerr 2004). Nigeria's university system has its origins in the British colonial system, following the recommendation of the Ashby Commission, but it now more resembles that of the United States. It includes an undergraduate bachelor's degree followed

by a master's degree, and a doctoral degree. The system includes postgraduate diplomas, as well as a non-university National Diploma, and Higher National Diploma programmes. Research activities in Nigeria are bedevilled by lack of research facilities, poor infrastructures and lack of research grants. The bulk of research undertaken by academics is prompted in most cases by the need to generate research articles towards fulfilling promotion requirements and not driven towards solving societal challenges. The latter research is often self-funded. A number of high-level research projects being undertaken are done in collaboration with colleagues outside the country. The country has a dedicated fund called Tertiary Education Trust Fund (TETFUND), which should fund the infrastructural needs of the tertiary institutions, train academic/non-academic staff, provide travel grants to attend conferences and workshops.

Main Findings

- Researchers overwhelmingly rely on proprietary software.

Microsoft Office remains overwhelmingly the most used software, which is probably linked to the provision of the Windows operating system when purchasing computers, with no alternative options specified or provided. Besides Microsoft Office, the most desired and used software includes paid, proprietary software of three main types:

[1] Statistical data analysis software such as Matlab, SPSS, Genstat, C, Endnote, Mathematica, STATA (notably, R is the only FOSS that has really made it into the league of seriously and widely used research software, apart from some that are very discipline-specific such as Quantum Espresso. R could be used as a role model for FOSS and promoted in countries where users still prefer pirated versions of competitors such as STATA.)

[2] graphics/design programmes (e. g. AutoCAD, ChemDraw)

[3] text analysis (Endnote, NVIVO)

Also, particularly in Nigeria there were requests for instrument-related software, which signals the presence of tools to produce data (such as donated machines from higher-income countries, or machines acquired by institutions) in the absence of computing facilities that help store and analyse those data.

- The desired research software is highly field-specific and diverse.

There is a very wide diversity in the software being used, much of which is specific to researchers' particular areas and methods of research.

- Lack of access to software significantly affects research content and networks.

Lack of access has a significant effect on research design, as well as on collaborations and research networks both nationally and internationally. It is also notable that the time needed to install and learn software and get support is significant, particularly for those with unreliable access to bandwidth. Ways to work around lack of access are time-consuming and may result in subpar solutions.

- There is a significant gap in the uptake and even awareness of FOSS alternatives in low-income countries.

Over 65 % of respondents had either never heard of FOSS or never used it. 42 % had never heard of it (but may of course use it unwittingly), and around 23 % knew about it but had never used it. Furthermore, 6.2 % do not need it, 21.9 % sometimes use it, 10.3 % use it regularly, 4.6 % promote it. In parallel, there is widespread confusion in responses around what software is proprietary, what is free, what is open source and what is a hybrid model, with many respondents listing freely available software (or software available on special licenses to their own country) as software to which they have no access.

- There is interest in adopting and developing FOSS.

On the one hand, an overwhelming majority of respondents indicate that they wish to learn more about FOSS. On the other hand, since many do not have a clear idea about FOSS, and their level of commitment to learning more is not known, this interest cannot be taken for granted and should be developed and nurtured. A better understanding of the obstacles to getting to know and to using FOSS is also required.

- There is a dire need for training and support in software usage, and especially regarding FOSS.

Responses strongly evidence the need for training in software usage, and funding to implement, develop and support software usage. There was also a strong view that additional software licenses should be waived for low-income countries, and if discounted licenses exist, this should be clearly listed on the homepage and in promotional materials. At the same time, the confusion around which software is actually available, and how (see above), calls for better information and support around software identification, access and use.

- Expectations from and responsibilities of individual researchers and institutions with regard to providing and utilising research software are unclear.

Most researchers have access to a personal computer, while only half the respondents declare to have access to a work computer and related licensed software. This finding can be interpreted in various ways, depending on what respondents understood 'work computer' to mean, but the authors take it to signal a stronger confidence in the access procured through personal means than in the resources provided by the work place and research institutions. This interpretation fits the widespread concerns detailed in free-text comments by respondents about perceived corruption and institutional mismanagement of funds, and lower confidence in institutions than in personal resources and networks.

Follow-up Questions

There are several areas where a better understanding of attitudes towards and uses of FOSS in low-income countries is needed. The data which was collected is very useful for questioning expectations, for raising new questions, and for identifying some tendencies. Partisans of open software and policy makers often assume that researchers in low-income countries should be keen on adopting FOSS because it is so cost efficient in areas with few financial resources for research. Nevertheless, the current analysis shows that proprietary software continues to be strongly preferred and desired by these researchers in their everyday practice, and it needs to be understood exactly why this is the case. Several possibilities come to mind. There may be concerns about the cost of switching to other software, specifically FOSS, from what researchers are using now. This cost can take several forms, such as time, training cost, intellectual energy, compatibility with previous data and results, problems of compatibility with other researchers, financial costs of switching software, but also fears of underperformance as compared to their peers. It is also known that researchers in some low-income countries struggle to get published and get on with their work because the use of certain kinds of software (e.g. Matlab) acts as a seal of quality for the data/methods used, thus increasing researchers' credibility to international journals (Bezuidenhout et al 2017, Leonelli 2017). Future studies should research such issues in depth.

Furthermore, there may be a need to change attitudes in high-income countries. First, new data may force scholars and policy makers in high-income countries to revise their convictions about the use of FOSS in low-income countries. Second, if researchers in high-income countries use proprietary software, there is no reason to believe that researchers in low-income countries would not want to do the same. This means that if policy makers want to change attitudes in low-income countries, in particular with regard to adopting FOSS, they will also need to work on changing attitudes in high-income countries. Open Research Software is a global concern that demands global solutions.

The detailed data analysis in the Appendix raises more specific questions that need to be explored in follow-up studies. "What does a "work computer" mean in Nigeria, and why is access to what they call a work computer so different than in other countries?" is one of the questions raised. "What do people understand by open software in different contexts, and why are there variations in understanding and knowledge?" is another issue that should have researchers' attention.

The general tendency that comes to the fore after analysing the data is that there seems to be a lot of confusion about FOSS. It seems self-evident that FOSS is a good solution for researchers in low-income countries, but the data also shows that the subjects are not (yet) convinced of this. This indicates that there is a need for more awareness so that researchers can make informed decisions, while at the same time their objections against FOSS if there are any need to be taken into account more clearly.

Discussion and Emerging Issues

The success of FOSS over the last three decades is due to the high levels of engagement in software development, which in turn generated an active community of users and a wealth of widely available tools (Kelty 2008). However, not all scientists who use software have the interest, time capacity and/or expertise to engage actively in FOSS development, and this may deprive them of the opportunity to make use of FOSS for their own research purposes. This report documents situations where the software users do *not* see themselves as a collective, have no high-level skills in information technology and do not feel capable of providing alternatives to solutions they already know. These users have different priorities in mind: they need software that can fit their research practice and available infrastructures and institutions, and enhance the reputation and credibility of their methods, so that they can collaborate with colleagues at home or abroad, produce the best scientific results that they can, and publish them in international journals. Researchers face numerous challenges in their work, and responses indicate that those whose research is not directly on computer science or information systems are in need of additional IT support.

Given this, it is striking that the overwhelming majority of respondents express a strong interest in using FOSS and even in becoming active in FOSS development. This interest provides a promising platform for extensive discussions around what types of FOSS would fit the local research environments, and what kinds of skills, training, support and communication avenues need to be developed in order to encourage a fruitful and constructive use of FOSS to expand the capabilities of researchers in different regions of the world. In the absence of relevant training and support, and of institutional networks favouring the development of homegrown solutions, researchers take less responsibility for the software they use and the role that they can play in developing it; and proprietary software continues to be strongly preferred and desired by these researchers in their everyday practice. These findings should inform broader discussion and research about the usage of Open Research Software.

It is highly desirable to increase FOSS usage in low-income countries, and there is clearly a lot that should be done, given the gaps in awareness of FOSS and in the provision of relevant training and tools. Nonetheless, within the academic communities of high-income countries the use of proprietary software often significantly outweighs the use of FOSS. Thus effort must also be put into improving access to proprietary software in these regions. Access to proprietary software remains a priority for many researchers wishing to collaborate and publish internationally. Respondents felt that they did not have the ability to purchase the software that they wanted to conduct their research. This preference for proprietary software (and the corresponding ignorance of FOSS) present clear avenues for immediate action.

First of all, researchers and organisations in high-income countries can show that FOSS is adequate and welcome to be used in a research context.

Researchers in low-income countries also require improved access to proprietary software: they also need discounted licenses, institutional licenses and funds for software acquisition; and they need to be given a choice when they (or their institutions on their behalf) purchase a computer, concerning which operating systems and software they may wish to use. More research is urgently needed on how such needs and preferences should be ranked and assimilated into governmental policies and offerings of software providers. Debates around research assessment worldwide, and particularly in high-income countries driving research policies such as the United States and nations within Northern Europe, need to take account of the inequalities created by differential access to proprietary software, and ensure that standards for research evaluation are not unnecessarily predicated on the availability of specific kinds of equipment and software.

Moreover, researchers need clearer information about which software companies currently offer free versions of their software, or discounts for academics from low-income countries. In the course of writing this report, many software companies that were contacted for their comments expressed an interest in offering reduced fees for researchers from low-income countries. Yet such policies, when they exist, are not well publicised. It is often up to individual researchers to contact (and negotiate) with software providers – something that is not only laborious, but may also not be part of the academic (and

national) culture of many of these researchers. There is thus a clear lack of mediation and communication, which cross-national consortia, international agencies and funding bodies could address very effectively.

It should be noted that a couple of decades ago, there was a similar gulf in access to journals, databases and books. Today international programmes such as INASP (PERI, PERii and SRKS), EIFL, TEEAL, Research4Life (AGORA, HINARI, OARE and ARDI) etc., have gone a long way in addressing these issues. In a few countries, some of these initiatives are in a wind-up mode, having already successfully set up consortia and trained human resources to look after future negotiations. This kind of success can only be achieved through such coordinating and training initiatives, and in many cases there is need for further prolonged support. **This is why the authors recommend the set-up of a similar programme in relation to access to software, which development funding agencies would be well positioned to fund and manage.** This calls for the set-up of an international programme to facilitate such action. The newly formed African Open Data Platform and the Open Knowledge Foundation, for instance, could be ideally placed to facilitate the creation of such an international programme.

Detailed Recommendations

In view of these observations, based on the data analysis, interpretation and contextual information, below is a set of recommendations for improving research conditions around the world, and particularly for improving the uptake and development of research software that is not proprietary and can be usefully employed to support the Open Science agenda.

1. **Researchers' access to proprietary software of relevance to academic work needs to be improved.** The software listed by respondents as most desirable and used is very expensive, institution-wide licensed software with a high access bar. Access to these tools is in urgent need of scrutiny and institutions may need external support in order to provide this access if these tools are indeed crucial for researchers. This is particularly relevant in situations where access to specific software is viewed as a necessary condition to publish in leading journals and participate in international collaborations. It is hoped that increased acceptance of FOSS worldwide, as encouraged below, will change such situations in the longer term.

2. **Software producers should consider sponsoring discounted licenses to individual researchers/groups, particularly those working in low-resourced environments.** Proprietary software providers should be encouraged to develop cheaper licenses for individual researchers based in low-income countries, at least as a temporary measure. It is important to focus on individuals (certified researchers) rather than institutions where possible, as institutions are often perceived as unreliable (in terms of allocating budgets and sometimes misappropriating funds) and half the respondents work on personal rather than work computers. This would also help to crack down on extensive piracy, as well as on reliance on Freemium or older versions of software which puts computers at risk of security breaches, but which also compromises the quality and international standard of research.

3. **There is a need for empirical research on which proprietary software is needed in different research areas, and why many researchers prefer proprietary software to FOSS alternatives.** The data shows that there is a lot of confusion around the notion of FOSS also need to be understood, and awareness of FOSS should be increased. The perceived obstacles to the use of FOSS also need to be understood, so that these can be taken into account in policy actions.

4. **There is a need for field-specific discussion and informative events around software access and use (either at a national or regional level), particularly FOSS.** It is essential to encourage field/research area-related discussions and informative events around software access and use, including how to find and use FOSS. This could help researchers to discuss discipline-specific software, existing FOSS alternatives to proprietary software and the advantages and disadvantages of using those alternatives.

5. **The use of Free and Open Source Software should be widely encouraged, for instance by promoting local champions and role models.** There is a unique opportunity, particularly in countries within which access to research software remains problematic, to change existing scientific cultures by encouraging widespread adoptions of FOSS. Relevant training and access should be supported, while taking account of existing disparities between low-resourced and high-resourced research environments. Researchers who are discriminated against by virtue of their location, and/or who are struggling to retain confidence and work ethos in the face of severe constraints in resources and infrastructure, should be supported. There is a real risk that using FOSS alternatives to existing proprietary software will exasperate existing divides. To mitigate this risk, programmes to promote FOSS in high-income countries should also be strongly supported. An international approach to managing the identification of alternative software (FOSS) appropriately is sorely needed. Such an approach needs to build strong local support, and it is therefore suggested to promote local champions / role models / success stories for FOSS use, which could visibly demonstrate the advantages of open software and encourage discussion among researchers on the ground. Generally, there are serious difficulties in introducing people who would like to use FOSS to the right people who could support them and provide them with the information that they need to get started. Finding ways to address this gap should be a top priority for science policy and all groups concerned with improving research conditions around the globe, particularly in places where the enthusiasm for learning new tools and adopting alternative frameworks is high.

6. **There is a need for cross-national collaboration around software acquisition and training.** The regional level could be particularly effective (e.g. Data Science schools for East Asia and West Africa, the African Open Data Platform).

7. **Research institutions need to enhance researchers' access to software and related training opportunities.** Institutions have a responsibility to provide effective tools for researchers to the best of their capacity. This report shows that the current lack of IT support is detrimental for research productivity, and stakeholders should strongly consider organising IT support for individual researchers at an institutional, national, and/or regional level. In particular, the adoption of FOSS tools would constitute a long-term, cost-cutting measure that may pay back the resources placed into training staff.

8. **Computer dealers should offer a choice of software options to potential buyers, specifying related costs**. In particular, the pricing and assistance available to researchers based in low-income countries should be prominently and clearly displayed in the dealers' websites and advertisements, making it easier for users to assess and select services and tools.

9. **FOSS developers should aim for easy interface and access to their tools, and major packages of operating systems such as Linux should be available in offline versions (CD or USB disk) for use in the absence of reliable broadband**. This would facilitate the adoption of FOSS in the absence of IT support and relevant in-depth training, as well as the use of FOSS operating systems in situations of unreliable infrastructure.

10. **Funders and charities that support instrument acquisition in low-resource environments should also provide related software and training.** Unless researchers have access to relevant software for data storage and analysis, the acquisition or donation of research instruments to research projects or groups risks being fruitless. Thus, it is essential that research funders allocating funds to purchase equipment should also consider funding software acquisition and training. Also, it is very important for software and related training materials to accompany hardware and tools donations (in the same way as meta-data should always accompany data when they are disseminated, so as to facilitate their re-use).

11. **National governments should support institutions, infrastructures and tax regimes appropriate to the acquisition and effective use of research software**. Particularly significant are high-speed internet access and IT facilities, and tax regimes that enable the purchase of software from abroad without serious financial burden for universities (e.g. Bangladesh). Again, cross-national lobbying at a regional level can be very effective.

12. **Academies of Science should work closely with national governments and funding agencies to organise IT support for individual researchers at the national or regional level.** IT support is urgently needed to make researchers aware of possible FOSS alternatives, existing opportunities and expertise, and ways to access them. If this is not possible locally, it could happen in the form of national research support offices run and sponsored by central government and/or science academies, which researchers across the country can call for advice on software issues. Note that central help for IT already exists, and online webinars or other online resources do not always help researchers with low bandwidth access. National or regional training programmes and summer schools would be useful.

13. **There is a need for dedicated international programmes to look at the issue of access to software, working towards discounted licensing of proprietary software as well as greater promotion of FOSS alternatives in low-income and high-income countries.** The success of similar initiatives in providing access to research literature makes it imperative to adopt a similar approach. Given the diversity of software needs, the approach for licensing will have to be thought over and a direct replication of consortia-based subscriptions as common for journals, databases and books may not be successful. Innovative ideas will need to be explored for access to proprietary software. However, for FOSS, it is obvious that there is a lot to do immediately, in terms of training and raising awareness. At the same time, there is less than the critical amount of funding and momentum within low-income countries to achieve this. An international programme supported by international development agencies is needed to start addressing this issue. International programmes such as INASP, EIFL, TEEAL, Research4Life can be seen as a model, and the authors recommend setting up a similar programme in relation to access to software, which development funding agencies would be well positioned to fund and manage.

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Project set-up

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Data collection

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Data analysis

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Appendix 1: Data Analysis

Demographic Data

A total of 748 respondents completed the questionnaire. The authors recognise that the sample may have had biases in discipline spread, locations and institutions, which was due to issues of access and networks of surveyors at the time of the data collection. As far as possible, this is taken into account in the data analysis, where specific cases are flagged as outliers or as case studies for particular situations. Nonetheless, the study sample contains a reasonable spread of respondents across discipline, age and career stage. While there was a greater representation of the natural sciences than social sciences and humanities, this is not unexpected and indeed follows academic trends in most countries. Moreover, the sampling did focus on disciplines that are likely to need specialised software for research, which again biases towards the natural sciences and engineering disciplines. Around 30 % of the respondents were female, which reflects current gender distribution, particularly in low-income countries. Responses were provided by researchers from all career stages, ranging

Countries	Gender	Discipline							Total
		Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities	
Bangladesh	Female	29 15.5 %	4 2.1 %	2 1.1 %	1 0.5 %	3 1.6 %		1 0.5 %	40 21.4 %
	Male	99 52.9 %	18 9.6 %	10 5.3 %	8 4.3 %	8 4.3 %	1 0.5 %	2 1.1 %	146 78.1 %
	Prefer not to say	1 0.5 %							1 0.5 %
	Total	129 69.0 %	22 11.8 %	12 6.4 %	9 4.8 %	11 5.9 %	1 0.5 %	3 1.6 %	187 100.0 %
Nigeria	Female	21 13.5 %	5 3.2 %	4 2.6 %	17 10.9 %	1 0.6 %	3 1.9 %		51 32.7 %
	Male	50 32.1 %	17 10.9 %	8 5.1 %	21 13.5 %	1 0.6 %	2 1.3 %	4 2.6 %	103 66 %
	Prefer not to say	1 0.6 %			1 0.6 %				2 1.3 %
	Total	72 46.2 %	22 14.1 %	12 7.7 %	39 25 %	2 1.3 %	5 3.2 %	4 2.6 %	156 100.0 %
Ghana	Female	8 3.6 %	6 2.7 %	25 11.1 %	10 4.4 %	11 4.9 %	4 1.8 %	13 5.8 %	77 34.2 %
	Male	25 11.1 %	17 7.6 %	27 12.0 %	21 9.3 %	10 4.4 %	17 7.6 %	17 7.6 %	134 59.6 %
	Prefer not to say		1 0.4 %	3 1.3 %		1 0.4 %	3 1.3 %	6 2.7 %	14 6.2 %
	Total	33 14.7 %	24 10.7 %	55 24.4 %	31 13.8 %	22 9.8 %	24 10.7 %	36 16.0 %	225 100.0 %
Other Countries	Female	5 8.1 %	1 1.6 %	10 16.1 %	3 4.8 %	3 4.8 %	1 1.6 %	6 9.7 %	29 46.8 %
	Male	12 19.4 %	4 6.5 %	5 8.1 %	9 14.5 %	1 1.6 %		2 3.2 %	33 53.2 %
	Total	17 27.4 %	5 8.1 %	15 24.2 %	12 19.4 %	4 6.5 %	1 1.6 %	8 12.9 %	62 100.0 %
Percentages and totals are based on responses.									

Table 1: Discipline, gender and country-wise distribution of the respondents.

from students to full professors; this was reflected in self-declared numbers of publication, for instance, where 20 % of respondents stated that they had not published any scientific papers yet. Notably, but unsurprisingly given the sampling and methods of dissemination used

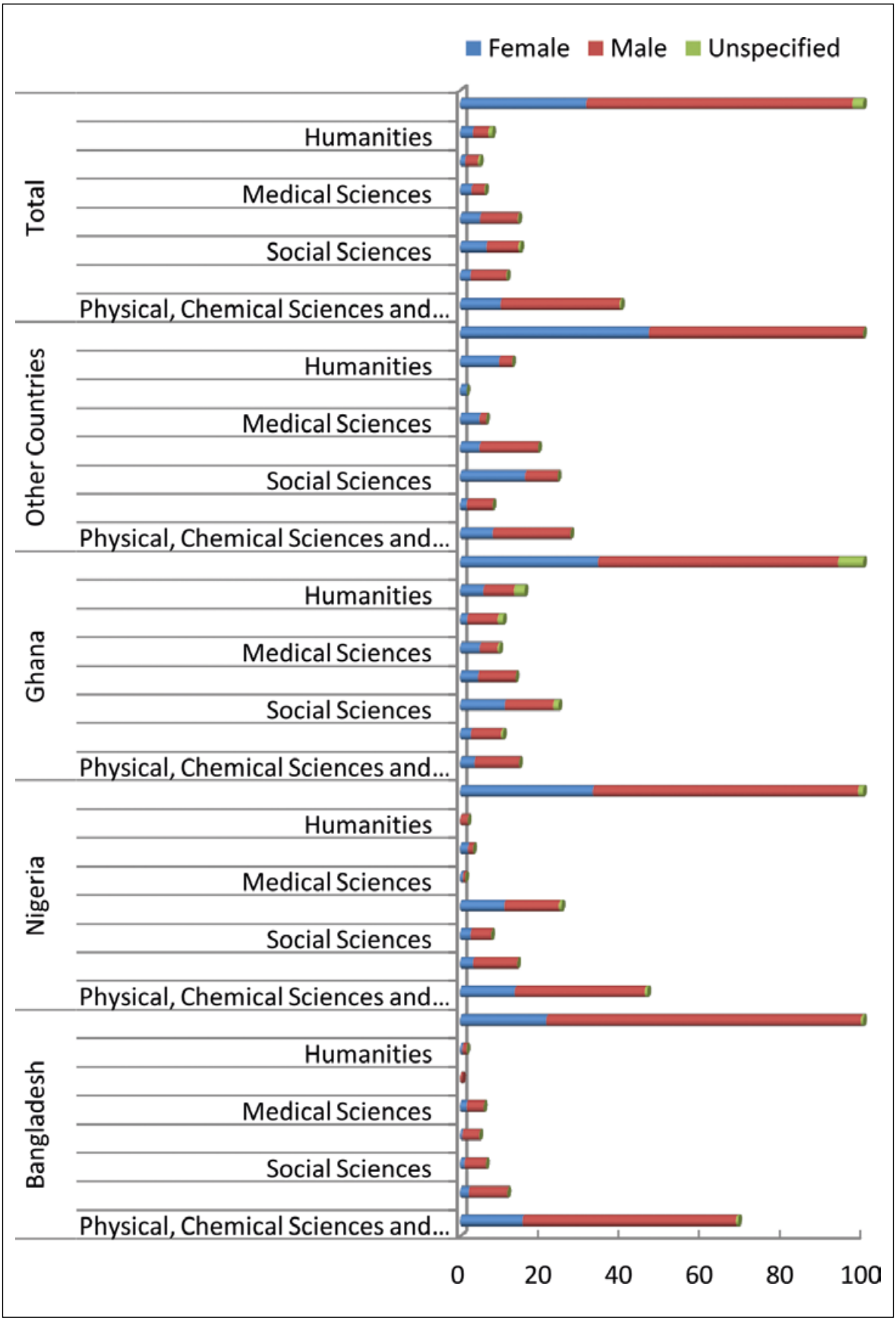

Figure 1: Discipline, gender and country-wise distribution of the respondents.

as well as the relative numbers of researchers in public and private sectors in these countries, the overwhelming majority of respondents was from the public sector (with only 2.4% describing themselves as working in the private sector). Apart from any limitations in sampling, this may reflect the general dominance of the public sector in low-income countries.

