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Review: Egyptian science - how good is it ? Can it be improved ?

Francis Gilbert [1]* & Samy Zalat [2]

1 School of Biology, University Park, University of Nottingham, Nottingham NG7 2RD, UK
2 Department of Zoology, Suez Canal University, Ismailia, Egypt

Introduction

In collaboration with the British Council, the Ministry of Higher Education in Cairo held a workshop on scientific research in Egypt in 2006. This addressed two main points, teaching and research, both concerned with how to assess and hence improve the quality of Egyptian university science. The British Council invited a number of people from the UK so that they could contribute their experience to the debate. This review stems from our contribution to this workshop. Our ideas arise from our experience over 25 years in UK and Egyptian universities, and having worked together in Sinai over the last 20 years, both doing research together ourselves, and trying to facilitate the work of others. In 2004-8 we ran BioMAP, a project funded by Italian Cooperation and managed in the EEAA; the project tried to improve the recording, monitoring, research on and public awareness of biodiversity in Egypt. Our experience of BioMAP has informed this review.

It is interesting and instructive to compare the structure of science support in the UK and in Egypt. There are some startling contrasts, which go a long way towards explaining why the UK is in general very good at scientific research, and why Egypt, in general, is not. The reasons concern the level and distribution method of funding, the way PhD research is conducted, how subsequent scientific careers develop, and (for biology) the Cinderella nature of some aspects of research.

UK funding of science and its output

Higher Education (HE) in the UK is carried out by about 130 institutions, including 84 universities. Nearly all the universities are constituted as charities, legally and actually independent of the government. In 2004 there were about 2.3 million students in these institutions, taught by about 160,500 staff. The job of these academics is normally both to teach and to do research, and they are supported in their jobs by about 182,000 non-academic staff (administrators, technicians, library staff, computing support staff, etc). The overall student:staff ratio is 14:1, of course with significant but not huge variation among disciplines. The total income of HE in the UK in 2004 was £ 16.9 billion (about LE 188 billion), only 60% of which comes from the UK government.

The UK in general spends about 1.9% of its Gross National Product on science research and development (R&D), which is quite low on the international scale: countries such as the USA, Japan and the Scandinavian countries spend a much higher proportion. When worked out per head of the population, the UK spends £ 283 (LE 3140) on science R&D for each person in the UK. There are about 2690 researchers per million people, and over the 15 years between 1990 and 2005 they each published on average 3.16 publications. If this seems low, remember that although trained in the universities, many of these researchers work in industry where publishing is not part of their job, and they can be prevented from publishing anything of their work.

The key element of the way in which the UK government supports science research in the universities is the *dual-support* system. The government gave £ 1.7 billion (LE 18.6

* Author for correspondence: tel +44 115 951 3215 email : francis.gilbert@nottingham.ac.uk

billion) to them as general support for their research (e.g. for laboratories and infrastructure), a quarter of which was specifically targeted at particular kinds of research (climate change, for example). This is the first ‘arm’ of the dual-support system. The second arm is grants to particular researchers. Via the Research Councils, the government gave an additional £ 2.2 billion to support projects put forward by particular individuals or groups of researchers in open competition. Proposals are assessed by other researchers in the field, and the resulting winners get support. A further £ 500 million (LE 5.5 billion) is given as grants in the same way by charities such as the Welcome Trust.

Teaching has a separate funding stream. The UK government supplies £ 4 billion (LE 44 billion) directly to the universities, and a further £ 1.6 billion (LE 17.6 billion) via the Local Education Authorities who run the schools from which the new undergraduates are recruited. There are other sources of teaching funding too. After a fairly long period in the UK when university education was essentially free to everyone who gained a place (via goverment grants for subsistence and fees), with the huge recent expansion in student numbers the UK government has started to charge students significant amounts of money to study for their degrees. It thus comes into line with most developed countries, where such charges have been normal for a long time. Hence in 2005 there was a further income stream for teaching derived from student fees, amounting to £ 2.5 billion (LE 28 billion).