Data Analysis

This section reports responses for each survey question, followed by a brief discussion of their potential significance and implications. More specifically, the following information is provided for each question in the questionnaire:

- the question and (where applicable) multiple choice answers available to respondents
- a summary of the main findings (including the number of respondents who chose not to answer the question)
- a quantitative breakdown of the answers in table form (the full dataset is fully and freely available as a data paper, currently under review)
- a qualitative analysis of the free-text responses, where applicable
- a discussion section

Question 1: Access to Software

Question text: *Do you have access to the following (tick as many as applicable):*

- *A personal computer*
- *A work computer*
- *None of the above*
- *Other access to a computer (please specify)*

Main findings: While 94.7% of 748 respondents had access to a personal computer, only 42% of respondents reported having access to a work computer.

Quantitative analysis: While access to personal computers was consistent across all countries, it is important to note the differences in reported access to work computers.[4] While 34.6% and 51.1% of respondents from Bangladesh and Ghana respectively reported to have access to work computers, only 19% of Nigerian respondents reported having access. In further contrast, 83.2% of respondents from other countries reported having access to work computers.

1.1 Country-wise

Statements	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
A personal computer	210 96.8%	191 95.0%	214 93.4%	93 92.1%	**708** **94.7%**
A work computer	75 34.6%	38 18.9%	117 51.1%	84 83.2%	**314** **42.0%**
None of above	3 1.4%			1 1.0%	**4** **0.5%**
Other	1 0.5%	7 3.5%	4 1.7%	6 5.9%	**18** **2.4%**
Total number of respondents	**217** **29.0%**	**201** **26.9%**	**229** **30.6%**	**101** **13.5%**	**748** **100.0%**
System missing: Respondents did not respond to country option					

Table 2: Country-wise access to computers.

[4] Note that in 2017, the three countries had a similar ranking of internet inclusivity, according to a study by The Economist, even if there were considerable differences in internet availability, affordability, and skills. See https://theinclusiveinternet.eiu.com/explore/countries/performance

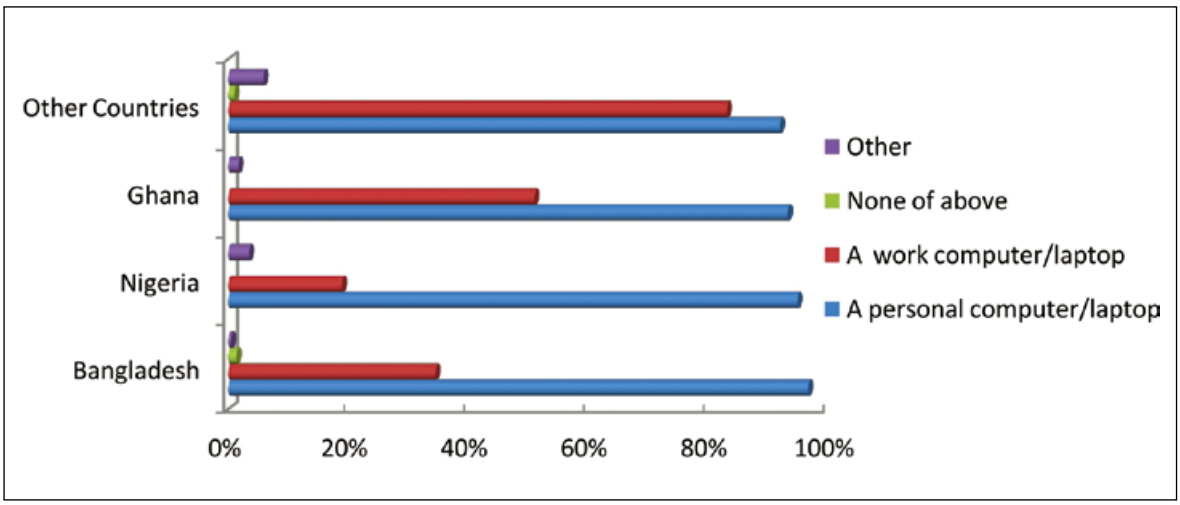

Figure 2: Country-wise access to computers.

Similarly, when the responses were analysed according to discipline, access to personal computers remained the primary means of ICT engagement.

1.2 Discipline-wise

Discussion: First, it should be noted that what constitutes a "personal" versus a "work" computer is open to interpretation, especially since a personal computer (PC) is also the name of a general-purpose computer whose size, capabilities, and price make it feasible for individual use. The contrast between a personal computer and a work computer may therefore relate to issues of institutional mediation and personal purchase of information technologies, in some disciplines it may also reflect differences between small-scale computing and mainframe computers that have considerable computing power (this may explain the relatively high percentage of "work computers" in the humanities as opposed to the sciences, where a work computer may mean a mainframe computer).

Nevertheless, the interviewers know the cultural context of the respondents and estimate that most respondents would interpret a "personal" computer in this question as a personally owned computer. The interesting point to note here is that the institutions are not providing many of their researchers with computers; rather researchers have to buy their own computers. This will have to be considered in any licensing for software, because to be effective, the software must be installed on the personal laptops and PCs of the researchers, and therefore a site license for multiple users will not suffice.

Computer Types	**Discipline**							**Total**
	Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities	
Personal computer/ laptop	245 97.6%	68 93.2%	89 94.7%	88 96.7%	35 89.7%	28 90.3%	48 94.1%	**601** **95.4%**
Work computer/ laptop	82 32.7%	32 43.8%	46 48.9%	33 36.3%	21 53.8%	13 41.9%	34 66.7%	**261** **41.4%**
Other	2 0.8%	1 1.4%	2 2.1%	7 7.7%	1 2.6%	1 3.2%		**14** **2.2%**
Total no of respondents	**251** **39.8%**	**73** **11.6%**	**94** **14.9%**	**91** **14.4%**	**39** **6.2%**	**31** **4.9%**	**51** **8.1%**	**630** **100.0%**
System missing: 118								

Table 3: Discipline-wise access to computers.

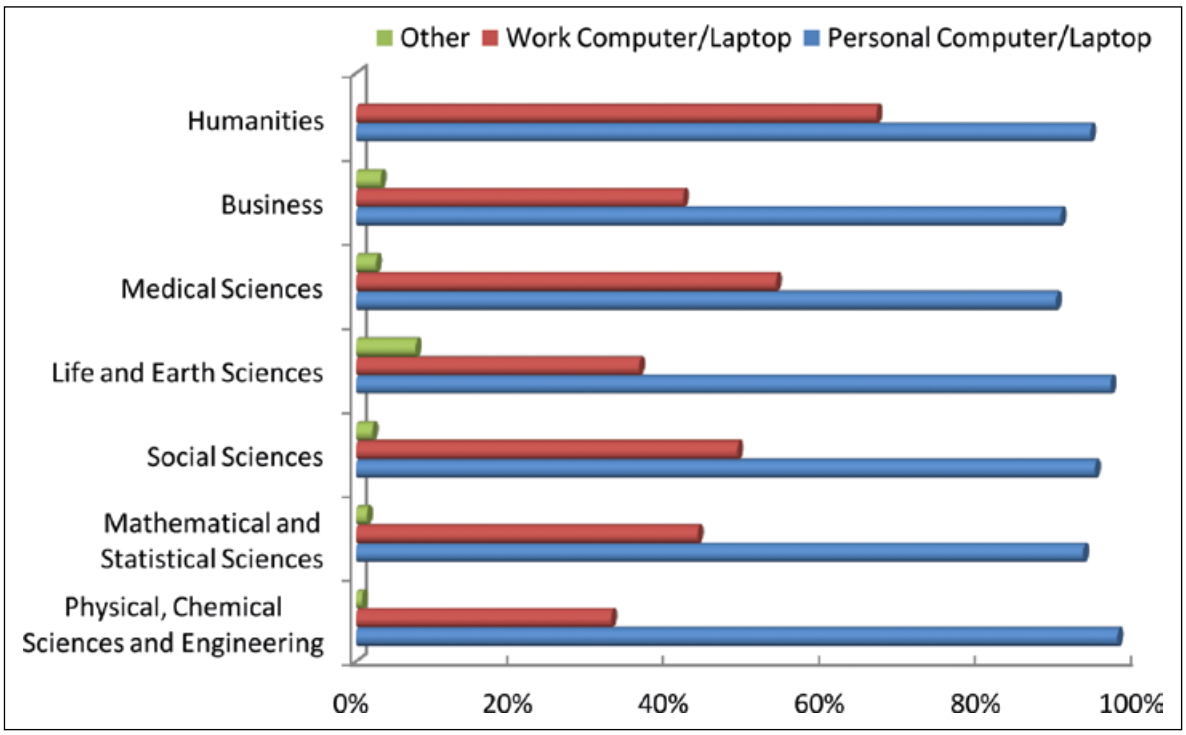

Figure 3: Discipline-wise access to computers.

Second, it should be noted that the survey was made accessible through the internet via SurveyMonkey, but was also distributed by means of paper copies. In order to ensure participation, paper-based responses from Bangladesh, Ghana and Nigeria were collected. It is not the aim of this question to draw definite conclusions about computer access in general. Of interest are responses about research software, for which access to a computer is presupposed.

It is also of interest that seven qualitative respondents highlighted community facilities as important alternative means of accessing computing facilities. Two Nigerian respondents mentioned the Argo cluster of ICTP, Trieste; and five respondents in the "other" group mentioned high performance computing clusters. The number of these respondents who had access to these facilities can feasibly be expected to be low and discipline-curtailed, and this result thus highlights the importance of these alternative computing avenues.

Question 2: Operating System

Question text: *What operating system do you use (tick as many as applicable):*

- *Windows*
- *Linux*
- *MacOS*
- *Old OS (before year 2000)*
- *Don't know*
- *Other (please specify)*

Main findings: Almost all of the respondents reported using Windows, while only a fifth of respondents reported also using Linux (over 80% of them in conjunction with Windows). This result highlights the dominance of proprietary operating systems over free and open versions.

Quantitative analysis:
715 respondents
33 did not answer the question

The respondents could choose multiple answers for this question, and percentages should be read accordingly.

92.6% of respondents reported using Windows as (one of) their operating system(s). This compares to 22.1% using Linux and 18.0% using MacOS. The dominance of Windows over other operating systems was consistent across all country categories, although Bangladesh (97.6%) and Nigeria (96.2%) were higher than average, while Ghana (88.6%) and other countries (83.9%) were lower.

The use of other operating systems, such as Linux and MacOS were less consistently distributed across the country groups. Far less respondents in Nigeria (6.5 %) used Linux in comparison to the other groups (average 22.1 %), while there were far more MacOS users in Ghana (27.1 %) and other countries (47.3 %) than in Bangladesh (8.7 %) and Nigeria (2.7 %). This may be because there was a greater proportion of respondents from Ghana in the age group 41–50, the age where one is more likely to reach the economic solvency required to buy an Apple computer.

2.1 Country-breakdown

Operating Software	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
Windows	203 97.6 %	178 96.2 %	203 88.6 %	78 83.9 %	**662** **92.6 %**
Linux	55 26.4 %	12 6.5 %	70 30.6 %	21 22.6 %	**158** **22.1 %**
MacOS	18 8.7 %	5 2.7 %	62 27.1 %	44 47.3 %	**129** **18.0 %**
Old OS (from before the year 2000)	3 1.4 %	3 1.6 %			**6** **0.8 %**
Don't know	1 0.5 %	1 0.5 %	1 0.4 %	1 1.1 %	**4** **0.6 %**
Other			3 1.3 %	2 2.2 %	**5** **0.7 %**
Total no of respondents	**208** **29.1 %**	**185** **25.9 %**	**229** **32.0 %**	**93** **13.0 %**	**715** **100.0 %**
System missing: 33					

Table 4: Country-wise breakdown of operating system (OS) used.

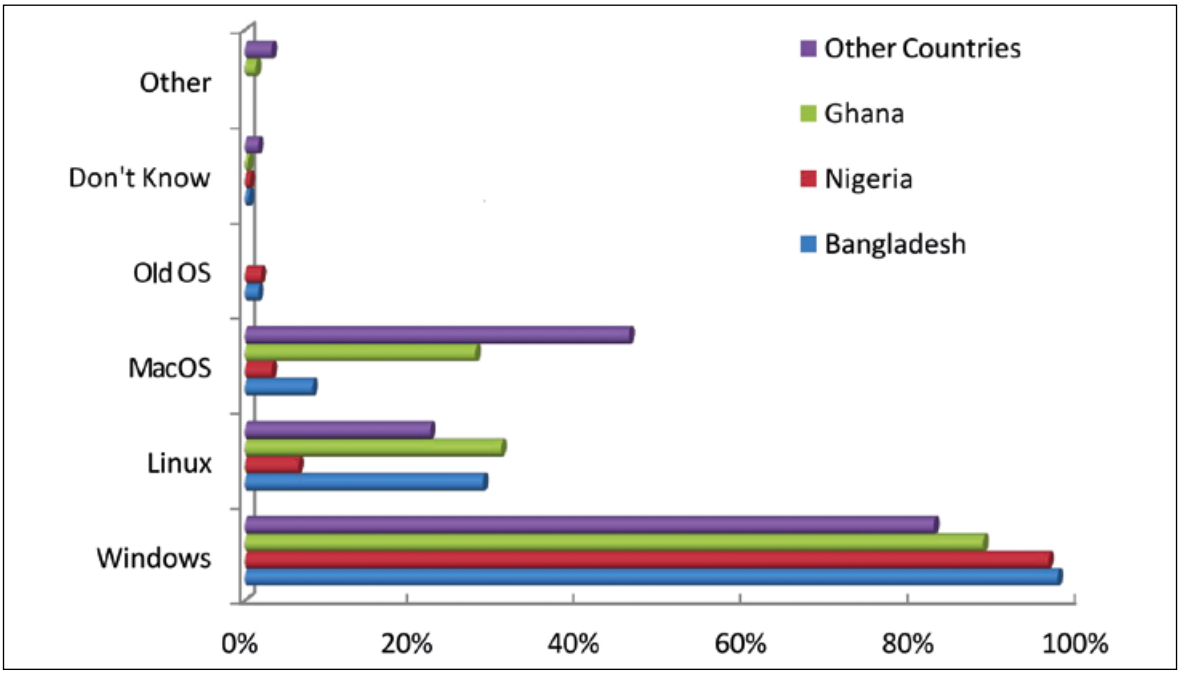

Figure 4: Country-wise breakdown of OS used.

2.2 *Discipline-breakdown*

Although the survey indicates that Windows is dominant across disciplines, the use of operating systems varied according to discipline. While the use of Linux in the physical/chemical/engineering sciences (26.3%) and mathematics/statistics (26%) is not surprising, 35.3% of respondents from the humanities reported using Linux.

Computer Types	Discipline							Total
	Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities	
Windows	238 94.8%	70 95.9%	82 87.2%	86 94.5%	32 82.1%	31 100.0%	43 84.3%	**585** **92.4%**
Linux	66 26.3%	19 26.0%	18 19.1%	12 13.2%	8 20.5%	5 16.1%	18 35.3%	**146** **23.2%**
MacOS	24 9.6%	8 11.0%	29 30.9%	13 14.3%	9 23.1%	6 19.4%	22 43.1%	**111** **17.6%**
Old OS (from before the year 2000)	4 1.6%		1 1.1%	1 1.1%				**6** **1.0%**
Don't know	1 0.4%	1 1.4%	1 1.1%		1 2.6%			**4** **0.6%**
Other	1 0.4%	2 2.7%		2 2.2%				**5** **0.8%**
Total no of respondents	**251**	**73**	**94**	**91**	**39**	**31**	**51**	630
System missing: 118								**748**

Table 5: Discipline-wise breakdown of OS used.

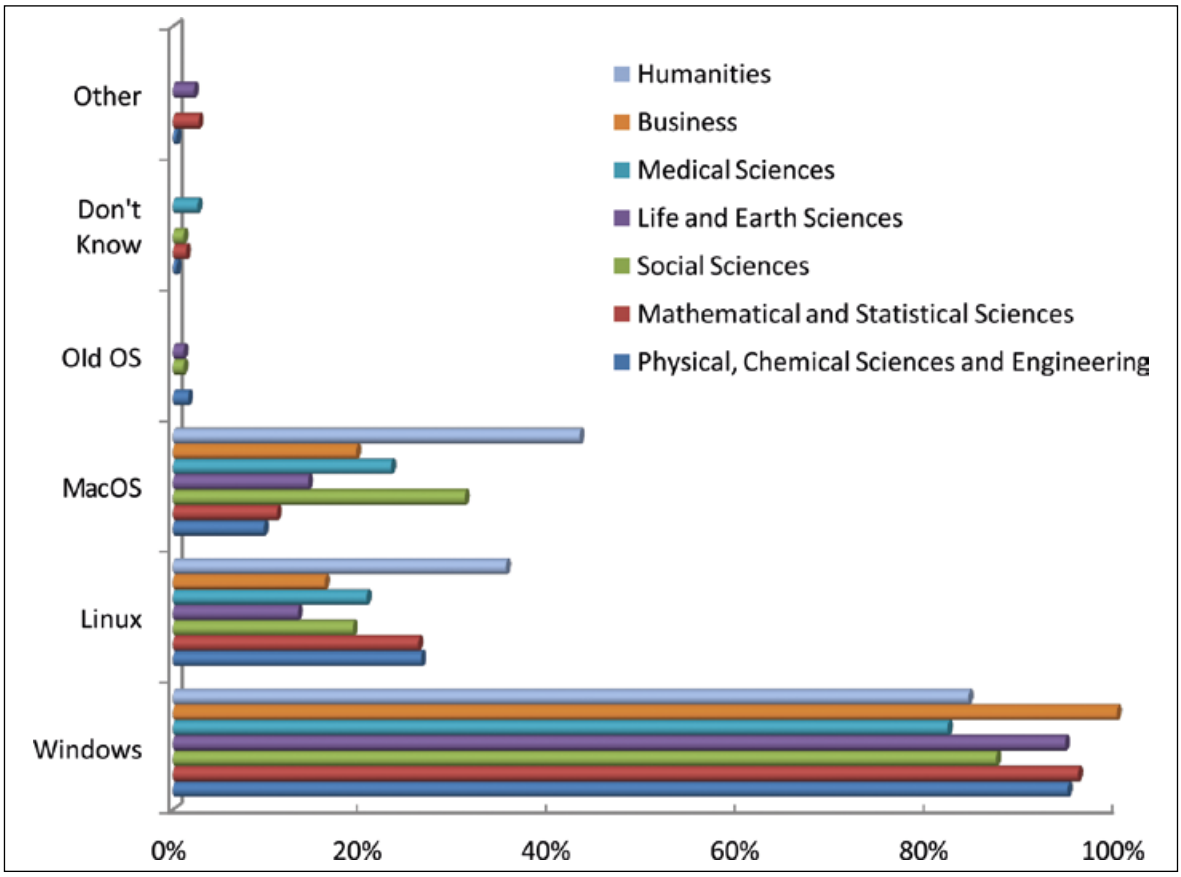

Figure 5: Discipline-wise breakdown of OS used.

Also of interest was a preference amongst the social sciences (30.9%) and humanities (43.1%) for the MacOS operating system.

As the respondents were able to choose multiple answers for this question, the data were also analysed according to the number of responses per respondent.

Discussion: There was a preference amongst the social sciences (30.9%) and humanities (43.1%) for the MacOS operating system. While communities of academics may be said to often favour certain technologies over others, it would require further investigation to explain why Apple computers are preferred in these disciplines. Whether it is due to features on the computer, disciplinary trends, or the use of iPads remains unclear. From the analysis of differentiation according to age, it is interesting to note that respondents between 41 and 50 displayed a marked preference for the Linux operating system, while those over 50 unanimously used Windows. It is possible that this may reflect global trends, promotion of specific software through the years, or the fact that most computers purchased by universities come with pre-installed Windows software – thus indirectly charging users for it, and creating technological lock-in. The dominance of Windows over other operating systems across countries and disciplines cannot be underestimated.

2.3 Age breakdown

The survey also revealed differences in operating systems across age groups. Between the ages of 20 and 40 the dominance of Windows over Linux persisted, however between 41 and 50 there were less Windows users and more Linux users. A possible inference is that younger users are not more attracted to FOSS operating systems than older users. In contrast, respondents over 50 years unanimously used Windows. Moreover, the highest concentration of MacOS users was between 31 and 50. This might be because the cost of Apple computers does not permit purchase of such computers before a researcher has reached a certain level in his or her career.

Operating Software	**Age Group**					**Total**
	20–30	31–40	41–50	Over 50	Prefer not to say	
Windows	179 94.2%	195 94.2%	132 84.6%	51 100.0%	105 94.6%	**662** **92.6%**
Linux	41 21.6%	46 22.2%	47 30.1%	9 17.6%	15 13.5%	**158** **22.1%**
MacOS	20 10.5%	42 20.3%	38 24.4%	7 13.7%	22 19.8%	**129** **18.0%**
Old OS	1 0.5%	3 1.4%	2 1.3%			**6** **0.8%**
Don't know	2 1.1%		1 0.6%		1 0.9%	**4** **0.6%**
Other	2 1.1%	2 1.0%		1 2.0%		**5** **0.7%**
Total no of respondents	**190**	**207**	**156**	**51**	**111**	**715**
System missing: 33						**748**

Table 6: Age-wise breakdown of OS used.

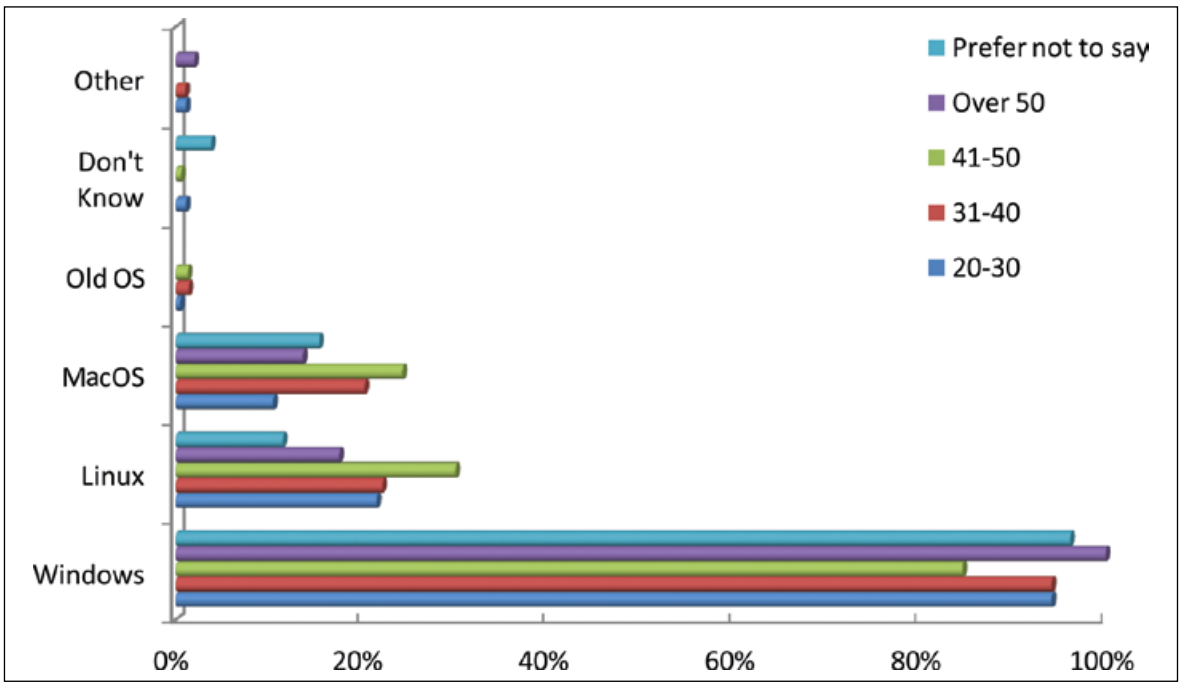

Figure 6: Age-wise breakdown of OS used.

2.4 Number of Operating Systems

Over 74 % of Windows users were found to use only Windows as their OS, whereas only 9 % of Linux and 15 % of MacOS users did the same. Rather around 60 % of Linux users and 50 % of Windows users used a second OS as well, with 30 – 40 % of them using all three. This may reflect the dependence of some software on Windows. It still may be difficult to find software to do everything only on Linux or MacOS.

	Windows	Linux	MacOS	Old OS (from before the year 2000)	Don't know	Other (Android)	Do not use Windows, Linux, MacOS
One	491 74.2%	14 8.9%	19 14.7%	4 80.0%	1 50.0%	2 40.0%	
Two	122 18.4%	95 60.1%	61 47.3%	1 20.0%	1 50.0%	3 60.0%	
Three	49 7.4%	49 31.0%	49 38.0%	0 0.0%	0 0.0%	0 0.0%	
	662	158	129	5	2	5	36

Table 7: Number of OSs used

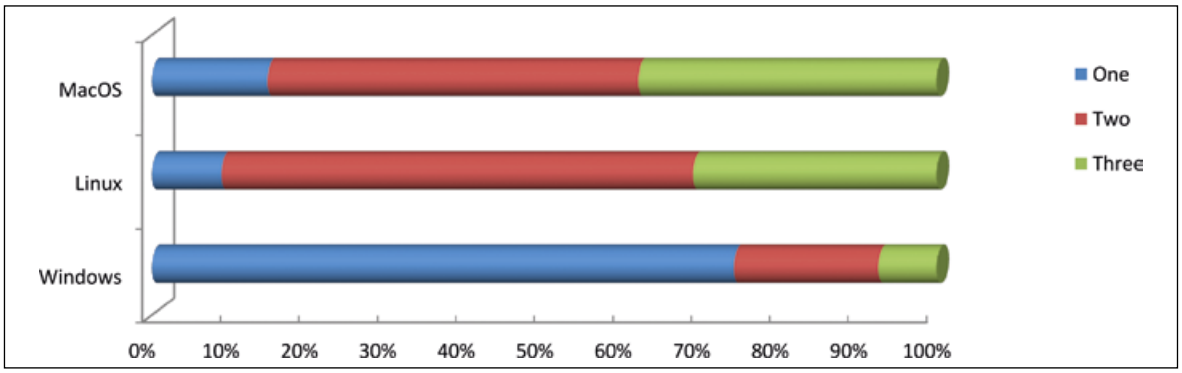

Figure 7: Number of OSs used (only Windows, Linux and MacOS users shown).

Question 3: Office Software

Question text: *What office software do you use (tick as many as applicable):*

- *Microsoft Office*
- *Libre Office*
- *Open Office*
- *Other (please specify)*

Main findings: An overwhelming majority of respondents indicated that they worked with Microsoft Office. Less than 6% declared that they worked with the FOSS alternative Office (the two main FOSS Office programmes were listed: Libre Office and Open Office) – and even then in conjunction with Microsoft Office.

Quantitative analysis:

715 respondents
33 did not answer the question

The respondents could choose multiple answers for this question, and percentages should be read accordingly.

99.2% of respondents reported using Microsoft Office, once again showing the dominance of proprietary software over free alternatives, and the potential clash between FOSS adoption and the purchase of computers with (sometimes pre-installed) Windows programmes. Indeed, the number of respondents using Libre (6%) or Open (4.1%) Office was very low. Interestingly, when analysed according to country, respondents from Bangladesh (13.5%) and other countries (10.8%) showed heightened preferences for Libre Office, while Open Office was only preferred by respondents in other countries (14%). Libre Office is the more popular and faster-growing fork of the two.

3.1 Country-wise

Office Software	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
Microsoft Office	207 99.5%	181 97.8%	228 99.6%	93 100.0%	709 99.2%
Libre Office	28 13.5%	3 1.6%	2 .9%	10 10.8%	43 6.0%
Open Office	6 2.9%	7 3.8%	3 1.3%	13 14.0%	29 4.1%
Other				4 4.3%	4 0.6%
Total no of respondents	208 29.1%	185	229	93	715 25.9%
System missing: 33					

Table 8: Office software used by country.

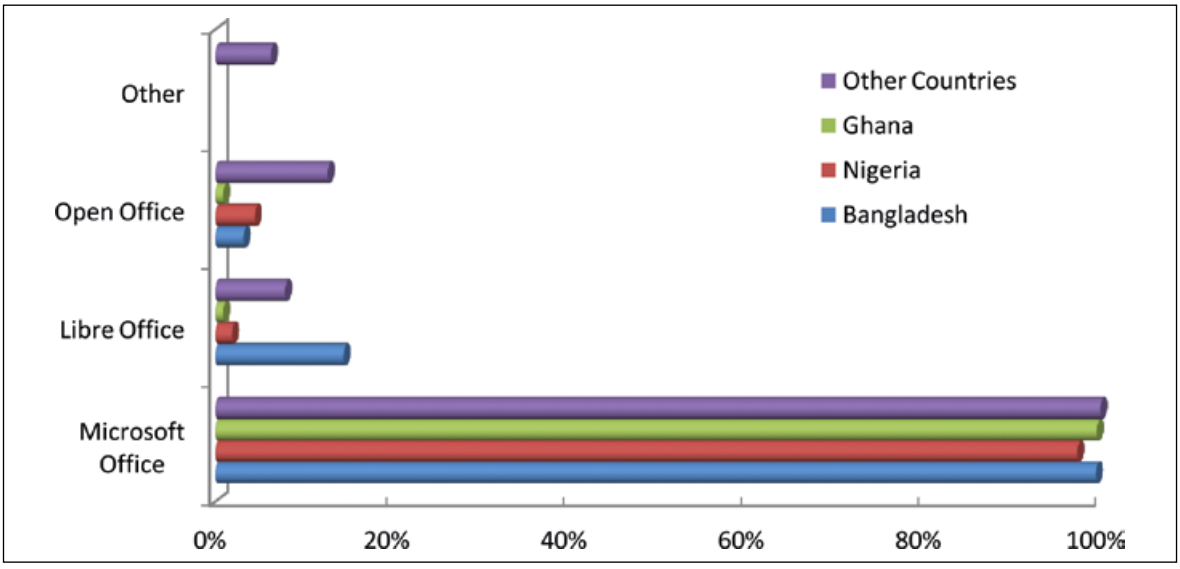

Figure 8: Office software used by country.

When analysed according to discipline, the dominance of Microsoft Office over free alternatives was equally apparent. It is especially significant that although respondents from physical/chemical/engineering sciences and life/earth sciences showed some evidence of Libre and Open Office use, their responses show that these are used in conjunction with Microsoft Office, and rarely as an alternative.

3.2 Discipline-wise

Discussion: From this analysis, it is evident that Open Office or Libre Office are not used as self-sufficient systems, but overwhelmingly in conjunction with Microsoft Office. Open alternatives, thus, show no sign of replacing the dominant proprietary software or acting as an alternative. This continues to reflect the trend that was observed in question 2 (Operating System).

Nonetheless, respondents from Bangladesh (13.5%) showed heightened preferences for Libre Office, but not Open Office (2.9%), which follows the global trend of Open Office being superseded by Libre Office. However, researchers in Ghana and Nigeria still have more users of Open Office, suggesting a distinct country preference for one free software over another. It is possible that communities of software users become established in specific settings, and the additional exposure and support that this affords facilitates the persistence of one version over another.

Computer Types	**Discipline**							**Total**
	Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities	
Microsoft Office	247 98.4%	73 100.0%	93 98.9%	90 98.9%	39 100.0%	31 100.0%	51 100.0%	**624** **99.0%**
Libre Office	26 10.4%	2 2.7%	1 1.1%	7 7.7%	1 2.6%			**37** **5.9%**
Open Office	11 4.4%	2 2.7%	1 1.1%	6 6.6%	1 2.6%		2 3.9%	**23** **3.7%**
Other	1 0.4%			2 2.2%			1 2.0%	**4** **0.6%**
Total no of respondents	**251**	**73**	**94**	**91**	**39**	**31**	**51**	**630**
System missing: 118								**748**

Table 9: Office software used according to discipline.

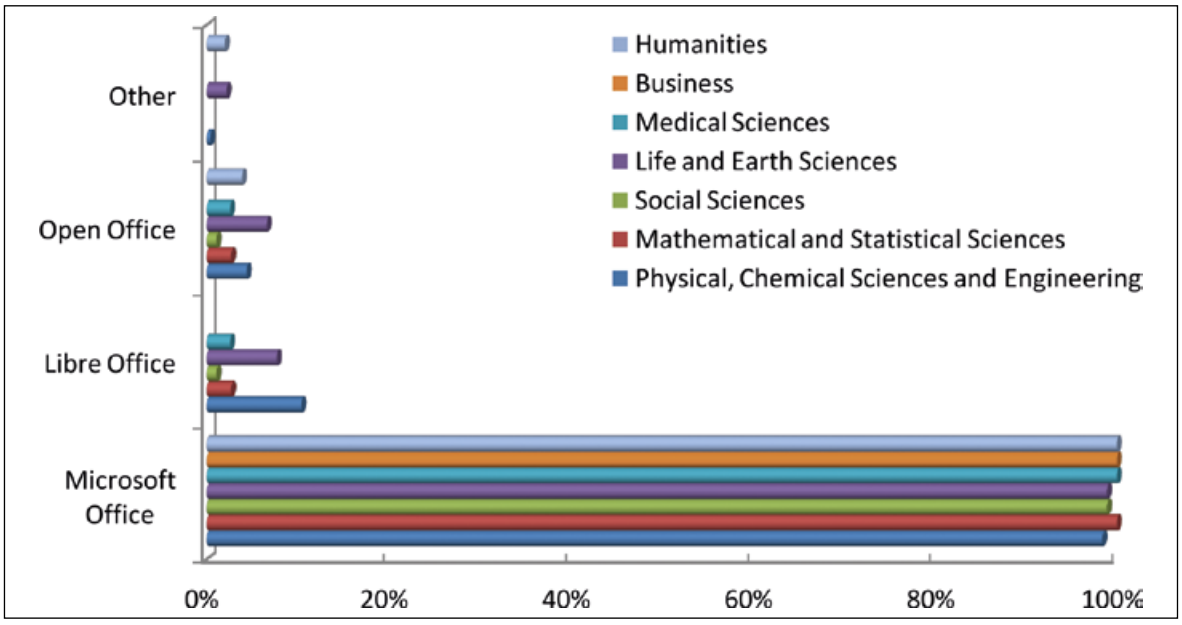

Figure 9: Office software used, according to discipline.

Question 4: General Software

Question text: *What general software do you use (please tick as many as are applicable):*

- *Compilers/interpreters*
- *Data analysis*
- *Databases*
- *Don't know*
- *Presentation*
- *Reference managers*
- *Spreadsheet*
- *Word processing*
- *Other (please specify)*

Main findings: The responses show that word processing, spreadsheet and presentation software (i.e. Microsoft Office programmes) were the dominant ones used.

Quantitative analysis:

715 respondents
33 did not answer the question

The respondents could choose multiple answers for this question, and percentages should be read accordingly.

From the responses, it was apparent that the most common general software used were part of suites such as Microsoft Office. These included presentation programmes (65.5%), spreadsheets (61.1%) and word processing programmes (80.3%). Also popular were data analysis programmes (36.8%). When considered according to country, less respondents in Nigeria (29.2%) made use of presentation software than their colleagues in other countries. Similarly, less respondents from Nigeria used spreadsheet software (39.5%) than those from Bangladesh (52.4%), Ghana (79%) or other countries (79.6%). 0.8% of total respondents were unclear about the software they used, and this was similarly represented across countries.

4.1 Country-wise

Analysing the data according to discipline revealed expected trends, such as physical/chemical/engineering sciences as well as mathematics/statistics making more use of compilers/interpreters and data analysis software than business or the humanities.

Software	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
Compilers/interpreters	109 52.4%	22 11.9%	0 .0%	29 31.2%	**160** **22.4%**
Data analysis	113 54.3%	71 38.4%	7 3.1%	72 77.4%	**263** **36.8%**
Database	83 39.9%	46 24.9%	5 2.2%	46 49.5%	**180** **25.2%**
Don't know	2 1.0%	2 1.1%	0 .0%	2 2.2%	**6** **0.8%**
Presentation	158 76.0%	54 29.2%	177 77.3%	79 84.9%	**468** **65.5%**
Reference managers	16 7.7%	16 8.6%	7 3.1%	54 58.1%	**93** **13.0%**
Spreadsheet	109 52.4%	73 39.5%	181 79.0%	74 79.6%	**437** **61.1%**
World processing	134 64.4%	134 72.4%	221 96.5%	85 91.4%	**574** **80.3%**
Other (AUTO-CAD, C, C++)	10 4.8%	3 1.6%	12 5.2%	10 10.8%	**35** **4.9%**
Total no of respondents	**208**	**185**	**229**	**93**	**715**
System missing: 33					**748**

Table 10: Type of general software use according to country.

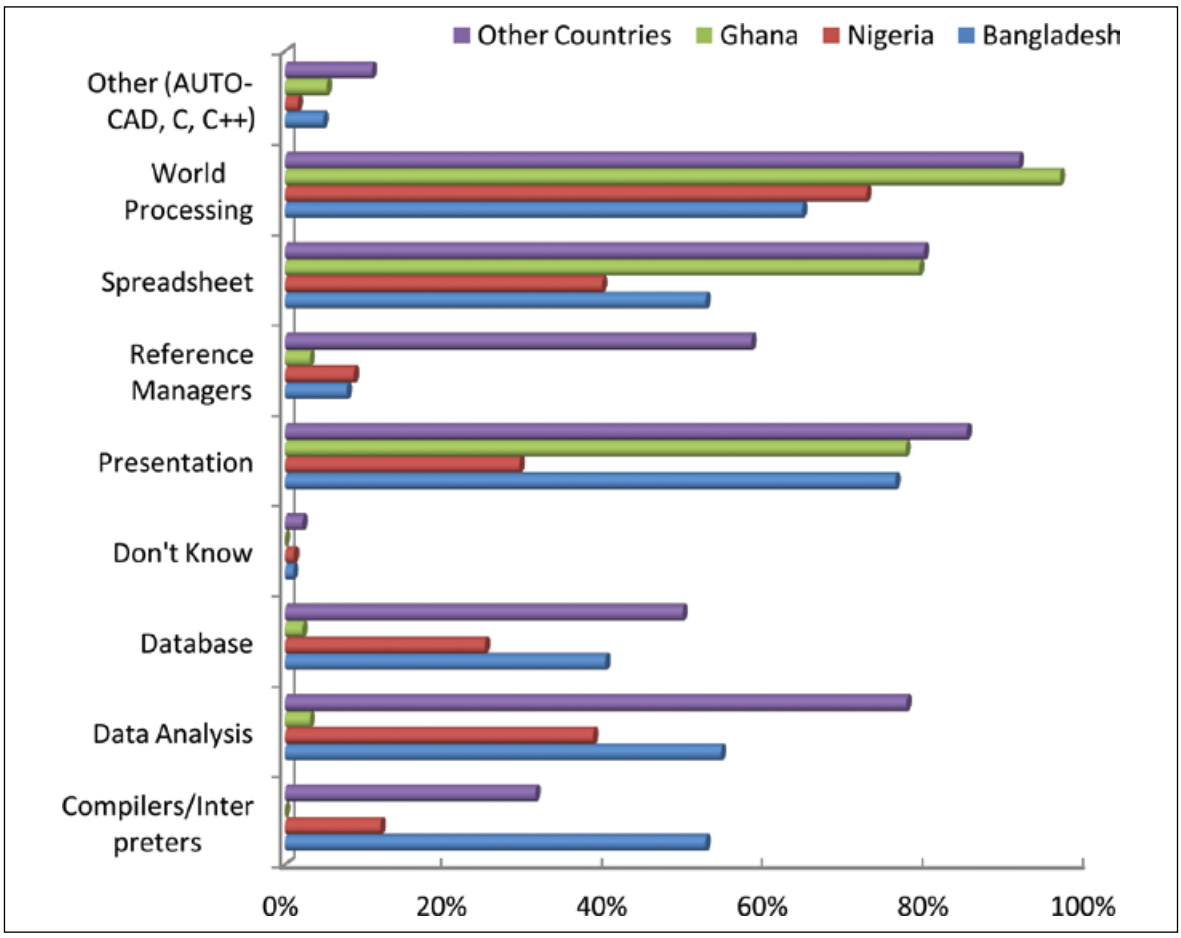

Figure 10: Type of general software use according to country.

4.2 Discipline-wise

Computer Types	Discipline							Total
	Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities	
Compilers/ interpreters	90 35.9%	20 27.4%	8 8.5%	13 14.3%	3 7.7%	1 3.2%	1 2.0%	136 21.6%
Data analysis	103 41.0%	33 45.2%	26 27.7%	33 36.3%	14 35.9%	3 9.7%	9 17.6%	221 35.1%
Database	74 29.5%	19 26.0%	17 18.1%	17 18.7%	11 28.2%	4 12.9%	7 13.7%	149 23.7%
Don't know	3 1.2%			1 1.1%			1 2.0%	5 0.8%
Presentation	143 57.0%	53 72.6%	63 67.0%	60 65.9%	33 84.6%	22 71.0%	37 72.5%	411 65.2%
Reference managers	19 7.6%	4 5.5%	17 18.1%	15 16.5%	9 23.1%	1 3.2%	6 11.8%	71 11.3%
Spreadsheet	121 48.2%	45 61.6%	63 67.0%	64 70.3%	31 79.5%	26 83.9%	36 70.6%	386 61.3%
World processing	180 71.7%	56 76.7%	86 91.5%	71 78.0%	38 97.4%	27 87.1%	48 94.1%	506 80.3%
Other (AUTO-CAD, C, C++)	12 4.8%	7 9.6%	3 3.2%	4 4.4%	0 .0%	2 6.5%	3 5.9%	31 4.9%
Total no of Respondents	251	73	94	91	39	31	51	630
System missing: 118								**748**

Table 11: Type of general software use according to discipline.

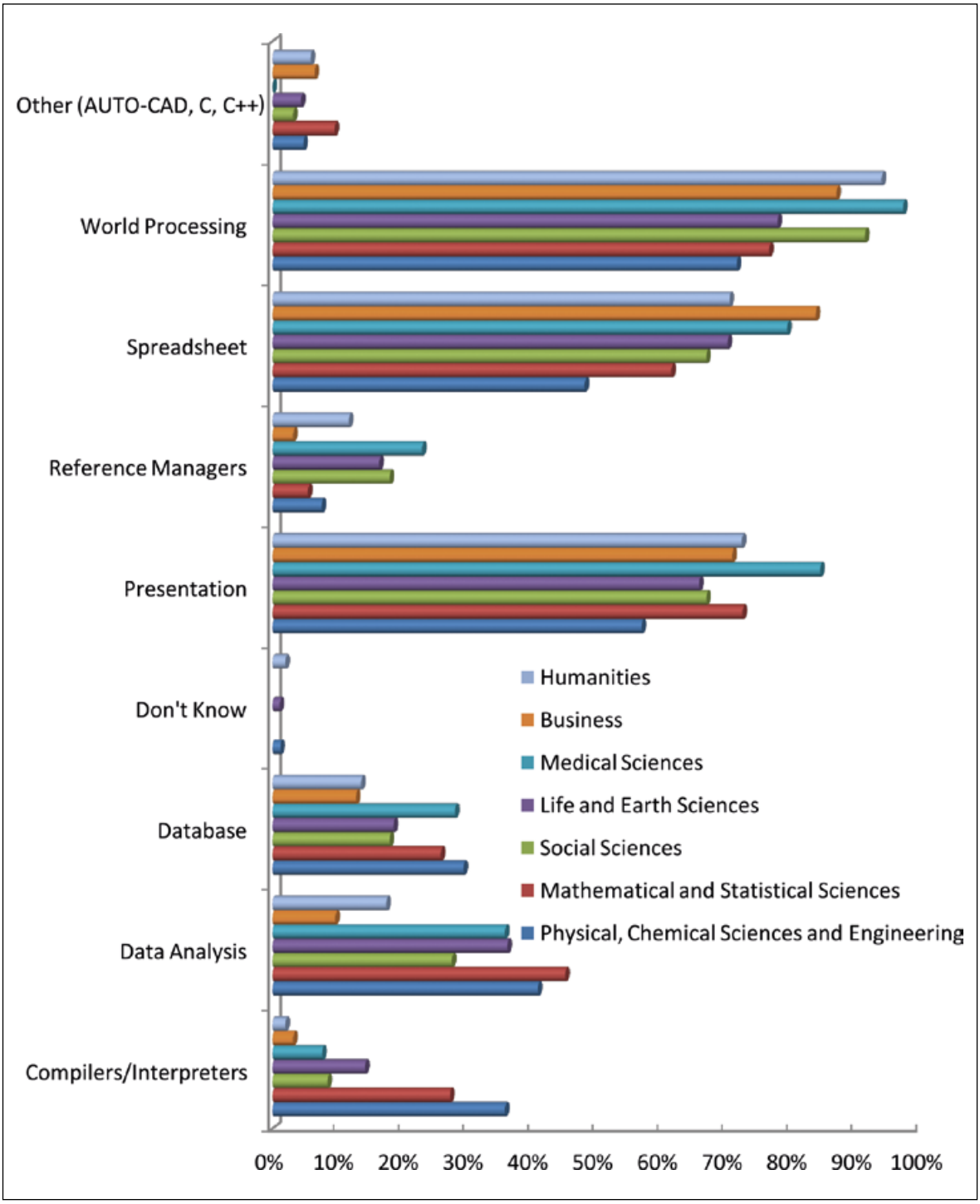

Figure 11: Type of general software use according to discipline.

Qualitative analysis: From the "other" box, 35 responses were collected that described 36 different types of data. These are summarised in the table below. While these responses indicated the wide variety of software in use, question 6 (Specific Software in Use) offers a much more exhaustive list of the software currently in use by respondents.

Discussion: When analysing the use of different software according to countries, some idiosyncrasies became apparent. Respondents from Nigeria, for example, made less use of spreadsheet software or reference managers than their colleagues in other countries. This may reflect characteristics of the respondent cohort, but could also be a reflection on academic culture. As spreadsheet software would undoubtedly be included in packages such as Microsoft Office (which is evidently in use, based on question 3 (Office Software)), it is unlikely that this distinction is solely due to a lack of software.

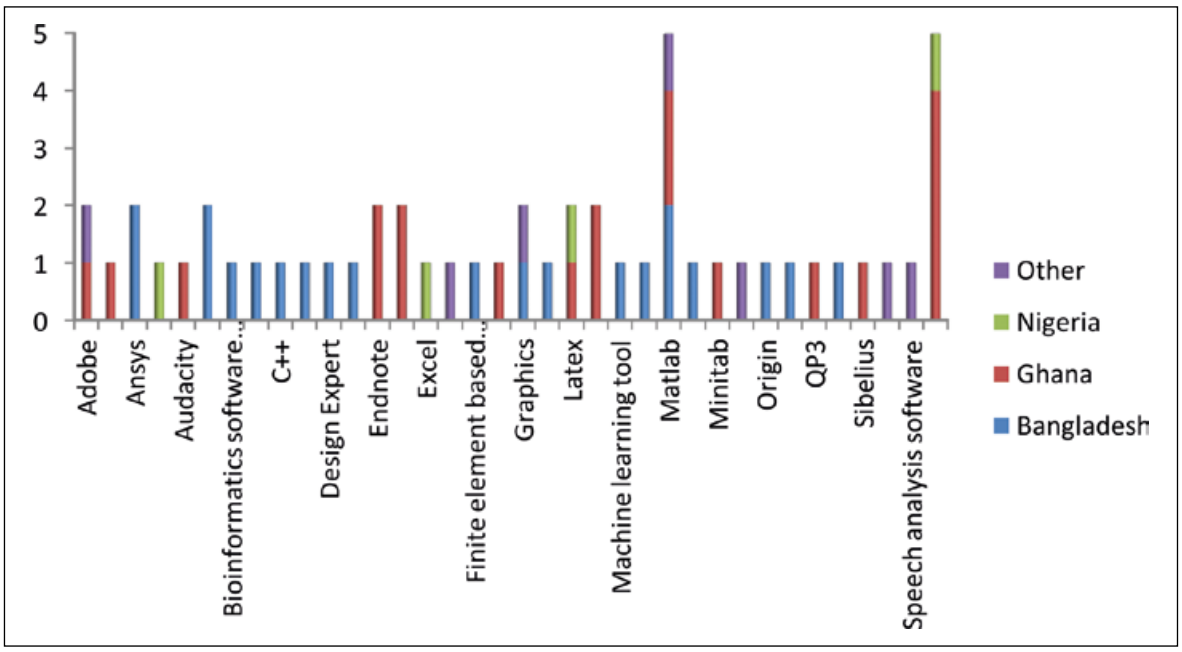

Figure 12: Cumulative bar diagram of "other" software named by respondents. See Question 6 (Specific Software in Use) for more specific details on research software.

Question 5: Access to Software

Question text: *How did you get access to this software (please tick as many as are applicable)*

- *It's free, Open Source software*
- *My institution paid for a license to the software*
- *I paid for a personal license to the software*
- *A colleague brought the software from another institution*
- *I use an unpaid-for copy of the licensed software*
- *Don't know*
- *Other (please specify)*

Main findings: Over half of respondents felt that they used free, Open Source software, which is quite surprising as questions 3 (Office Software) and 4 (General Software) highlighted the dominance of proprietary (usually Microsoft) software. Only 40 % of respondents agreed that their institution had paid for a license to the software, while a quarter of respondents personally paid for their software licenses or used unpaid copies. Moreover, when analysed according to number of responses, it is evident that many respondents use multiple channels to access the software they need.

Quantitative analysis:

715 respondents with 1024 different responses
33 did not answer the question

The respondents could choose multiple answers for this question, and percentages should be read accordingly.

It is of considerable interest that 52 % of respondents felt that they were using free, Open Source software in their research. This trend persisted across all country categories, although Ghana respondents (38.9 %) were below the total average.

41.1 % of respondents agreed that their institution paid for licenses to software, although the respondents from Nigeria were a marked outlier. Only 14.6 % of these respondents agreed with that statement. Also of note were the responses to the statement "I paid for a personal license". While 10.6 % of Bangladeshi respondents agreed, 26.5 % of Nigerian and 32.3 % of Ghanaian respondents agreed with this statement. In contrast, however, the number of Bangladeshi respondents (39.9 %) who used unpaid-for copies of software vastly exceeded the group average (23.8 %).

5.1 Country-wise

As this was a question to which respondents could choose multiple answers, it was also important to analyse the data according to the number of statements each respondent chose. 31 % of respondents chose two statements, while 12.2 % chose three. Respondents from Nigeria were less likely to choose multiple answers than those from Bangladesh, Ghana or other countries.

Statements	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
It is free, Open Source software	135 64.9%	99 53.5%	89 38.9%	49 52.7%	**372** **52.0%**
My Institution paid for a license to the software	85 40.9%	27 14.6%	112 48.9%	70 75.3%	**294** **41.1%**
I paid for personal license of the software	22 10.6%	49 26.5%	74 32.3%	39 41.9%	**184** **25.7%**
A colleague brought the software from another institution	12 5.8%	21 11.4%	50 21.8%	11 11.8%	**94** **13.1%**
I use an unpaid-for copy of the license software	83 39.9%	34 18.4%	35 15.3%	18 19.4%	**170** **23.8%**
Don't know	11 5.3%	11 5.9%	11 4.8%	1 1.1%	**34** **4.8%**
Other	9 4.3%	2 1.1%	1 .4%	3 3.2%	**15** **2.1%**
Total no of respondents	**208**	**185**	**229**	**93**	**715**
System missing: 33					**748**

Table 12: Country-wise mode of obtaining access to software.

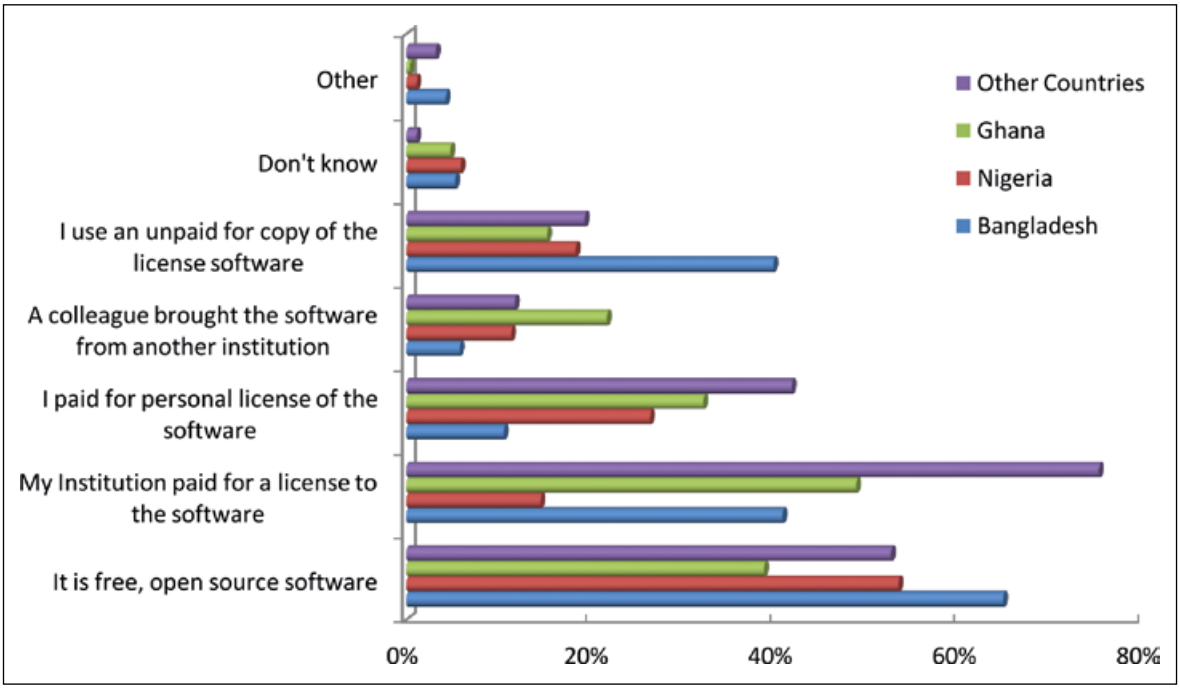

Figure 13: Country-wise mode of obtaining access to software.

5.2 Number of options chosen

Table 13 shows the number(s) of options chosen under Q5.

Discussion: Over half of respondents felt that they used free, Open Source software. This is an especially interesting result as questions 3 (Office Software) and 4 (General Software) highlighted the dominance of proprietary software – particularly when considering the list of software listed in the open text answer of question 4 (General Software). As respondents subsequently noted in question 13 (Awareness of FOSS) that they either had no prior knowledge of FOSS (40.9%) or had never used it (24.7%), it becomes very plausible that respondents are unclear about how to understand or define FOSS.

Options Chosen	Country				Total
	Bang-ladesh	Nigeria	Ghana	Other Coun-tries	
One	97 46.6%	145 78.4%	122 53.3%	25 26.9%	**389** **54.4%**
Two	75 36.1%	28 15.1%	75 32.8%	44 47.3%	**222** **31.0%**
Three	34 16.3%	7 3.8%	28 12.2%	18 19.4%	**87** **12.2%**
Four	2 1.0%	4 2.2%	4 1.7%	6 6.5%	**16** **2.2%**
Five		1 0.5%			**1** **0.1%**
Total	**208**	**185**	**229**	**93**	**715**
System missing: 33					**748**

Table 13: Number of different ways in which access to software was obtained.

Only 41.1% of respondents agreed that their institution had paid for a license to the software, although the respondents from Nigeria were a marked outlier with only 14.6% of respondents agreeing. On average, a quarter of respondents personally paid for their software licenses or used unpaid copies, however this showed country-specific variations. Less Bangladeshi reported paying for a personal license, while those using unpaid-for copies of software vastly exceeded the group average. Similarly, many Nigerian and Ghanaian respondents agreed that their software had come from a colleague in another institution. Together these responses indicate that a considerable amount of respondents are acquiring software through illicit means.

Together the data highlight some important considerations: First, that respondents in Bangladesh, Nigeria and Ghana are unlikely to rely on their institutions for all the software licenses they require. The analysis according to the number of responses per respondent show that many individuals use multiple channels to access the software they need. Interestingly, gaining access to software through illegal means remained a popular channel – particularly in Bangladesh. It is plausible that the high number of respondents claiming to use FOSS may be confusing illegal (i.e. pirated) software with that which is both legally free and Open Source. In fact, the personal experience of the authors of this report working in these countries is that there is very little software that is paid for by the institution, apart from exceptional cases, and that generally, apart from exceptional personal or research group purchases, software is generally pirated, either available in the market or brought by a colleague from abroad.

Nonetheless, 25.7% of respondents indicated that they had paid for their own personal li-

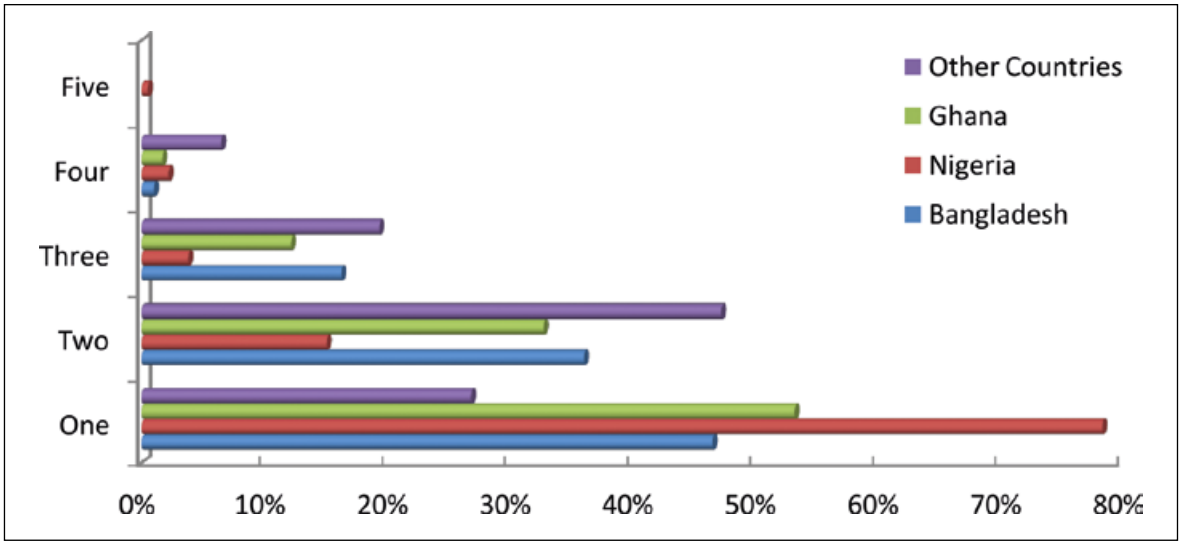

Figure 14: Number of different ways in which access to software was obtained.

cense. This may be problematic as the burden of software costs should not be on researchers – especially considering the high costs of the specialised programmes mentioned in question 4 (General Software). Using personal money for software purchases also means that there is no oversight on which version of the software is used, and it is likely that these costs yield a strong incentive to go for older and cheaper but less efficient versions.

Question 6: Specific Software in Use

Question text: *What specific software do you use for your research that you did not mention in questions 3 and 4?*

Main findings: This question was a free-text question for which 320 respondents listed 192 different types of software (See Appendix 2). Within this highly diverse list, statistical and mathematical software such as SPSS and Matlab were most frequently cited.

Qualitative analysis:

The extended list of this software is contained in Appendix 2. Within this list, there is a high level of diversity among software that respondents use in different disciplines – as evident from the fact that 192 different types of software were independently named. Below are the 9 most frequent responses. These were SPSS (92), Matlab (48), Genstat (30), C (28), Endnote (17), STATA (16), Mathematica (13), R (12), Java (10).

Discussion: As evident from the graph, responses to different programmes were often clustered around countries. While it is impossible to draw country-specific conclusions from this sample, interesting issues are highlighted by specific cases. For example, all Genstat responses were from Ghana. This may be an artefact of the distribution channels/disciplines/specific institution, but is something that could be looked into further with regard to software promotion, licensing rights etc. Nonetheless, it must be noted that this is clearly not an exhaustive list, however it provides a view on what people prioritise in their work.

It is also very significant that for many of these programmes, there exist viable FOSS alternatives. This again indicates minimal acquaintance with, and understanding of, FOSS software.

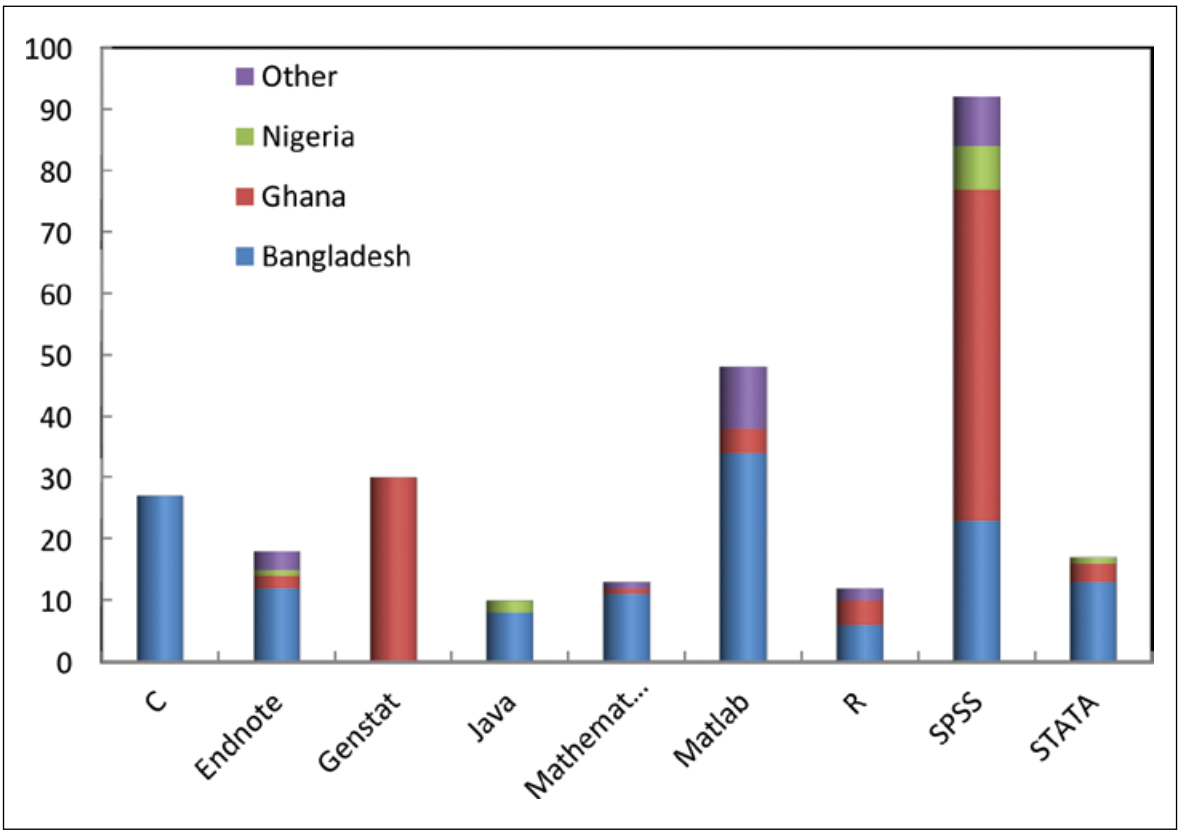

Figure 15: Specific software used for research.

Question 7: Impact of Lack of Access to Software on Research

Question text: *In what ways, if any, has lack of access to software affected your work? Lack of access to software means that I have ...*

- *Had to adapt/modify my research so that it did not require any software*
- *Had to adapt/modify my research to match the software that is available to me*
- *Had to change publication plans and/or venues*
- *Stopped doing some of the research I wanted to do*
- *Had to completely change my research topic/field*
- *Not been able to do any research*
- *Other*

Main findings: Over half of respondents felt that they had to adapt/modify their research to suit the software that was available, while a third felt they had to adapt/modify their research so as not to require software at all. These responses show the considerable long-term effects that software access issues have on personal research careers.

Quantitative analysis:

655 respondents
93 did not answer

Over half of respondents (53.4%) agreed that they had to adapt/modify research to the software that was available. Moreover, 32.2% said that they had to adapt/modify their research so that it required no software. These responses were equally distributed across all country categories.

In the other categories there were some country-based idiosyncrasies, for instance, a higher-than-average number of Ghanaian respond-

	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
Had to adapt/modify research that required no software	62 31.3%	55 31.4%	77 34.2%	17 29.8%	**211** **32.2%**
Had to adapt/modify research so that software is available	94 47.5%	88 50.3%	129 57.3%	39 68.4%	**350** **53.4%**
Had to change publication plans and/or venues	22 11.1%	15 8.6%	3 1.3%	5 8.8%	**45** **6.9%**
Stopped doing some of the research I wanted to do	30 15.2%	22 12.6%	55 24.4%	10 17.5%	**117** **17.9%**
Had to completely change my research topic/field	17 8.6%	3 1.7%	30 13.3%	3 5.3%	**53** **8.1%**
Not been able to do any research	13 6.6%	12 6.9%	1 0.4%	4 7.0%	**30** **4.6%**
Other	6 3.0%	2 1.1%	27 12.0%	10 17.5%	**45** **6.9%**
Total no of respondents	**198** **30.2%**	**175** **26.7%**	**225** **34.4%**	**57** **8.7%**	**655** **100.0%**
System missing: 93 respondents did not reply to this question about how access of software affected their work					

Table 14: Effect of lack of access to software on research.

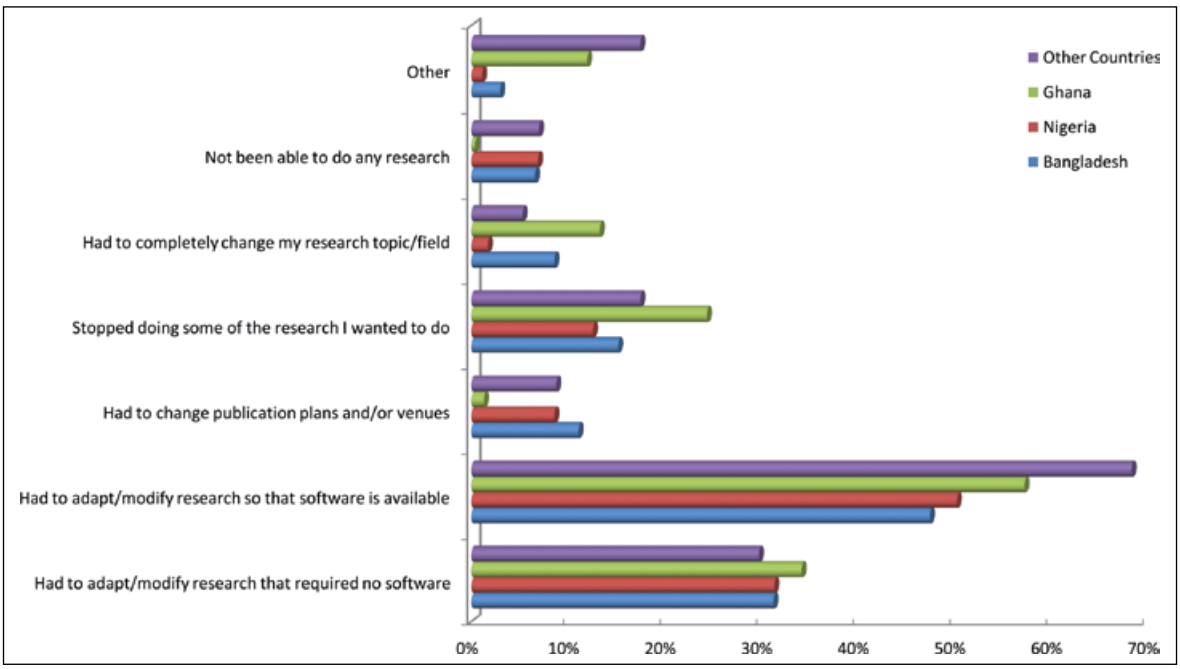

Figure 16: Effect of lack of access to software on research.

ents (24.4%) felt that they had to stop doing some of the research they wanted to do (average 17.9%). In contrast, far less Nigerians (1.7%) felt that they had to completely change their research topic in contrast to the average responses (8.1%), while very few (0.4%) Ghanaians felt that software access had precluded them from doing any research at all (average 4.6%).

Qualitative analysis: 35 respondents to the free-text option explicitly noted "no effect" to their research. The 10 other free-text responses, however, continued to reflect themes shaping conduct, content and direction of research. These included

- *Had to omit teaching topics that the university couldn't buy software for* (Ghana)
- *Increased the duration of my work. Had to create work around non-optimal software* (Other)
- *Used a friend's in another institution. Meant travel* (Other)

Discussion: Over half of respondents agreed that they had to adapt/modify research to the software that was available. Moreover, a third said that they had to adapt/modify their research so that it required no software. Together these responses clearly indicate that the availability of software has a strong effect on research content and directions. As these responses were equally distributed across all country categories, it must be assumed that these issues are widespread and pervasive.

In the other categories there were some country-based idiosyncrasies, for instance, a higher-than-average number of Ghanaian respondents (24.4%) felt that they had to stop doing some of the research they wanted to do (average 17.9%). In contrast, far less Nigerians (1.7%) felt that they had to completely change their research topic in contrast to the average responses (8.1%), while very few (0.4%) Ghanaians felt that software access had precluded them from doing any research at all (average 4.6%). While these difference may be due to the levels of institutionalised piracy in the respective countries; the responses also seem to show resilience amongst researchers for working around software constraints. They nonetheless highlight an important consideration for capacity-building, as talented academics may potentially be diverted from highly productive research on certain topics due to software constraints.

The free-text answers further serve to underline these concerns. In 10 quotes, respondents reflected that the software access issues shaped research conduct, content and direction. Together, the qualitative and quantitative results emphasise the disruptive effect of lack of software on the research process and its potential to undermine productive research in certain affected regions.

Question 8: Impact of Lack of Access to Software on Career

Question text: *In what ways, if any, has lack of access to software affected your career?*

- *It had no negative consequences*
- *It had positive consequences*
- *It hampered my career progression (promotion opportunities)*
- *It made it more difficult to recruit students/postdocs*
- *It forced me to modify or relinquish collaborations with peers*
- *It prevented me from joining research networks*
- *It prevented me from participating in international discussions*

Main findings: The highest proportion of respondents felt that lack of access to software had not had any negative effects on their career, less than 1% of respondents felt that the situation had positive consequences. Themes highlighted relating to career progression were grouped around the difficulties of international communication due to software access issues.

Quantitative analysis:

649 respondents
99 did not answer

While 48.8% of respondents felt that issues of software access did not have negative effects on their career, very few (6%) felt that it had had positive consequences. When considering the different country categories, however, it is important to note the differences between the Nigerian (15.1%) and Ghanaian (0%) responses.

While there was a good spread of responses to the other statements, a country-specific analysis highlights some distinctions. Bangladeshi respondents were more likely to consider access issues as influential in preventing them from joining research networks. In contrast, Nigerian respondents felt it hampered career progression. Ghanaians felt that it forced them to modify or relinquish collaborations with peers.

Discussion: It is notable that almost half of respondents replied that issues of software access did not have negative effects on their career. Note, however, that 90% of those also choose one or more of the first five options (specifying what one

	Country				Total
	Bangladesh	Nigeria	Ghana	Other Countries	
No negative consequences	96 49.7%	59 34.3%	126 56.2%	36 60.0%	**317** **48.8%**
Positive consequences	9 4.7%	26 15.1%	0 .0%	4 6.7%	**39** **6.0%**
Hampered career progression	27 14.0%	31 18.0%	21 9.4%	12 20.0%	**91** **14.0%**
Made difficulties to recruit students/ postdocs	11 5.7%	19 11.0%	43 19.2%	9 15.0%	**82** **12.6%**
Force to modify or relinquish collaborations with peers	27 14.0%	20 11.6%	74 33.0%	9 15.0%	**130** **20.0%**
Prevent from joining research networks	36 18.7%	25 14.5%	32 14.3%	10 16.7%	**103** **15.9%**
prevent from participating in international discussions	30 15.5%	12 7.0%	23 10.3%	11 18.3%	**76** **11.7%**
Total no of respondents	**193** **29.7%**	**172** **26.5%**	**224** **34.5%**	**60** **9.2%**	**649** **100.0%**
System missing: 99 Respondents did not respond to the question on the effect of lack of access to software on career					

Table 15: Effect of lack of access to software on career.

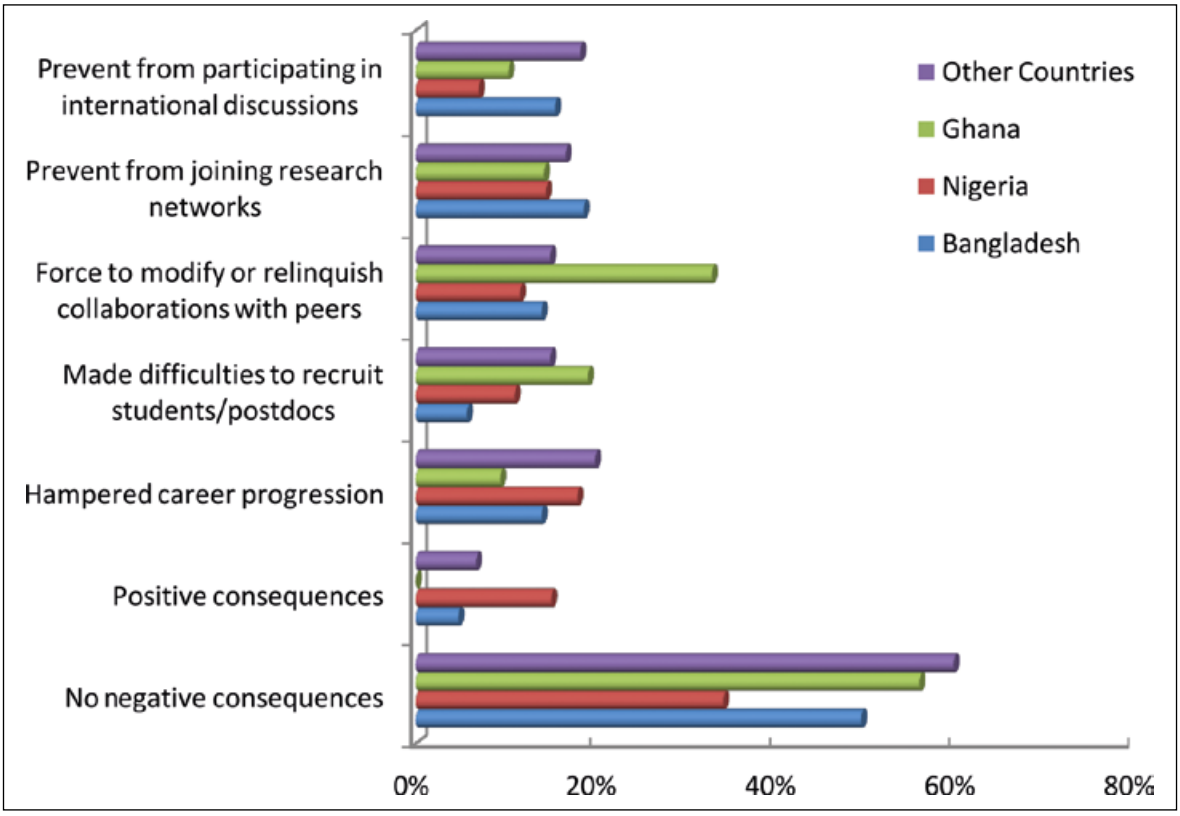

Figure 17: Effect of lack of access to software on career.

could assume are negative consequences). This could mean that they felt the workarounds they needed to execute had been effective and that lack of software access did not weigh heavily on their current circumstances – even though they might have had to shift or adapt research paths or to obtain software illicitly.

It may be worth mentioning that a few replied that lack of access had a positive impact. Unfortunately, a free-text box was not included to allow respondents to specify what positive effects lack of access to software might have had. Interestingly, a higher proportion (15 %) of Nigerian respondents did feel that it had had a positive effect – something that may require further investigation.

While the country-specific analysis highlighted different concerns in different regions, it is salient to note that the two top concerns related to international communication. Joining research networks and collaborating with peers were felt to be highly desirable in career progression, and that lack of access to software adversely impacted these activities. Similarly to responses to question 7 (Impact of Lack of Access to Software on Research), these responses give a clear picture of lack of access to software affecting the conduct, content and direction of research.

Question 9: Frequency of Impact of Lack of Access to Software on Research

Question text: *How often have these problems affected your work?*

- *Daily*
- *Weekly*
- *Monthly*
- *A few times a year*
- *About once a year*
- *Once in a few years*
- *Never*

Main findings: A third of respondents agreed that lack of access to software affected their career a few times a year. Saliently, however, a quarter of respondents felt that these issues affected their careers on a monthly or more frequent basis.

Quantitative analysis:

663 respondents
85 did not answer

	Country				Total
	Bang-ladesh	Nige-ria	Ghana	Other Coun-tries	
Daily	14 7.2%	25 14.6%	45 20.0%	13 17.8%	**97** **14.6%**
Weekly	18 9.3%	22 12.9%	20 8.9%	1 1.4%	**61** **9.2%**
Monthly	38 19.6%	13 7.6%	21 9.3%	4 5.5%	**76** **11.5%**
A few times a year	56 28.9%	59 34.5%	84 37.3%	16 21.9%	**215** **32.4%**
About once a year	8 4.1%	11 6.4%	31 13.8%	5 6.8%	**55** **8.3%**
Once in a few years	10 5.2%	18 10.5%	1 .4%	12 16.4%	**41** **6.2%**
Never	50 25.8%	23 13.5%	23 10.2%	22 30.1%	**118** **17.8%**
Total	**194** **29.3%**	**171** **25.8%**	**225** **33.9%**	**73** **11.0%**	**663** **100.0%**

System missing: 85 respondents did not respond to the question on frequency of impact of lack of access to software on research

Table 16: Frequency of impact of lack of access to software on research.

The highest percentage of respondents (32.4%) felt that lack of access to software affected their career a few times a year. Nonetheless, when collectively summed, it is also apparent that 25.3% of respondents felt that they were affected on a monthly or more frequent basis. A country-specific analysis reveals that Ghanaian respondents (20%) felt most affected on a daily basis, with Nigerians (12.9%) on a weekly and Bangladeshi (19.6%) on a monthly basis.

Discussion: The highest percentage of respondents felt that lack of access to software affected their career a few times a year. Nonetheless, when collectively summed, it is also apparent that a quarter of respondents felt that they were affected on a monthly or more frequent basis. Only 17.8% of respondents agreed that they were never affected by lack of access to software. It is thus important to realise that access to software is an issue that influences research (and career) progress on a very frequent basis, and can thus have considerable impact on research and capacity building in many areas.

Discussion of Triangulation of Questions 7, 8 and 9:

Question 8 (Impact of Lack of Access to Software on Career): "No Negative consequences": 48.8% (317 responses on 649)

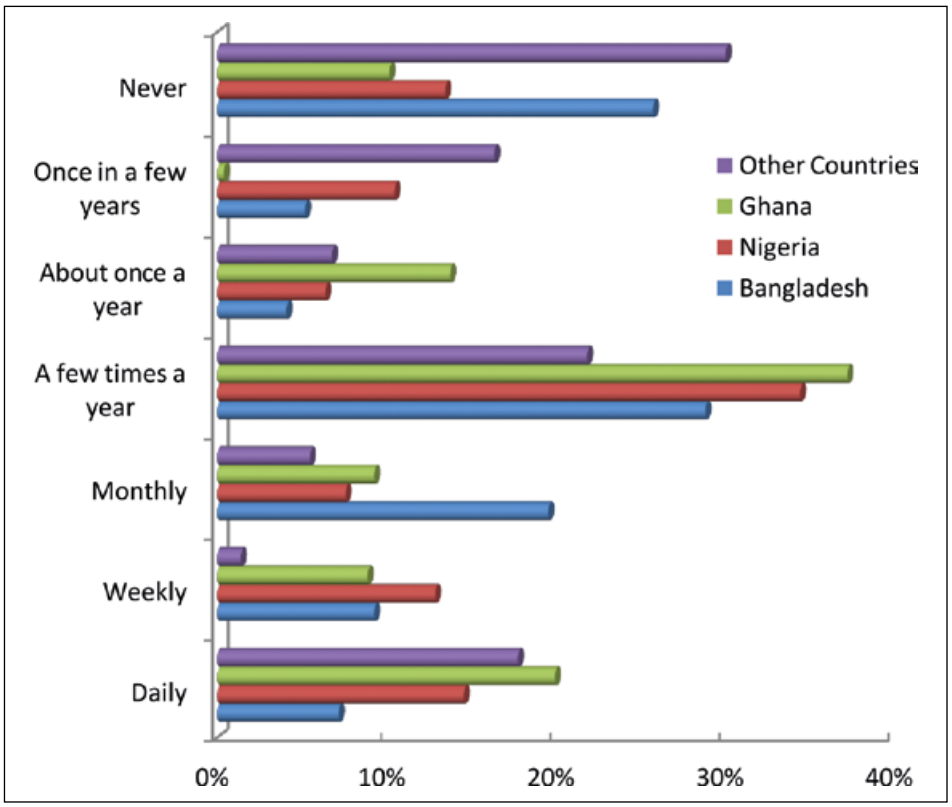

Figure 18: Frequency of impact of lack of access to software on research.

Question 9 (Frequency of Impact of Lack of Access to Software on Research): "How often have these problems affected you": 82,2% (545 responses on 663)

(Note that there are different "System missing" numbers for the two questions, so the percentages are not perfectly comparable)

Around half of the respondents indicate that there is not a problem with access to software, while in the responses to the next question, 82% infer that there is a problem.

This indicates that people react differently depending on how the question is framed, opening up the possibility that there are more negative effects under the surface that people recognise prima facie.

This finding also demonstrates the importance of raising awareness with researchers about these questions. So far, many seem not to have consciously reflected on the impact of (lack of) access to Research Software on their research and career.

Question 10: Software Wished For, But Inaccessible

Question text: *What software, if any, do you need but not have access to?*

Main findings: This was a free-text question for which 237 respondents reported 108 different types of software. The main software reported related to statistical/data analysis, text analysis and graphics/imaging software. It is evident that there is a strong affinity between this list and the software currently used that was noted in question 6 (Specific Software in Use).

Qualitative analysis:

The graph below highlights the 8 most frequent responses. These software related to statistical / data analysis software (Matlab, NVIVO, SAS, SPSS,STATA), text analysis (Endnote, NVIVO) and graphics/imaging software (Cadence).

Also of interest was the number of software listed that related to specific equipment or methodologies within the laboratory.

- CLC genomics for next generation sequencing
- Density functional theory software
- GC-MS interpreting software
- Gold docking software
- Health economics software
- Image processing software for nanoparticles
- IR interpreting software
- Mass spectroscopy software
- Mitsubishi automation software
- NMR interpreting software
- Spectroscopic software
- Top spin software

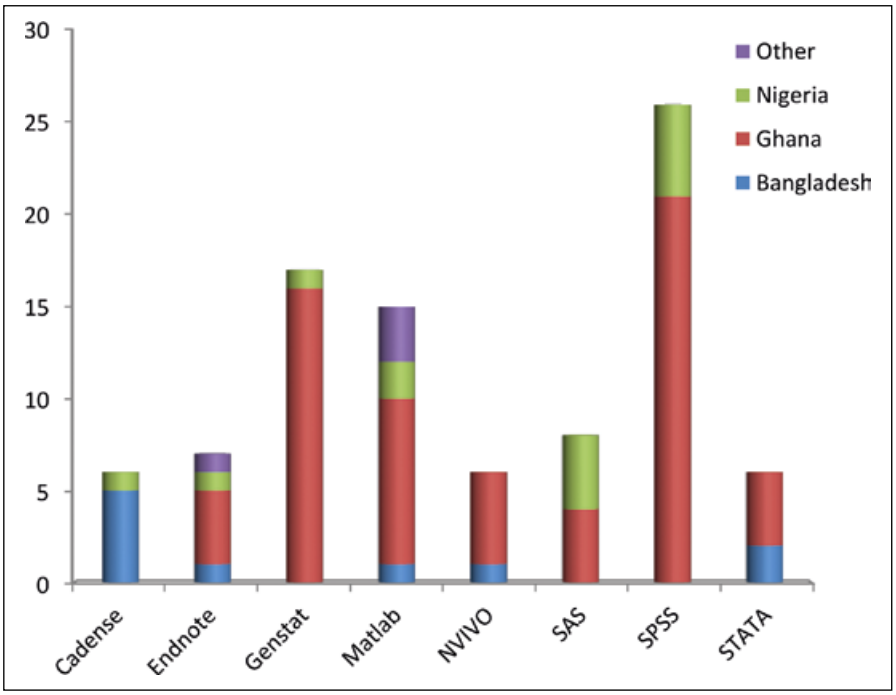

Figure 19: Software needed, but not available.

Discussion: It is evident that there is a strong affinity between this list and the software currently used that was noted in question 6 (Specific Software in Use). Similarly, when assessing the full list of software provided in Appendix 2, the diversity of software needs is particularly apparent.

Most of the other software noted in the list are proprietary. While some, such as Mendeley, are free in their basic version, or offered a free trial, the vast majority of the mentioned software was not accessible without a license fee. Moreover, the average cost of personal licenses for such software was high. Furthermore, as evident from the responses of question 5 (Access to Software), it was unlikely that institutional licenses would be available. This places a heavy financial burden on researchers wishing to use this software, and is a key area in which change can be affected. A brief survey of the software listed revealed that few companies had specific fee waivers in place for individual researchers from low-income countries.

Of additional interest was the number of respondents who highlighted the need for equipment or methodology-specific software. These responses seemed to indicate that respondents were not in possession of all the software necessary to make use of the equipment that they had in the lab, or had access to through collaborations. This is an issue of considerable importance that appears to reflect a disjunction between equipment acquisition and the ability to access the software necessary to not only use the equipment but also to analyse the results. This emphasis on equipment/methodology-specific software highlights a key area in which funders and scientific bodies can enact change.

Question 11: Difficulties in Accessing Software

Question text: *What difficulties, if any, have you had in getting access to software (please select all applicable)*

- *I have not had any difficulties in accessing the software I need*
- *I don't know what software I need*
- *I don't know what software is available*
- *I am not sure how to use the software available*
- *I have had problems communicating with the software company*
- *I could not afford the license*
- *My institution could not afford the license*

	Country				Total
	Bangladesh	Nigeria	Ghana	Other countries	
Had no difficulties in accessing software I need	81	50	87	45	**263**
	40.1%	28.6%	38.5%	55.6%	**38.5%**
Don't know what software I need	18	17	15	2	**52**
	8.9%	9.7%	6.6%	2.5%	**7.6%**
Don't know what software is available	35	30	32	8	**105**
	17.3%	17.1%	14.2%	9.9%	**15.4%**
Not sure how to use the software available	21	23	33	6	**83**
	10.4%	13.1%	14.6%	7.4%	**12.1%**
Had problems with communicating with software company	26	13	41	4	**84**
	12.9%	7.4%	18.1%	4.9%	**12.3%**
I could not afford the license	72	66	87	33	**258**
	35.6%	37.7%	38.5%	40.7%	**37.7%**
My institution could not afford the license	17	16	30	19	**82**
	8.4%	9.1%	13.3%	23.5%	**12.0%**
Other	1	1		3	**5**
	0.5%	0.6%		3.7%	**0.7%**
Total no of respondents	**202**	**175**	**226**	**81**	**684**
	29.5%	**25.6%**	**33.0%**	**11.8%**	**100.0%**
System missing: 64 respondents did not respond the question on difficulties in accessing software.					

Table 17: Difficulties in accessing software.

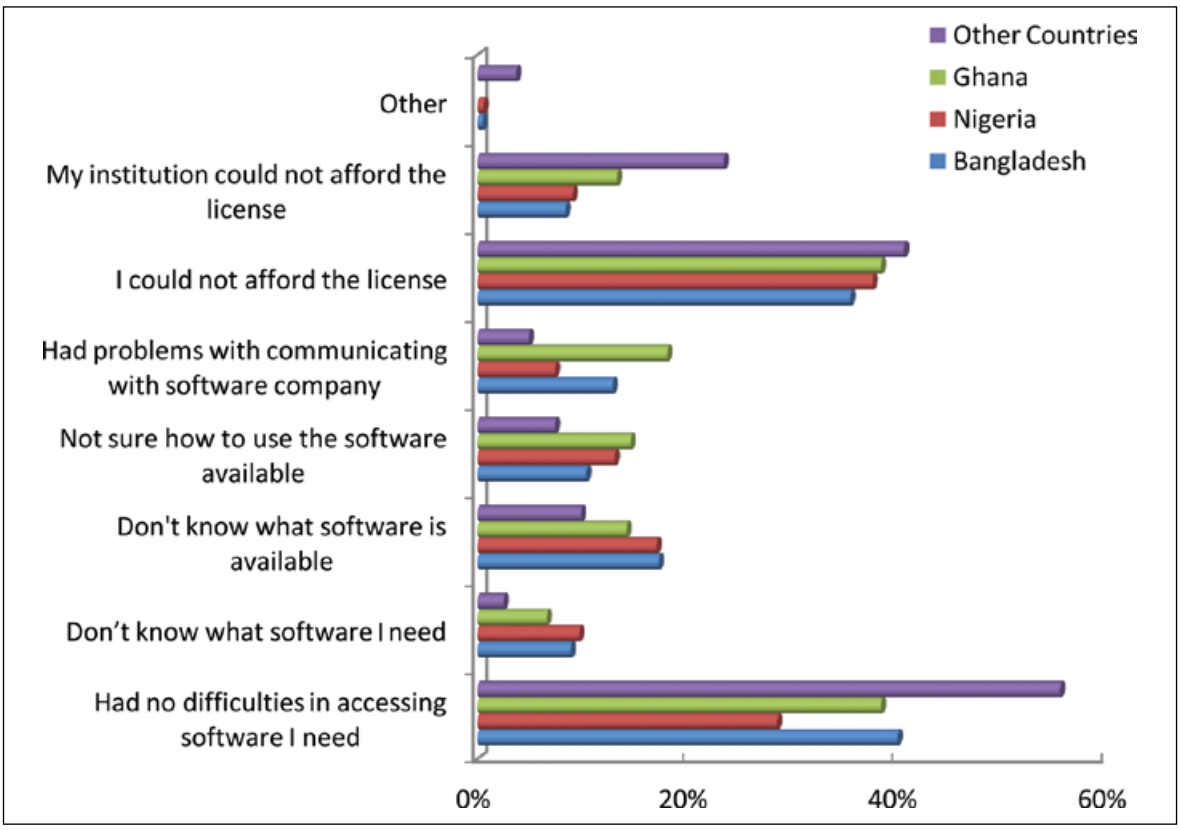

Figure 20: Difficulties in accessing software.

Main findings: Similar numbers of respondents had no difficulties accessing software as could not afford the licenses for software. This further serves to underpin both the prevalence of the use of personal licenses for research and the prohibitive costs of many of these licenses.

Quantitative analysis:

684 respondents
64 did not answer

While 38.5% of respondents reported having no difficulties accessing the software they needed, fewer Nigerian respondents (28.6%) agreed with this statement than those in Bangladesh (40.1%) or Ghana (38.5%). In contrast, 37.7% of respondents reported that they could not afford the licenses for the software they desired, and the distribution of responses was markedly similar over all three countries.

Discussion: It is of considerable importance to note the prevalence of respondents reporting problems affording personal licenses for software, which holds up the observations from question 10 (Software Wished For, But Inaccessible). Moreover, it is salient to recognise that this is a widespread problem, as very similar numbers of responses to this question were collected from Bangladesh, Nigeria and Ghana.

In contrast, only 12% of respondents agreed that lack of access to software was due to their institutions not being able to afford the licenses. The low number of responses to this statement may be taken as further confirmation of the importance of personal software licenses in the three countries being surveyed. Whether institutions could not – or would not – provide software copies was rated as less prohibitive than individual researchers' ability to acquire their own licenses. This appears to correlate with the findings of question 1 (Access to Software) that emphasise the importance – and prevalence – of personal computers.

Question 12: Difficulties in Using Software

Question text: *What difficulties, if any, have you had in using software (please tick as many as are applicable):*

- *I did not encounter any problems*
- *I do not have access to relevant training*

- *I do not have dedicated IT support*
- *I do not have colleagues to consult on technical issues*

Main findings: While half of respondents did not encounter any problems using software, over a quarter felt that they did not have access to relevant training or dedicated IT support.

Quantitative analysis:

684 respondents
64 did not answer the question

While 49.3 % of respondents did not feel that they had encountered problems when using software, respondents from Ghana (67.7 %) were more in agreement than those from Bangladesh (44.1 %) or Nigeria (30.3 %). While at least 27.8 % of respondents felt that they did not have access to relevant training, this was by far a bigger issue for the Nigerian respondents (43.4 %) than for those from Bangladesh (29.2 %) or Ghana (13.3 %).

28.5 % of respondents felt that they did not have dedicated IT support. In contrast to the other statements, however, this concern was evenly distributed across all categories.

Difficulties using Software	Country				Total
	Bangladesh	Nigeria	Ghana	Other countries	
I didn't encounter any problems	89 44.1 %	53 30.3 %	153 67.7 %	42 51.9 %	**337** **49.3 %**
Don't have access to relevant training	59 29.2 %	76 43.4 %	30 13.3 %	25 30.9 %	**190** **27.8 %**
Don't have dedicated IT support	62 30.7 %	47 26.9 %	63 27.9 %	23 28.4 %	**195** **28.5 %**
Don't have colleagues to consult on technical issues	24 11.9 %	27 15.4 %	2 .9 %	20 24.7 %	**73** **10.7 %**
Other	0 .0 %	1 .6 %	2 .9 %	2 2.5 %	**5** **0.7 %**
Total no of respondents	**202** **29.5 %**	**175** **25.6 %**	**226** **33.0 %**	**81** **11.8 %**	**684** **100.0 %**
System missing: 64 respondents did not respond to the question on difficulties in using software.					

Table 18: Difficulties in using software.

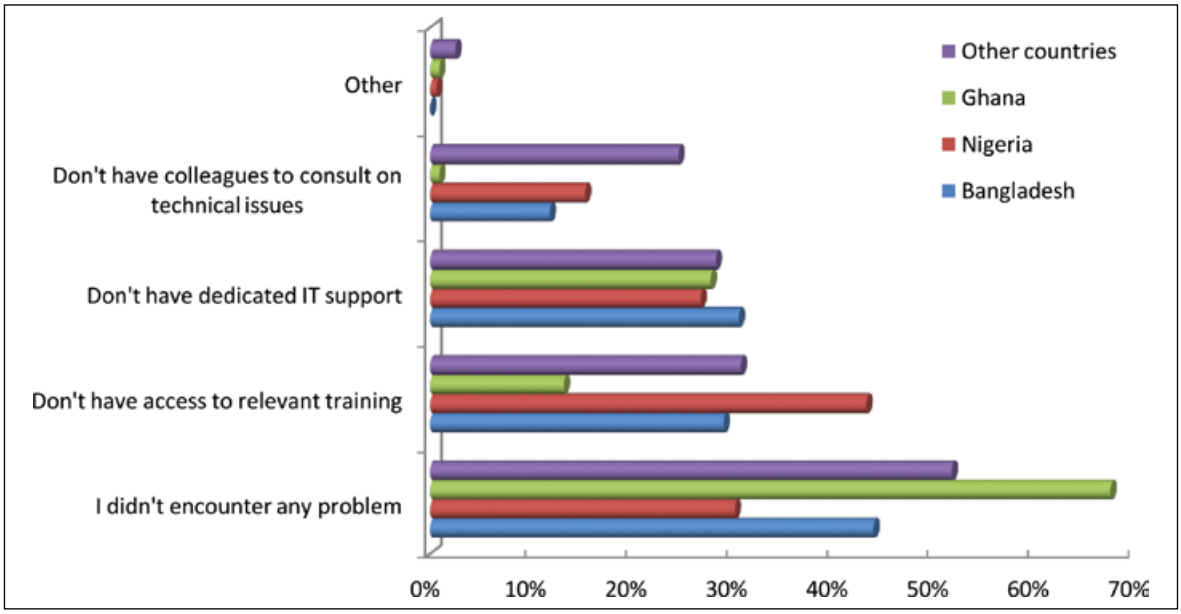

Figure 21: Difficulties in using software.

Discussion: While issues of training were of concern particularly to Nigerian respondents, issues of IT support were a unanimous concern. These responses highlight an important issue that has multiple implications. A lack of IT support – particularly when individuals are working on personal computers – can be highly detrimental to research productivity.

Moreover, a lack of dedicated IT support can influence which programmes can be gainfully used, and which not due to lack of local expertise and support. As at least 10% of respondents felt that they had no colleagues to consult for IT issues, the lack of IT support undoubtedly shapes what types of software are used in research contexts. It is thus of considerable importance that access to software issues be considered in conjunction with access to IT support. While institutions need to take responsibility for providing their researchers with adequate technical expertise, this is also an issue that can be acted upon at a national level. Moreover, promoting the existing support of the international community – already evident in many online software communities – will be of key value.

Question 13: Awareness of FOSS

Question text: *Please tick the statement that is most accurate for you:*

- *I have never heard of FOSS*
- *I have heard of FOSS but never used it*
- *I do not need to use FOSS*
- *I use FOSS sometimes*
- *I use FOSS regularly*
- *I use and promote FOSS*

Main findings: Two thirds of respondents had either never heard of FOSS, or never used it.

Quantitative analysis:

683 respondents
65 did not answer

42% of respondents had never heard of FOSS. This was lowest in Bangladesh (26.9%) and highest in Ghana (59.7%). Moreover, 23.3% of respondents had heard of FOSS, but never used it. Collectively, only 37.1% of respondents had any experience using FOSS.

Discussion: Thus, while 37.1% of respondents had some experience of FOSS, 62.9% had no experience using FOSS. This stands in contrast to responses to question 5 (Access to Software), where 52% of respondents indicated that the software they used in their research was free and open source. If anything, the disjunction between these two answers indicates the current confusion surrounding FOSS, and the critical need for more education and training in this area.

It is important to signal the inconsistencies between question 5 (Access to Software) and 13 (Awareness of FOSS), as this calls for more research on the underlying situation.

	Country				Total
	Bangladesh	Nigeria	Ghana	Other countries	
Never heard of FOSS	54 26.9%	74 42.3%	135 59.7%	24 29.6%	**287** **42.0%**
Heard of FOSS but never used	41 20.4%	33 18.9%	73 32.3%	12 14.8%	**159** **23.3%**
Don't need to use FOSS	25 12.4%	6 3.4%	7 3.1%	7 8.6%	**45** **6.6%**
Use FOSS sometimes	50 24.9%	42 24.0%	31 13.7%	24 29.6%	**147** **21.5%**
Use FOSS regularly	31 15.4%	16 9.1%	12 5.3%	15 18.5%	**74** **10.8%**
Use and promote FOSS	7 3.5%	8 4.6%	9 4.0%	9 11.1%	**33** **4.8%**
Total no of respondents	**201** **29.4%**	**175** **25.6%**	**226** **33.1%**	**81** **11.9%**	683 **100.0%**
System missing: 65 respondents did not respond to the awareness of FOSS question.					

Table 19: Country-wise awareness of FOSS.

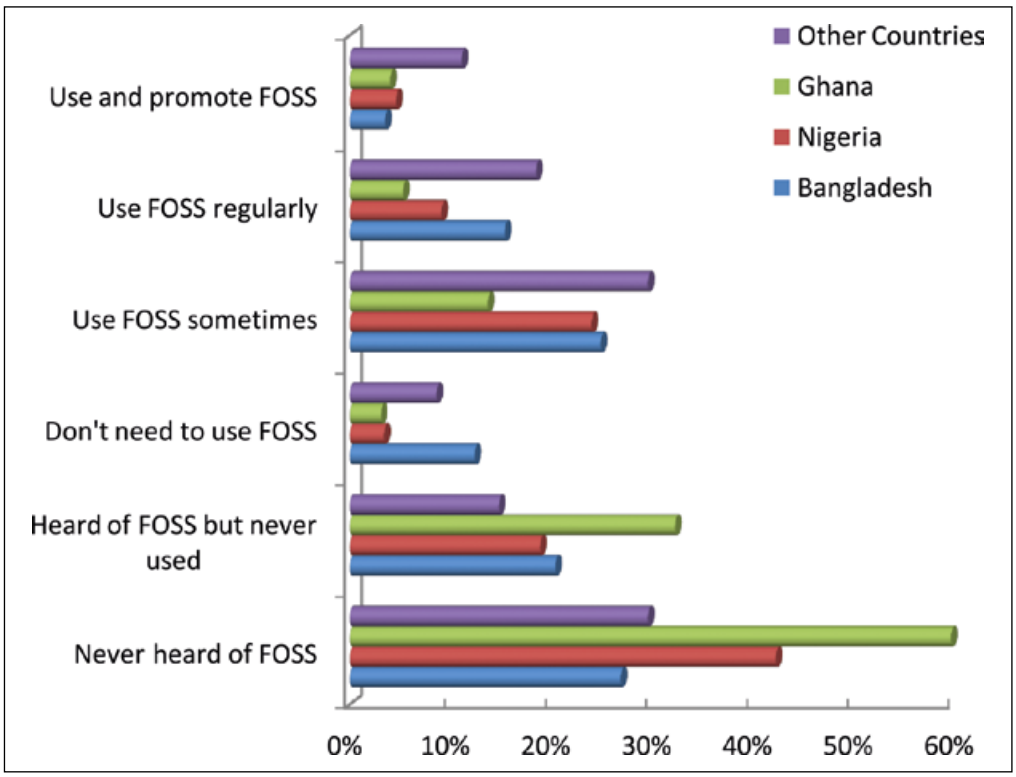

Figure 22: Country-wise awareness of FOSS.

One point of interest is the higher proportion of Bangladeshi respondents (12.4%) who did not feel that they needed to use FOSS. This contrasts significantly to the responses from Nigeria (3.4%) and Ghana (3.1%). It may be that this result reflects the prevalence of pirated software in this country, as explored in question 5 (Access to Software).

Question 14: Reasons for Not Using FOSS

Question text: *What are the reasons you have not used FOSS?*

- *I don't know what FOSS software are available*
- *I think they would be difficult to use*

	Country				Total
	Bangladesh	Nigeria	Ghana	Other countries	
Don't know what FOSS is available	65 71.4%	69 63.9%	146 85.4%	23 74.2%	**303** **75.6%**
Think they would be difficult	12 13.2%	21 19.4%	45 26.3%	3 9.7%	**81** **20.2%**
Will not get enough support in installing and use	9 9.9%	11 10.2%	20 11.7%	4 12.9%	**44** **11.0%**
No FOSS for my particular research	12 13.2%	6 5.6%	7 4.1%	3 9.7%	**28** **7.0%**
Available FOSS is not of the quality for my research	2 2.2%		3 1.8%	3 9.7%	**8** **2.0%**
Don't have access to reliable internet	1 1.1%		2 1.2%	2 6.5%	**5** **1.2%**
Not entitled to install software	1 1.1%	1 0.9%		1 3.2%	**3** **.7%**
Other	1 1.1%	1 0.9%		2 6.5%	**4** **1.0%**
Total no of respondents	**91** **22.7%**	**108** **26.9%**	**171** **42.6%**	**31** **7.7%**	**401** **100.0%**
System missing: 347 respondents did not respond to the question on reasons for not using FOSS.					

Table 20: Reasons for not using FOSS.

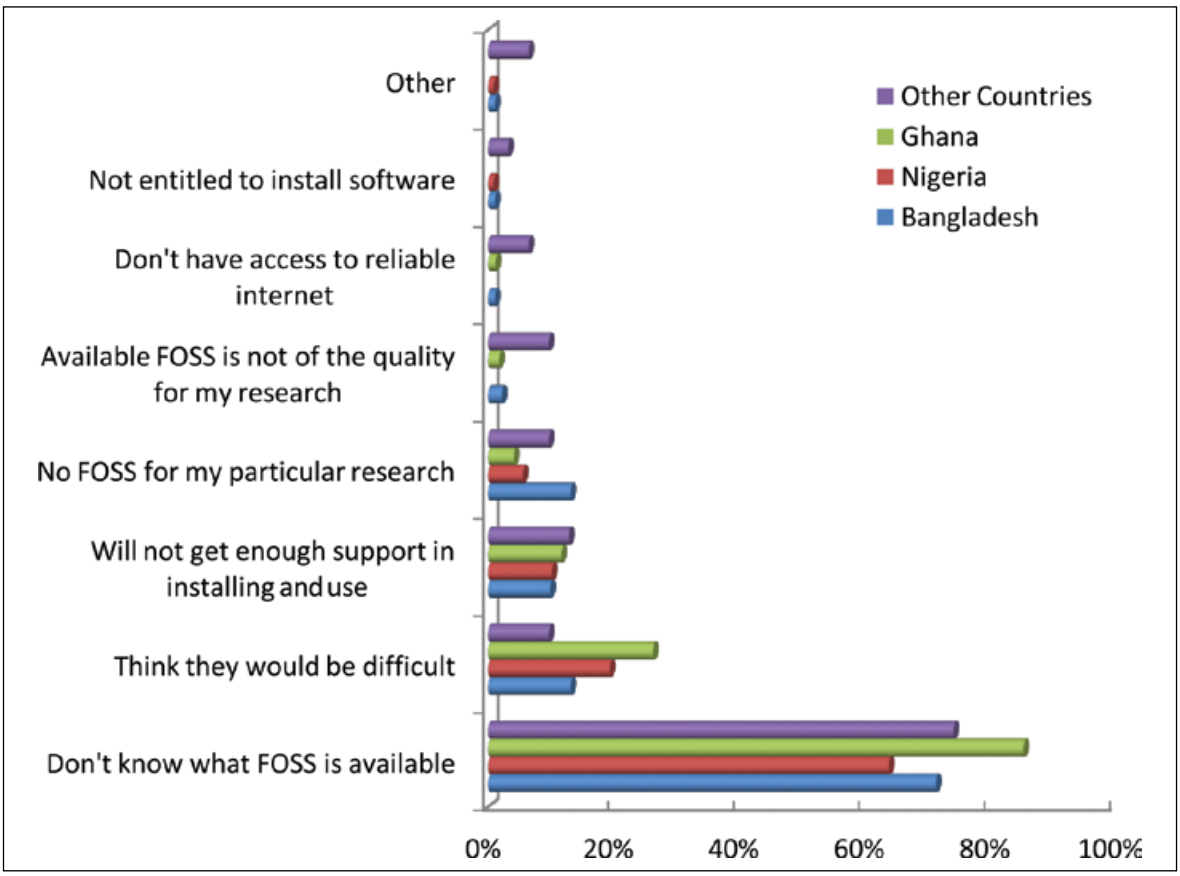

Figure 23: Reasons for not using FOSS.

- *I think I will not get enough support in installing and using it*
- *There is no FOSS for my particular research*
- *The FOSS available is not of the quality needed for my research*
- *I do not have access to a reliable internet connection*
- *I am not entitled to install software*

Main findings: Three quarters of respondents did not use FOSS because they were not aware of what was available. There were also concerns that using FOSS would be difficult and that they would not get the necessary support for installing and using it.

Quantitative analysis:

401 respondents
347 did not answer

75.6% of respondents did not use FOSS because they did not know what was available. This perception was lower in Nigeria (63.9%) and higher in Ghana (85.4%), but was by far the dominant response for all countries. Other key concerns were that FOSS was difficult to use (20.2%) and there was a lack of support for installing and using FOSS (11%).

Discussion: The results of this question corresponded with those of question 13 (Awareness of FOSS) that indicated a dominant lack of awareness of available FOSS. Indeed, three quarters of respondents to this question admitted that they did not use FOSS because they did not know what was available.

There was a widely spread perception that FOSS could be difficult to use. In a similar response to question 12 (Difficulties in Using Software), concerns about IT support for installing and using FOSS also ranked as a concern. Together, these statements point to a negative image of FOSS amongst respondents. Even with very little (or no) knowledge of FOSS, one in five respondents felt that it would be difficult to use. Such perceptions need to be actively ameliorated if FOSS use is to increase in these countries. These findings all point to the need for further education, training and advice. It is also possible that providing such information on a discipline-specific level may have considerable impact.

It is important to note that almost half of survey respondents (347) did not answer this question. While this may indicate that a considerable number of respondents do use FOSS, the responses from question 13 (Awareness of FOSS) make this unlikely. It is more feasible to speculate that the non-responses were from individuals with no prior knowledge of or experience with FOSS.

Together with question 13 (Awareness of FOSS), these results clearly highlight the need for considerable building of awareness of FOSS within these countries. They also highlight a key disjunction in current discussions that promote FOSS as a convenient alternative for researchers currently struggling with access to software. These results show that FOSS is not currently used to overcome software access issues. In addition, it is likely to be used without considerable educational and training initiatives, as evident in the negative responses within this question and those in question 15 (Further Information on FOSS use) below.

Question 15: Further Information on FOSS Use

Question text: *Please give us a little more information about your answer (e.g. Why you don't need to use FOSS or what FOSS you use/have used, how you are involved in promoting FOSS).*

Main findings: 158 respondents answered this free-text question. 41 respondents raised concerns about the quality and usability of FOSS. 14 respondents explicitly endorsed FOSS because they were free and usable, while 30 mentioned that they would promote FOSS use to colleagues and students. 66 respondents mentioned 35 different types of FOSS that they currently or previously have used.

Qualitative analysis: The analysis of the text was split into four parts: why I don't use FOSS, why I do use FOSS, what FOSS I use, and how I promote FOSS. The responses to these four headings were grouped thematically.

There were 41 answers to the question: why I don't use FOSS. These included:

- Issues of quality (8: 6 Bangladesh, 2 Ghana)
- It's difficult to use (7: 1 Bangladesh, 5 Ghana, 1 Nigeria)
- There's not enough support for installation and use (7: 3 Bangladesh, 3 Ghana, 1 Nigeria)
- Have all the software I need (9: 2 Ghana, 3 Nigeria, 4 Other)
- Compatibility issue (3: 2 Bangladesh, 1 Other)
- I don't know what FOSS is (3: 2 Bangladesh, 1 Nigeria)
- Other comments: not available, use pirate software, poor internet makes it difficult to use

There were also 14 answers to: why I use FOSS

- It's free (8 Bangladesh)
- Easy to use (3 Bangladesh)
- Other comments: I can't afford the licenses, some files open automatically with FOSS

In addition, 30 respondents said they encouraged others to use FOSS. Little detail was given, however, in how such encouragement was acted upon.

66 respondents listed 35 different types of FOSS software that they use or have used. Key amongst the responses was the use of operating systems such as Linux and Ubuntu, and programming languages such as Python. Also heavily used were programmes such as Open Office and R/GNU.

Discussion: The 41 responses as to why respondents did not use FOSS correspond very closely to the findings of questions 13 (Awareness of FOSS) and 14 (Reasons for Not Using FOSS). While it was unfortunate that respondents did not give any further detail regarding their activities, it was interesting to note that 30 respondents considered themselves to be actively promoting and recommending FOSS to their peers and students.

It must nonetheless be noted that only 9% of the entire respondent pool identified FOSS software that they currently or previously had used. This list of FOSS software used was much smaller than the previous lists of software used or desired, but continued to display considerable diversity. Key amongst the responses was the use of operating systems and programming languages.

These findings match responses to previous questions that emphasise the importance of ac-

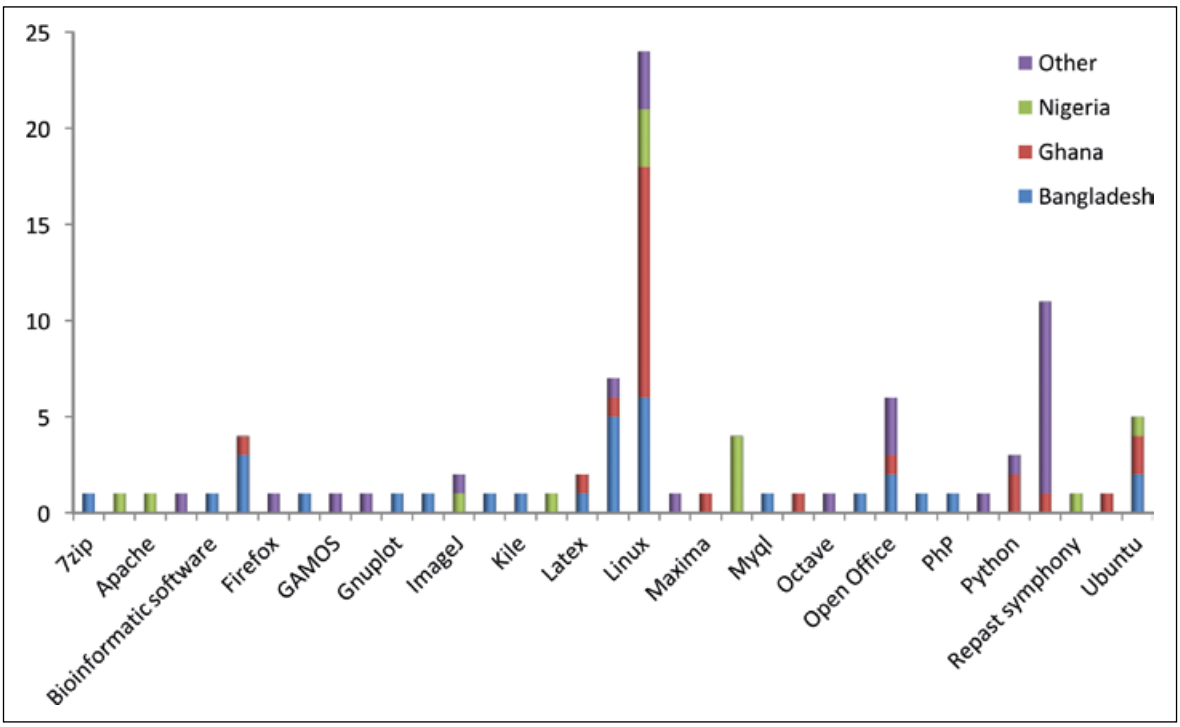

Figure 24: FOSS used (number of users in vertical axis).

cess to non-FOSS software, and the diversity of software needed by researchers. Nonetheless, the responses to this question also highlight some confusion surrounding FOSS, as among software mentioned is Matlab, which is proprietary with free add-ons.

Answers to this question should also be understood in light of the responses to question 13 (Awareness of FOSS), where the majority indicated that they do not know what FOSS is.

Question 16: Attitudes to FOSS

Question text: *Please pick the statement that is most accurate for you:*

- *I am interested in using the software and do not need the code to be open*
- *I am interested in acquiring the source of the code for the software I use*
- *I am interested in being able to modify the source of the code for the software I use*
- *I am interested in using free and open source software. I don't know the difference between having access to software and having access to source code*
- *I am not interested in using free and open source software*

Main findings: Only 3.5 % of respondents had no interest in using FOSS, although understandings of – and desires to acquire – source code varied considerably.

Quantitative analysis:

630 responded
118 did not answer

The highest percentage of respondents (28.3 %) were interested in acquiring the source of the code of the software they use. 24.3 % of respondents wanted to modify the source of the code for the software they use. 22.7 % respondents were not interested regarding source code.

The majority of the respondents interested in acquiring source code are in the physical, chemical sciences and engineering disciplines. However, when interest using FOSS is observed, 21.3 % of respondents show interest in using FOSS but do not know how to access the software or source code. Only 3.5 % of respondents show no interest in using FOSS. A highly significant association ($p=0.0008$) is observed among opinions and discipline of the respondents.

Statement	Discipline							Total	*p*-value
	Physical, Chemical Sciences and Engineering	Mathematical and Statistical Sciences	Social Sciences	Life and Earth Sciences	Medical Sciences	Business	Humanities		
Interested in using the software and don't need the source code to be open	70 11.1%	23 3.7%	18 2.9%	12 1.9%	7 1.1%	1 .2%	12 1.9%	143 22.7%	0.0008
Interested in acquiring the source of the code for the software I use	71 11.3%	13 2.1%	27 4.3%	21 3.3%	16 2.5%	15 2.4%	15 2.4%	178 28.3%	
Interested in being able to modify the source of the code for the software I use	63 10.0%	15 2.4%	24 3.8%	20 3.2%	8 1.3%	12 1.9%	11 1.7%	153 24.3%	
Interested in using FOSS. Didn't know the difference between having access to software and having access to the source code	39 6.2%	20 3.2%	21 3.3%	33 5.2%	7 1.1%	2 .3%	12 1.9%	134 21.3%	
Not interested in using FOSS	8 1.3%	2 .3%	4 .6%	5 .8%	1 .2%	1 .2%	1 .2%	22 3.5%	
Total	251 39.8%	73 11.6%	94 14.9%	91 14.4%	39 6.2%	31 4.9%	51 8.1%	630 100.0%	

Table 21 Level of openness sought in software, according to discipline.

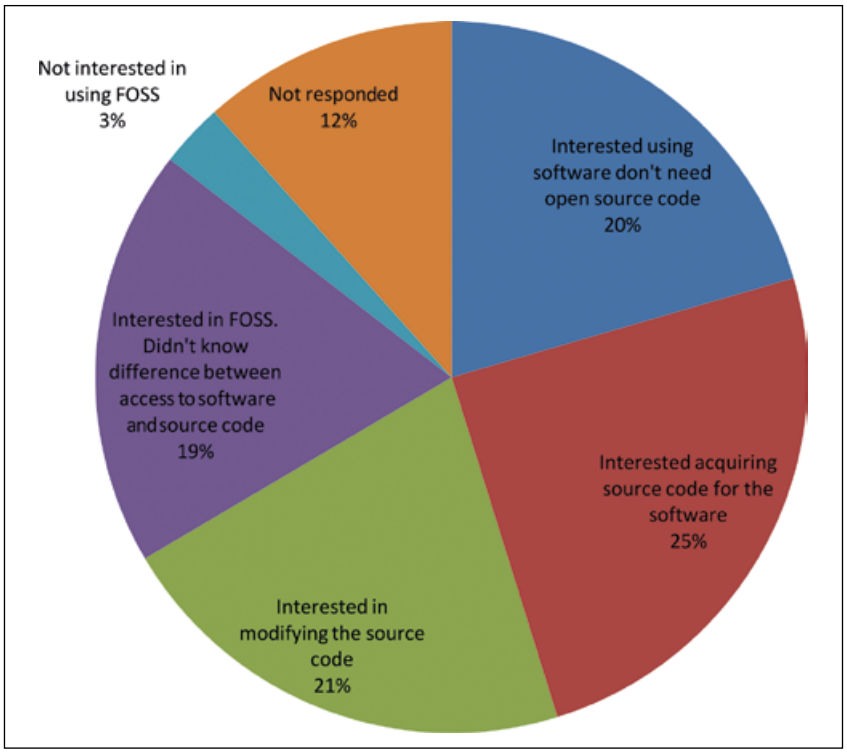

Figure 25 Level of openness sought in software, accumulated for all disciplines.

Question 17: Interest in FOSS

Question text: *To what extent do you agree with the following statements about FOSS:*

- *I am interested in FOSS*
- *The people that I work with are interested in FOSS*
- *I would like to have more information about FOSS*
- *I would like to receive training about FOSS*
- *I would like to use FOSS in the future*
- *I would like to be involved in developing FOSS*

Quantitative analysis:

661 responded
87 did not answer

As is evident from the table below, this question yielded uniform results: 87.2% of respondents either agree or strongly agree with the statement 'I am interested in FOSS'. Most declare their colleagues are also interested, although 27.5% disagreed or strongly disagreed (with a 14.7% in agreement drop from personal interest). 87.8% agreed or strongly agreed with 'I would like to have more information about FOSS', while 83.8% agreed or strongly agreed with 'I would like to receive training about FOSS'. Moreover, 89.4% of respondents wanted to use FOSS in the future, while 75.6% would like to be involved in developing FOSS. Highly significant country-wise association was observed for each of the FOSS statements ($p < 0.01$).

Discussion: The results from this question were very diverse, undoubtedly reflecting not only the variety of different opinions on FOSS, but also the varying levels of awareness. In light of the responses to questions such as 13 (Awareness of FOSS), however, these responses must be taken with caution. Although 89.4% of respondents to this question wanted to use FOSS in the future, and 75.6% wanted to be involved in developing FOSS, 71.9% of respondents to question 13 (Awareness of FOSS) had never heard of or used FOSS before. Thus, these responses may be an optimistic, rather than a realistic reflection of the status quo. Moreover, given the confusion surrounding FOSS that is evident in the free text answers to the earlier questions, it is possible that FOSS is being correlated with free access to licensed software.

It should also be noted that "interest" is a rather vague term that does not imply a clear

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
I am interested in FOSS	Strongly Disagree	4 2.1%	19 11.2%	11 4.9%	3 4.1%	37 5.6%	0.0024
	Disagree	12 6.2%	14 8.3%	20 8.8%	2 2.7%	48 7.3%	
	Agree	117 60.6%	84 49.7%	127 56.2%	33 45.2%	361 54.6%	
	Strongly Agree	60 31.1%	52 30.8%	68 30.1%	35 47.9%	215 32.5%	
	Total	193 29.2%	169 25.6%	226 34.2%	73 11.0%	661 100.0%	
People I work with are interested in FOSS	Strongly Disagree	1 0.5%	17 10.1%	6 2.7%	2 2.8%	26 3.9%	0.00005
	Disagree	54 28.1%	40 23.7%	50 22.1%	11 15.3%	155 23.5%	
	Agree	93 48.4%	93 55.0%	125 55.3%	37 51.4%	348 52.8%	
	Strongly Agree	44 22.9%	19 11.2%	45 19.9%	22 30.6%	130 19.7%	
	Total	192 29.1%	169 25.6%	226 34.3%	72 10.9%	659 100.0%	

Table 22: Interest in FOSS (*Continued on next page*)

Table 22, *Continuation.*

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
Like to have more information about FOSS	Strongly Disagree	1 0.5%	12 7.1%	9 4.0%	3 4.1%	25 3.8%	0.0008
	Disagree	14 7.3%	19 11.2%	12 5.3%	13 17.8%	58 8.8%	
	Agree	108 56.2%	76 45.0%	133 58.8%	37 50.7%	354 53.6%	
	Strongly Agree	69 35.9%	62 36.7%	72 31.9%	20 27.4%	223 33.8%	
	Total	192 29.1%	169 25.6%	226 34.2%	73 11.1%	660 100.0%	
Like to receive training about FOSS	Strongly Disagree	2 1.0%	13 7.7%	9 4.0%	5 6.8%	29 4.4%	0.0089
	Disagree	23 12.0%	17 10.1%	24 10.6%	17 23.3%	81 12.3%	
	Agree	98 51.0%	89 52.7%	113 50.0%	32 43.8%	332 50.3%	
	Strongly Agree	69 35.9%	50 29.6%	80 35.4%	19 26.0%	218 33.0%	
	Total	192 29.1%	169 25.6%	226 34.2%	73 11.1%	660 100.0%	
Like to use FOSS in the future	Strongly Disagree	3 1.6%	13 7.7%	8 3.5%	2 2.7%	26 3.9%	0.0084
	Disagree	15 7.8%	18 10.7%	13 5.8%	1 1.4%	47 7.1%	
	Agree	99 51.6%	84 49.7%	138 61.1%	42 57.5%	363 55.0%	
	Strongly Agree	75 39.1%	54 32.0%	67 29.6%	28 38.4%	224 33.9%	
	Total	192 29.1%	169 25.6%	226 34.2%	73 11.1%	660 100.0%	
Like to involve in developing FOSS	Strongly Disagree	5 2.6%	13 7.7%	14 6.2%	9 12.3%	41 6.2%	0.00005
	Disagree	37 19.3%	25 14.8%	37 16.4%	24 32.9%	123 18.6%	
	Agree	97 50.5%	107 63.3%	116 51.3%	25 34.2%	345 52.3%	
	Strongly Agree	53 27.6%	24 14.2%	59 26.1%	15 20.5%	151 22.9%	
	Total	192 29.1%	169 25.6%	226 34.2%	73 11.1%	660 100.0%	

commitment, not even a clear commitment to invest time and energy to learn more about FOSS.

Nonetheless, the responses to this question highlight an important consideration: respondents recognise and endorse future efforts to facilitate access to software that take into consideration the constraints of their research budgets. Even taking into consideration the confusion surrounding FOSS, this question clearly highlights that respondents advocate for more access to free software – be it FOSS, freemium, fee-waivers or free software.

Question 18: Perceptions of Support for FOSS

Question text: *To what extent do you agree with the following statements about FOSS:*

- *Learned societies relevant to my field support the use of FOSS*
- *Funding bodies I am involved with support the use of FOSS*

Main findings: Most respondents did not know if learned societies and funding bodies in their field supported the use of FOSS.

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
Learned societies relevant to my field support the use of FOSS	Strongly Disagree	3 1.6%	10 5.9%	1 0.4%	2 2.7%	16 2.4%	0.00001
	Disagree	19 9.8%	18 10.7%	16 7.1%	12 16.4%	65 9.8%	
	Agree	91 47.2%	79 46.7%	26 11.5%	22 30.1%	218 33.0%	
	Strongly Agree	23 11.9%	27 16%	1 0.4%	13 17.8%	64 9.7%	
	Don't know/ not applicable	57 29.5%	35 20.7%	182 80.5%	24 32.9%	298 45.1%	
	Total	193 29.2%	169 25.6%	226 34.2%	73 11.0%	661 100.0%	
Funding bodies I am involved with support the use of FOSS	Strongly Disagree	1 0.5%	5 3.0%	3 1.3%	3 4.1%	12 1.8%	0.00001
	Disagree	30 15.6%	31 18.3%	15 6.6%	17 23.3%	93 14.1%	
	Agree	50 26.0%	65 38.5%	19 8.4%	15 20.5%	149 22.6%	
	Strongly Agree	31 16.1%	23 13.6%		11 15.1%	65 9.8%	
	Don't know/ not applicable	80 41.7%	45 26.6%	189 83.6%	27 37.0%	341 51.7%	
	Total	192 29.1%	169 25.6%	226 34.2%	73 11.1%	660 100.0%	

Table 23: Country-wise perceptions of support for FOSS.

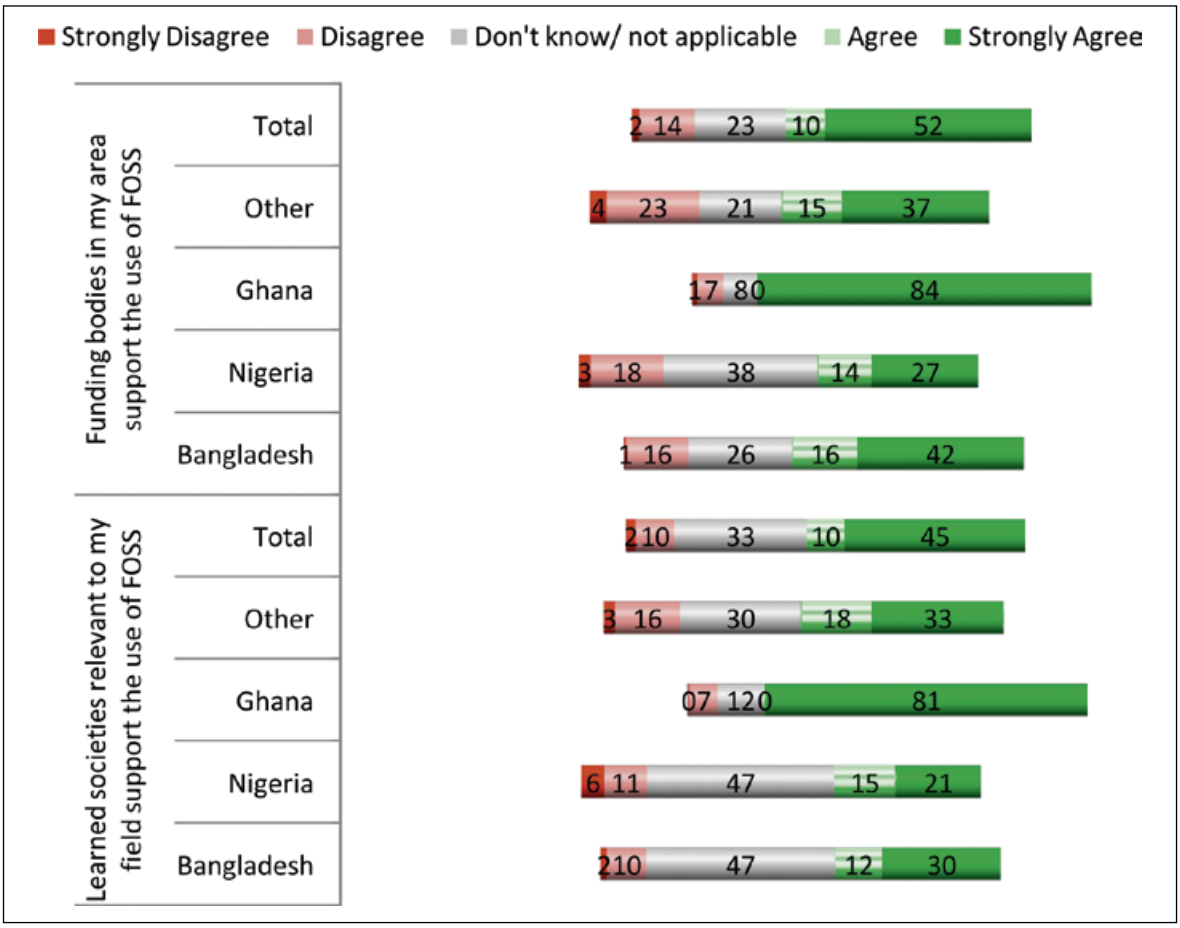

Figure 26: Country-wise perceptions of support for FOSS.

Quantitative analysis:

661 responded
87 did not answer the question

For both statements, the majority of respondents did not know the answer. 45.1% of respondents did not know whether learned societies relevant to their field of study supported FOSS, while 51.7% did not know whether funding bodies they were involved with did. Significant country-wise differences of the agreement on perceptions of support for FOSS were found (p = 0.00001).

Discussion: This response clearly highlights the need for the further involvement of learned societies and funding bodies in the promotion of FOSS. These bodies need to be more explicit about promoting the availability of, and use of, FOSS amongst their grant holders.

Question 19: Important Factors in Making Research Software More Available

Question text: *What do you think is the most important factor in making research software more available in the future (1 = most important, 5 = least important). There would be better access to research software if ...*

- *Appropriate FOSS alternatives were easier to find*
- *Appropriate FOSS alternatives were promoted and supported*
- *Appropriate licensed software was easier to find*
- *Software licenses were significantly discounted for individuals in developing and emerging countries*
- *Software licenses were significantly discounted for institutions and developing and emerging countries*

Statement	Agreement	Country				Total	p-value
		Bangladesh	Nigeria	Ghana	Other Countries		
Appropriate FOSS alternatives were easier to find	Strongly Disagree	46 29.9%	52 35.9%	59 26.2%	17 26.6%	174 29.6%	0.002
	Disagree	43 27.9%	23 15.9%	42 18.7%	24 37.5%	132 22.4%	
	Agree	23 14.9%	20 13.8%	37 16.4%	9 14.1%	89 15.1%	
	Strongly Agree	20 13.0%	14 9.7%	43 19.1%	9 14.1%	86 14.6%	
	Don't know/ not applicable	22 14.3%	36 24.8%	44 19.6%	5 7.8%	107 18.2%	
	Total	154 26.2%	145 24.7%	225 38.3%	64 10.9%	588 100.0%	
Appropriate FOSS alternatives were promoted and supported	Strongly Disagree	34 21.9%	22 15.1%	20 8.9%	23 35.9%	99 16.8%	0.00018
	Disagree	39 25.2%	47 32.2%	53 23.6%	14 21.9%	153 25.9%	
	Agree	38 24.5%	28 19.2%	59 26.2%	10 15.6%	135 22.9%	
	Strongly Agree	24 15.5%	32 21.9%	56 24.9%	13 20.3%	125 21.2%	
	Don't know/ not applicable	20 12.9%	17 11.6%	37 16.4%	4 6.2%	78 13.2%	
	Total	155 26.3%	146 24.7%	225 38.1%	64 10.8%	590 100.0%	

Table 24: Perceptions of factors important in making necessary software more accessible (*Continued on next page*).

Table 24, *Continuation*.

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
Appropriate licensed software was easier to find	Strongly Disagree	25 16.2%	21 14.1%	36 16.0%	3 4.7%	85 14.4%	0.00005
	Disagree	27 17.5%	19 12.8%	33 14.7%	7 10.9%	86 14.5%	
	Agree	44 28.6%	64 43.0%	62 27.6%	16 25.0%	186 31.4%	
	Strongly Agree	32 20.8%	26 17.4%	57 25.3%	8 12.5%	123 20.8%	
	Don't know/ not applicable	26 16.9%	19 12.8%	37 16.4%	30 46.9%	112 18.9%	
	Total	154 26.0%	149 25.2%	225 38.0%	64 10.8%	592 100.0%	
Software licenses were significantly discounted for individuals in developing and emerging countries	Strongly Disagree	19 12.3%	25 17.1%	45 20.0%	6 9.4%	95 16.1%	0.00
	Disagree	27 17.5%	35 24.0%	56 24.9%	11 17.2%	129 21.9%	
	Agree	28 18.2%	16 11.0%	26 11.6%	12 18.8%	82 13.9%	
	Strongly Agree	44 28.6%	50 34.2%	37 16.4%	28 43.8%	159 27.0%	
	Don't know/ not applicable	36 23.4%	20 13.7%	61 27.1%	7 10.9%	124 21.1%	
	Total	154 26.1%	146 24.8%	225 38.2%	64 10.9%	589 100.0%	
Software licenses were significantly discounted for institutes in developing and emerging countries	Strongly Disagree	31 20.1%	28 18.5%	65 28.9%	15 23.4%	139 23.4%	0.004
	Disagree	18 11.7%	24 15.9%	41 18.2%	8 12.5%	91 15.3%	
	Agree	21 13.6%	20 13.2%	41 18.2%	17 26.6%	99 16.7%	
	Strongly Agree	34 22.1%	24 15.9%	32 14.2%	6 9.4%	96 16.2%	
	Don't know/ not applicable	50 32.5%	55 36.4%	46 20.4%	18 28.1%	169 28.5%	
	Total	154 25.9%	151 25.4%	225 37.9%	64 10.8%	594 100.0%	

Main findings: A total of 670 respondents agreed or disagreed with these statements. Significant country-wise association was observed for each of the important factors ($p < 0.01$). It is hard to extract significant insight from these answers, because there is a very widely distributed ranking of factors, with respondents ranking relatively evenly across.

Quantitative analysis:

- 670 responded
- 78 did not answer the question

Discussion:

This set of responses again highlights a strong interest in FOSS. It is also notable that respondents are more interested in having significantly discounted individual license software compared to institutional licenses for developing and emerging countries.

However, no further emphasis should be put on the results for three reasons: (1) rankings were evenly distributed; (2) no benchmark was available, which indicates that respondents could still

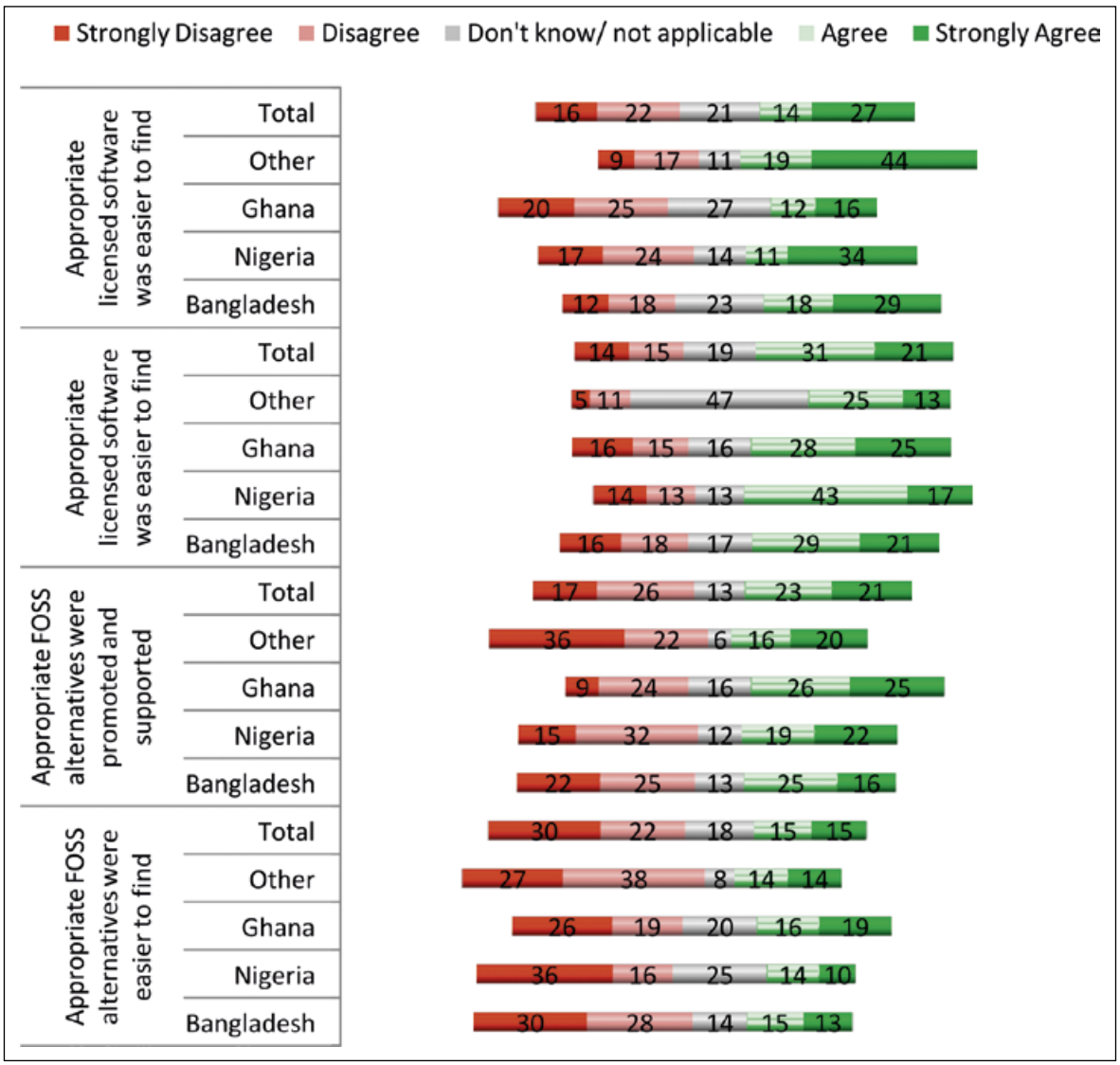

Figure 27: Perceptions of factors important in making necessary software more accessible.

value the lowest ranking item very highly, but regard it as a lower priority because longer-term or unrealistic; (3) the question heading failed to clarify the absolute magnitude of importance of the factors listed as options for the ranking. As a consequence, it is difficult to interpret why respondents ranked these factors as they did, and ranking does not necessarily relate to whether or not respondents think that a given factor is desirable. It is perfectly possible that respondents remain very interested in software licenses, but rank them lower priority relatively to FOSS.

Question 20: Other Factors for Making Research Software More Available

Question text: *Is there anything else that you think is important for making research software more available in the future?*

Main findings: This was a free-text question which 116 respondents answered. When the text was analysed, 7 main themes emerged: training, funding, making FOSS more accessible, more publicity, more development, helping the low-income countries, and making FOSS free.

Qualitative analysis:

The table below summarises the coding of the free-text responses, detailing the theme, number of respondents (and countries), a representative quote and any further discussion.

Discussion: Two strong themes from this question were the need for training in software usage, and the need for additional funding to implement, develop and support software usage, in agreement with previous questions. It is of importance to note that while 6 respondents

Theme	Respondents	Key quote	Discussion
Funding	28 5 B 11 G 12 N	More research funding to acquire tools	6 quotes mentioned the need for government funding, 2 quotes mentioned funding for software development
Training needed	23 3 B 14 G 5 N 1 O	training on the use of the software	Very similar quotes on need for training and education
No response	14 8 B 2 N 3 O	I don't know.	
Mismanagement of funds	9 9N	funds may be diverted for other research areas this may be overcome by organising a monitory body to make sure the fund is appropriately disturbed	These quotes drew attention to poor bureaucratic oversight, mismanagement of funds and diversion of funds intended for research
More development of software	9 2 B 7 G	Building and testing new software	Quotes mentioned need for development of specific software. One quote mentioned possible distribution of free trial packages, one mentioned installing FOSS automatically on new machines
Helping low-income countries	7 2 B 3 G 2 O	It should be free access for developing and undeveloped countries.	Quotes suggested that software should be free for low-income countries. This seemed to refer to licensed software and not FOSS
Making FOSS more accessible	6 3 B 2 G 1 N	User friendly and specific research related software	Software should be made user friendly and easily accessible
More publicity needed	6 1 B 5 G	They should be promoted so that more people will become aware	More publicity and marketing is needed so that scientists are aware of software available
Other single quotes		It would assist the younger generation of researchers to complete their researches faster and more convenient Avoid illegal copies promotions Making information more available.	

B = Bangladesh; G = Ghana; N = Nigeria; O = Other

Table 25: Perceived additional factors to make software more accessible.

mentioned FOSS explicitly, the majority of the respondents did not make such distinctions.

28 respondents mentioned issues of funding explicitly – highlighting not only the desire for licensed software, but also the current dearth of dedicated funds for software acquisition. In relation to funds, 6 respondents mentioned the responsibility of governments to provide these funds. Interestingly, 9 respondents from Nigeria explicitly drew attention to poor bureaucratic oversight, mismanagement of funds and diversion of funds intended for research. These quotes highlight a key tension existing in many countries – that increased software budgets may not necessarily translate into increased software acquisition.

23 of the respondents mentioned the need for more training. Such responses draw on themes that have been present in many questions throughout the survey, e. g. that respondents were not aware of possible software available, of alternative software acquisition pathways, of FOSS

alternatives, or how best to use the software that are available. These points underscore the key need to improve software awareness amongst researchers so that they may best exploit the resources that are already available to them.

Question 21: Perception of Future Access to Research Software

Question text: *To what extent do you agree with the following statements: In the future ...*

- *I will be able to buy the software licenses I need*
- *My colleagues will be able to buy the software they need*
- *My department or institution will be able to allocate regular budget to software licenses*
- *My department or institution will be able to allocate one-off budget to software licenses*
- *Research or project funds will include budget for software licenses*
- *A consortium could be formed in order to buy software licenses*
- *It would be easiest to pay for licenses through a (smaller) annual fee*
- *It would be easiest to pay for licenses through a (larger) once-off fee*

Main findings: There was a general recognition amongst respondents that funding was a particular problem in terms of access to software. Moreover, there was little clarity about how to address this or what would constitute sources of funding in the future. Significant country-wise association was observed for each of the important factors ($p < 0.01$).

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
Will be able to buy software license I need	No	63 33.2%	17 10.8%	29 12.9%	6 9.4%	115 18.1%	0.00
	May be	88 46.3%	82 51.9%	124 55.1%	29 45.3%	323 50.7%	
	Yes	21 11.1%	52 32.9%	61 27.1%	24 37.5%	158 24.8%	
	Don't Know	18 9.5%	7 4.4%	11 4.9%	5 7.8%	41 6.4%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
My colleagues will be able to buy software they need	No	33 17.4%	9 5.7%	15 6.7%	6 9.4%	63 9.9%	0.001
	May be	103 54.2%	78 49.4%	131 58.2%	33 51.6%	345 54.2%	
	Yes	30 15.8%	46 29.1%	51 22.7%	19 29.7%	146 22.9%	
	Don't Know	24 12.6%	25 15.8%	28 12.4%	6 9.4%	83 13.0%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
My department or institute will be able to allocate regular budget to buy software licenses	No	14 7.4%	11 7.0%	15 6.7%	11 17.2%	51 8.0%	0.01
	May be	85 44.7%	73 46.2%	102 45.3%	26 40.6%	286 44.9%	
	Yes	79 41.6%	48 30.4%	84 37.3%	25 39.1%	236 37.0%	
	Don't Know	12 6.3%	26 16.5%	24 10.7%	2 3.1%	64 10.0%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	

Table 26: Perception of future of access to research software *(Continued on next page)*.

Table 26, *Continuation*

Statement	Agreement	Country				Total	*p*-value
		Bangladesh	Nigeria	Ghana	Other Countries		
My department or institute will be able to allocate one-off budget to buy software licenses	No	12 6.3%	9 5.7%	9 4.0%	10 15.6%	40 6.3%	0.054
	May be	78 41.1%	73 46.2%	101 44.9%	28 43.8%	280 44.0%	
	Yes	71 37.4%	46 29.1%	84 37.3%	17 26.6%	218 34.2%	
	Don't Know	29 15.3%	30 19.0%	31 13.8%	9 14.1%	99 15.5%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
Research or project funds will include budget for software licenses	No	16 8.4%	9 5.7%	16 7.1%	8 12.5%	49 7.7%	0.636
	May be	75 39.5%	66 41.8%	84 37.3%	21 32.8%	246 38.6%	
	Yes	78 41.1%	60 38.0%	101 44.9%	29 45.3%	268 42.1%	
	Don't Know	21 11.1%	23 14.6%	24 10.7%	6 9.4%	74 11.6%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
A consortium could be formed in order to buy software licenses	No	12 6.3%	9 5.7%	5 2.2%	6 9.4%	32 5.0%	0.008
	May be	74 38.9%	61 38.6%	101 44.9%	27 42.2%	263 41.3%	
	Yes	74 38.9%	74 46.8%	79 35.1%	16 25.0%	243 38.1%	
	Don't Know	30 15.8%	14 8.9%	40 17.8%	15 23.4%	99 15.5%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
It would be easiest to pay for licenses through a (smaller) annual fee	No	14 7.4%	6 3.8%	18 8.0%	12 18.8%	50 7.8%	0.000
	May be	72 37.9%	63 39.9%	108 48.0%	22 34.4%	265 41.6%	
	Yes	85 44.7%	75 47.5%	74 32.9%	16 25.0%	250 39.2%	
	Don't Know	19 10.0%	14 8.9%	25 11.1%	14 21.9%	72 11.3%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	
It would be easiest to pay for licenses through a (larger) one-off fee	No	46 24.2%	20 12.7%	34 15.1%	13 20.3%	113 17.7%	0.001
	May be	60 31.6%	69 43.7%	101 44.9%	20 31.2%	250 39.2%	
	Yes	58 30.5%	51 32.3%	54 24.0%	13 20.3%	176 27.6%	
	Don't Know	26 13.7%	18 11.4%	36 16.0%	18 28.1%	98 15.4%	
	Total	190 29.8%	158 24.8%	225 35.3%	64 10.0%	637 100.0%	

Quantitative analysis:

637 responded
111 did not answer

Discussion: There was a general recognition amongst respondents that funding was a particular problem in terms of access to software. Moreover, there was little clarity about how to

address this or where funding is likely to be. Respondents appeared to have more confidence in external funding than in institutional funding, which correlated with the current lack of institutional involvement (such as questions 5 (Access to Software), 11 (Difficulties in Accessing Software) and 20 (Other Factors for Making Research Software More Available)).

A number of responses highlighted the difficulties that researchers experienced with the current system of software acquisition. There was little optimism for being able to self-finance licenses using current payment models, emphasising the need to change current methods of software acquisition. In keeping with the emphasis on proprietary software and the purchase of personal licenses, there was support for smaller annual payments over one-off larger payment. This would be of considerable importance if researchers in low-income countries are to continue to be largely responsible for their research software.

Moreover, the notion of software funds being included in research funding, or access negotiated through consortia received interest. These responses also clearly highlight the difficulties within the current model, and the urgent need for alternative means of acquisition of proprietary software to be investigated.

Question 22: Budget for Research Software

Question text: *What is the typical annual software budget you have access to (in USD)?*

Main findings: The largest group of respondents did not know what their annual software budget was. Of those who did, the majority had budgets lower than USD 500 annually.

Quantitative analysis:
637 responded
111 did not answer

Countries	Budget (USD)							Total	*p*-value
	0	1–200	201–500	501–1000	1001–5000	5000	Don't know		
Bangladesh	49 34.0%	27 23.5%	11 14.1%	9 26.5%	1 7.7%	6 50.0%	87 36.1%	190 29.8%	0.00001
Nigeria	50 34.7%	49 42.6%	10 12.8%	3 8.8%	5 38.5%	0 .0%	41 17.0%	158 24.8%	
Ghana	40 27.8%	27 23.5%	52 66.7%	17 50.0%	1 7.7%	2 16.7%	86 35.7%	225 35.3%	
Other Countries	5 3.5%	12 10.4%	5 6.4%	5 14.7%	6 46.2%	4 33.3%	27 11.2%	64 10.0%	
Total	144 22.6%	115 18.1%	78 12.2%	34 5.3%	13 2.0%	12 1.9%	241 37.8%	637 100.0%	

Table 27: Typical annual budget for software (in USD).

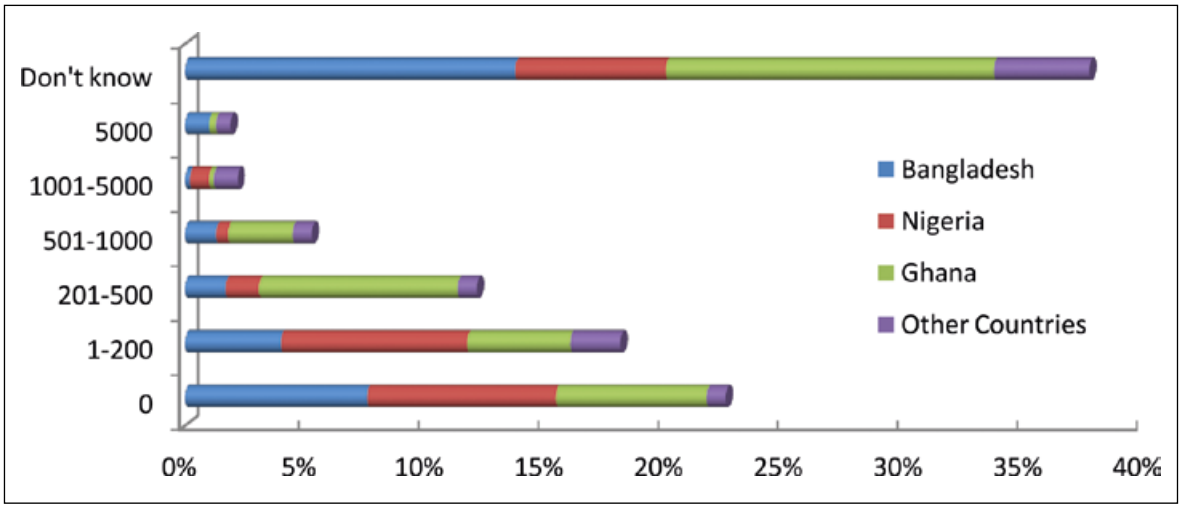

Figure 28: Typical annual budget for software (in USD).

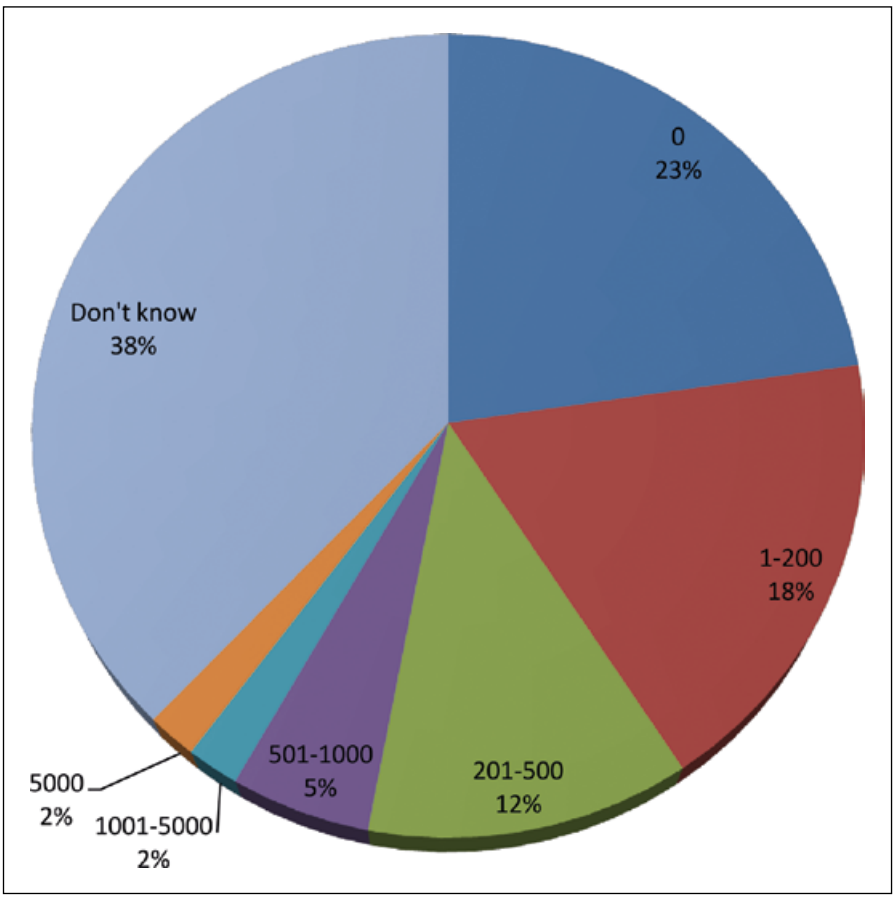

Figure 29: Distribution of typical annual budgets for software (in USD).

It is salient to recognise that 37.8% of respondents did not know what their annual software budget was. Of those that did respond, 52.9% had budgets of USD 500 or less, leaving only 9.2% with budgets above USD 500 per year.

Also striking is the association between country and budget diversity.

Discussion: Out of these responses, 32% of respondents did not know what kind of budget they have access to for software. Moreover, 19% reported that they had no dedicated budget for software at all. Only 9% of respondents reported that they have access to over USD 500 of software budget per year. It is important to note that this question did not provide any information on how such a budget could be spent – on personal licenses, on specific software, or on students.

When one considers the cost of personal licenses, it is very evident that the budgets being reported are by no means sufficient to address the shortage of software reported elsewhere in the survey. Moreover, the low use of FOSS amongst this same population of researchers clearly indicates that the current situation is untenable.

Question 23: Challenges in Allocating Funds for Software, and Possible Solutions

Question text: *What would be the greatest challenge in allocating funds for software, and how could it be overcome?*

Main findings: This was a free-text question that was answered by 148 respondents. Their answers grouped strongly into 6 main themes: issues with funding, need for budgeting, management of funds, lack of awareness, government policy and mentality, and issues with pricing.

Qualitative analysis:

The table below summarises the coding of the free-text responses, detailing the theme, number of respondents (and countries), a representative quote and any further discussion.

Discussion: These themes indicate the significant problems that lack of funds and problems in budgeting represent for the respondents of the survey. In some cases, particularly obvious from some Bangladesh responses, foreign purchases are also made difficult by issues related

Theme	Respondents	Representative quote	Discussion
Funding	37 8 B 27 G 2 O	Lack of funds	Many of the quotes were single statements about lack of funds. What funds these referred to (software purchasing, technical support or for equipment) is unclear
Government policy and mentality	31 29 B 2 G	Govt, policy, laws, willingness, price	The majority of these quotes were also brief, and no discussion was had on what aspect of the policy was at fault and needed to change. There were 7 Bangladeshi quotes mentioned *financial law* (concerning taxes over purchase orders abroad).
Budgeting	29 9 B 12 G 1 N 7 O	Improving the budget allocation.	Again, what the budget would be allocated for was unclear from the quotes
Price and purchasing	17 7 B 6 G 1 N 3 O	People are not willing to pay for software if they have unpaid copy.	These were miscellaneous quotes about the price of software being prohibitive.
Lack of awareness about software	11 4 B 6 G 1 O	Available information to get software	These quotes suggested that there was no information about what software was available
Management of funds	10 1 B 7 G 1 N 1 O	Misappropriation of funds.	It would seem that these quotes indicated not only that research funds were being poorly managed, but that the funds were being diverted away from the *purchase of software* (i.e. "funds not being used for software purpose")
Other single quotes		The number of researchers are great. Other competing demands Some closed source commercial software are very good but very field specific and thus license not provided by university	
B = Bangladesh; G = Ghana; N = Nigeria; O = Other			

Table 28: Obstacles in access to research software.

to tax or foreign currency transfer permissions. Indeed, the experience of one of the authors of this report is that every year the consortium managed by the Bangladesh Academy of Sciences for access to resources has to take permission from the central bank (Bangladesh Bank) for transferring funds abroad. This type of bureaucratic obstacle would also affect any attempt to procure software and needs to be addressed.

Appendix 2: Mentioned Software

2.1: All software mentioned as a response to Question 6: *"What specific software do you use for your research that you did not mention in questions 3 and 4?" (i. e., this question excludes Office Software and general software)*

Software	Bangladesh	Ghana	Nigeria	Other	Total
Own programme	1				1
3D max	1				1
Abacus	4				4
Adobe	2	2		4	6
Age	1				1
Amber				1	1
AMDIS			1	2	3
Amos		1			1
Ansys	3				3
ArcGIS	1				1
Ardunio	1				1
Arros 20		1			1
Aspen Hysis				1	1
Atlas	5	4			9
Audacity				1	1
AutoCAD	9			1	10
Axograph				1	1
Axsys				1	1
Biodiversity Pro		2			2
BioEdit	1				1
Bionumerix		1			1
Biovia	1				1
BLAST	1				1
C	27		1		28
C+	3				3
C++	2		2	1	5
Cad	1				1
Cadqas		1			1
Chembio office			2	2	4
Chemdraw	1		5	2	8
Chemsketch		1			1
Chem station			1	2	3
Chemistry	2				2
Chroma	1				1
ClustalW	1				1
ClustaX	1				1
CSI Bridge	1				1
Codeblocks	1				1
Comsol	1				1
Data-base		2			2
Delta 3D	1				1
Design Expert			2		2

Software	Bangladesh	Ghana	Nigeria	Other	Total
DNAStar	1				1
Dropbox		1		1	2
Eclipse ide	1				1
Embedded	1				1
Emgine	1				1
Endnote	12	2		3	17
EPANET	1				1
EPINFO		2			2
ESRI ArcGIS				1	1
ETABS	5				5
Eviews	1	2			3
Excel	1	9			10
Expassy	1				1
F4ANALYSW		2			2
Firefox	3				3
Fontran	6				6
Freesurfer				1	1
Full prof suite	1				1
GAMS		1		1	2
Gaussian	1			1	2
Geant4				1	1
GenDoc	1				1
Genstat		30			30
GET	1				1
GIS software		1			1
GNUPlot	2			1	3
Google			1		1
Google drive		1		1	2
Grace	1				1
Grapher			1		1
Graph pad prism		1	1		2
Graphics	4				4
GRASP	1				1
Gromacs				1	1
GTK	1				1
HSC	2				2
HTK	1				1
Hyper research		1			1
ITS		2			2
imageJ	1				1
Inkscape				1	1
Intel Compiler	1				1
ITS		2			2
Jabref				1	1
Java	8		2		10
JMP		1			1
Kile	1				1
Ki Plot	1				1
LabVIEW			1	2	3
LAMMPS	1				1

Software	Bangladesh	Ghana	Nigeria	Other	Total
Language	1				1
Latex	1	3		1	5
LCMsolution			2		2
Lighttools				1	1
Lingo				1	1
MAAAP5	1				1
Mathematica	11	1		1	13
Maple V	1		2		3
Material science studio	1				1
Mathcad				1	1
Matlab	34	4		10	48
MAXQDA		3			3
MCNP	1				1
MEGA6	1				1
Mendeley	1	1			2
Mercury			1		1
Mesrova			1		1
Meta-analysis software				1	1
Microsoft office	2		2	1	5
Microwind	3				3
Minitab	1	1		1	3
MNOVA	2				2
Modelling		1			1
Molden				1	1
MRICron				1	1
MSQL	3				3
Multism	1				1
Neuroscan ERP				1	1
NVIVO	5	5			10
Octave				1	1
OPNET		1			1
Oslo				1	1
Oracle enterprise edition	2				2
Origin	4		2	1	7
Outlook		1			1
OVITO	1				1
PHP	3				3
Plagiarism software	2				2
Practistat		1			1
ProFit				1	1
Protel				1	1
Proteus	4				4
Pspice	1				1
Pvsyst				1	1
Pymol	1			1	2
Python		1		2	3
Q1779		1			1
QDA miner		5			5
Opera mini torch		1			1
QP3		1			1

Software	Bangladesh	Ghana	Nigeria	Other	Total
Origin				1	1
QRS		2			2
QSAT		3			3
Quantum Espresso			2	1	3
R	6	4		2	12
RefMan				1	1
RELAP 5	1				1
RES2DINV			1		1
RES3DINV			1		1
RES2DMOD			1		1
RES3DMOD			1		1
Repast symphony 2.3.1			1		1
Sage		1			1
SAP-2000	2				2
SAS		2		2	4
Scopus				1	1
Sibelius		1			1
Sigma Plot	5		1	2	8
Simulator	1				1
Simulation soft	4				4
Solidworks				1	1
Spice	2				2
SPSS	23	54	7	8	92
STAADPRO	2				2
Starlogo	1				1
STATA	13	3	1		16
Statistica		1		2	3
Statistix	1	3		1	5
Sublime Text				1	1
TI	2				2
TICAD	1				1
Thunderbird				1	1
TracePro				1	1
TREE Age	4				4
Ucinet				1	1
Unscrambler	1				1
UV Probe	1				1
Virtual devices	1				1
Visio				1	1
Visual studio 2001	4				4
VMD				1	1
WebQDA		2			2
Windows			1		1
WINRESIST			1		1
XcrysFrn	1				1
Xmind				1	1
Yahoo			1		1
Zemax				1	1
Zotero				1	1
Zview	1				1

Table 29: Specific software used for research.

2.2: All software noted in response to Question 10: *"What software, if any, do you need but not have access to?"*

Software	Bangladesh	Ghana	Nigeria	Other	Total
Adobe products	1				1
Ansys	1				1
Antivirus software		2			2
Apache			1		1
Arc-GIS	3	1			4
Atlas TI	1	1			2
Bioinformatics software				1	1
Bionumerix		1			1
C			1		1
C++			1		1
Cadense	5		1		6
CASTEP code	1				1
CASQDAS		2			2
CATIA		2			2
Chemdraw			4		4
Classical molecular dynamics simulation code	1				1
CLC genomics for next generation sequencing		1			1
Comsol	2				2
Corel package				1	1
CSI bridge	3				3
Dedoose		1			1
DELF-3D	1				1
Design expert			1		1
Density functional theory software			1		1
Endnote	1	4	1	1	7
E-views		1			1
Excel			1		1
Fenstar		1			1
Finale		1			1
FOSS		2			2
Fullprof suite	1				1
GAMMA				1	1
Gaussian	1				1
GC-MS interpreting software			1		1
Geneious software		1			1
Genstat		16	1		17
GIS software			1		1
Gold docking software			1		1
Graph pad		1	3		4
Health economics software	1				1
HECHMS	1				1
HECRAS	2				2
HFSS	1				1
Hvivo		2			2

Software	Bangladesh	Ghana	Nigeria	Other	Total
Hyper research		2			2
ITS		5			5
Image processing software for nanoparticles	1				1
internet download manager			1		1
IR interpreting software			1		1
Jack the kipper	1				1
JMP		1			1
Latex			1		1
Lumerical	1				1
MAAP	1				1
MacOS		4			4
Maple V	1				1
Mass spectroscopy software			1		1
Mathematica	2		2		4
Matlab	1	9	2	3	15
MAXQDA		1			1
Mendeley			1	1	2
Mesorova			1		1
Metamorph				1	1
Microsoft software		2			2
Midus civil	4				4
Mitsubishi automation software	2				2
MODFLOW			1		1
NMR interpreting software			1		1
MPLUS		1			1
NVIVO	1	5			6
online journal access			1		1
OPNET		1			1
Optical design		1			1
Oracle		1			1
Origin	1		2		3
PDF converter			1		1
Prism		1			1
Pro Tools		1			1
R	1	1			2
Reference manage			1	1	2
Relap-5	1				1
SAS		4	4		8
Scrodinger			1		1
Sigmaplot		2			2
Simmer III	1				1
Simulation office		1			1
Spectroscopic software			1		1
SPSS		21	5		26
STATA	2	4			6
Statistical analysis software	1	1			2
Style writer		1			1
Top spin software			5		5

Software	Bangladesh	Ghana	Nigeria	Other	Total
Tree age	3				3
Turnitin		1	2		3
Q-STAT		1			1
QDA		1			1
Qiqqa		2			2
QSR		1			1
Qualitative analysis software	2	1			3
Qualnet network		2			2
Qualtrics and other software used to capture field data right on field		1			1
Quantum espresso			1		1
Windows OS	1				1
VASP crystal				1	1
Vienna code	1			1	2
VIGNE		1			1
X sight		3			3
Zview	1				1

Table 30: All software needed, but not accessible.

2.3: All software recorded in response to Question 15: *"What FOSS do/did you use?"*

	Bangladesh	Ghana	Nigeria	Other	Total
7zip	1				1
Antivirus			1		1
Apache			1		1
Audacity				1	1
Bioinformatic software	1				1
Fedora	3	1			4
Firefox				1	1
Fortran	1				1
GAMOS				1	1
GIMP				1	1
Gnuplot	1				1
Html	1				1
ImageJ			1	1	2
Javascript	1				1
Kile	1				1
Koha ILS			1		1
Latex	1	1			2
Libre Office	5	1		1	7
Linux	6	12	3	3	24
Matlab				1	1
Maxima		1			1
Manage MS office access code			4		4
Myql	1				1
NS-2		1			1

	Bangladesh	Ghana	Nigeria	Other	Total
Octave				1	1
Open Soft	1				1
Open Office	2	1		3	6
Oracle enterprise	1				1
PhP	1				1
PRAAT				1	1
Python		2		1	3
R		1		10	11
Repast symphony			1		1
Sage		1			1
Ubuntu	2	2	1		5

Table 31: FOSS used by the respondents.

Appendix 3: List of Abbreviations

AEC	Atomic Energy Centre (Bangladesh)
AGORA	Access to Global Online Research in Agriculture
ARDI	Access to Research for Development and Innovation
CNRS	National Centre for Scientific Research (France) / Centre national de la recherche scientifique
EIFL	Electronic Information for Libraries
FOSS	Free and Open Source Software
GARS	GYA Working Group on Global Access to Research Software
GC-MS	Gas chromatography–mass spectrometry
GETFUND	Ghana Education Trust Fund
GYA	Global Young Academy
HEQEP	Higher Education Quality Enhancement Project (a UGC initiative)
HINARI	Health Inter-Network Access to Research Initiative [use of this full name has been abandoned]
ICDDR, B	International Centre for Diarrhoeal Disease Research, Bangladesh
ICTP	International Centre for Theoretical Physics
INASP	International Network for the Availability of Scientific Publications
NMR	Nuclear Magnetic Resonance
OARE	Online Access to Research in the Environment
OS	Operating System
PERI	Programme for Enhancement of Research Information
PERii	Phase 2 of PERI
RUET	Rajshahi University of Engineering and Technology (Bangladesh)
SPSS	Statistical Package for the Social Sciences software
SRKS	Strengthening Research and Knowledge Systems
STEM	Science, Technology, Engineering, and Mathematics
TEEAL	The Essential Electronic Agricultural Library
TETFUND	Tertiary Education Trust Fund (Nigeria)
UGC	University Grants Commission (Bangladesh)
WG	Working Group

Notes

About the Global Young Academy

The Global Young Academy was founded in 2010 with the vision to be the voice of young scientists around the world. The GYA empowers early-career researchers to lead international, interdisciplinary, and intergenerational dialogue by developing and mobilising talent from six continents. Its purpose is to promote reason and inclusiveness in global decision-making. Members are chosen for their demonstrated excellence in scientific achievement and commitment to service. Currently there are 200 members and 171 alumni from 77 countries.

The GYA is hosted at the German National Academy of Sciences Leopoldina in Halle (Saale), Germany.

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