Lastly, the government also contributed £ 650 million (LE 7.2 billion) towards the general infrastructure of HE institutions. But because the universities are autonomous, they can also generate their own income in a variety of ways (e.g. conferences). In 2005, this amounted to almost £ 3.6 billion (LE 40 billion). The universities can use this money for anything they like.

Given this financial support, how does the UK do in science ? One of reasons for using the UK as a comparator to the Egyptian situation is that by any of the measures used, the UK is very good at doing science. Clearly in order to compare countries, we have to adjust for the size and wealth of the country, otherwise everything will be dwarfed by the contribution of the USA, which has both a large population (300 million) and is very wealthy (GDP more than $ 1.1 trillion). Thus we need to compare both inputs and outputs on a ‘per head’ basis. Inputs are usually measured as funding support, either GDP per head, or as the amount of funding spent on science R&D per researcher. Outputs are usually measured in terms of the number of publications, but recently other measures have been used. For example, an indication of the importance of a scientific paper is the number of times it gets used (cited) by other papers. Thus we can also use the number of citations, either on a per paper basis, or relative to GDP. When we adjust for country size in this way and relate inputs to outputs, we find that a country like the USA is actually doing rather poorly: relative to the amount it spends, it does not get the outputs that it should. Countries such as the UK, Switzerland, Canada, Israel, the Scandinavian countries and the Netherlands are all doing very well relative to the amount they spend on science R&D (see the by-now famous paper by Robert May, published in *Science* in 1997, called ‘The scientific wealth of nations’).

If we just look at the number of citations per £ spent on science R&D, then two countries are way out ahead: the UK and (especially) Canada. Canada has almost twice as many citations per £ spent as the USA. And what is it about the Canadian and the UK systems that distinguish them from the rest? It is the dual-support system. The key to understanding their success is that there is *some* money for *everyone,* for all scientists to be able to carry out *some* research. For large or expensive pieces of research, grant support is available, but this is for the few who are successful in the competition for grants. However, everyone is able to do something.

Egyptian funding of science and its output

Now let us turn to Egypt and the way Egypt supports its scientists. Egypt has about the same number of HE institutions as the UK, 130, including about 30 universities (but this is increasing all the time as more and more full-fee faculties and private universities open). In Egypt (and in most countries, in fact), universities are much larger than in the UK. Thus there are a few more students studying in HE in Egypt than in the UK (2.5 million), but they are taught by less than half the number of academics (81,500) supported by an unknown number of non-academic staff. The resulting student:staff ratio is 31:1, and in some faculties it is more than 350:1. No figures are available for the amount of money that HE receives from government, but this is virtually all their funding. They are not autonomous institutions.

Egypt is said currently to spend 0.9% of its GDP on science R&D, about 50% of that of the UK, and that translates into about £ 4 (LE 44) per head, only 1.4% of that of the UK. There are about 1130 researchers per million of the population, 42% of that of the UK. Between 1990 and 2005 these researchers produced an average of 0.2 publications, only 6.3% of the output of their UK colleagues. A key difference from the UK is that most Egyptian scientists work in applied research in institutes rather than in the universities - only 6% of science R&D spending is in the pure sciences.

Although these figures seem low, they are actually good relative to other Arab countries. The key issue here is that the political leaders of Arab countries historically have shown no interest at all in science, reflected in Arab countries collectively being the absolute bottom of the international league table of spending on science R&D. The UK (1.9%) is well below the average for developed countries (2.3%), and yet still produces well above expectation in terms of publications and citations. The average spending for Arab countries (0.2%) is way below the average for developing countries (0.8%), African Arab states being marginally better than those in Asia, where it is only 0.1%. There are other problems too, apart from the level of funding. In Arab countries there is no tradition of teaching students to be sceptical of what they are learning, a requirement of the scientific approach. On the other hand, Egypt is in a relatively good position as regards manpower: she has more than 50% of all the science researchers of the Arab world. In contrast to the UK, though, more than 97% of Egyptian scientists work in government-run institutions.

The Egyptian government distributes a block grant to each HE institution, to serve as the money to support teaching, infrastructure and research. Until very recently there were virtually no grants available to individuals - what grants there are come from foreign-funded projects that are usually short-term. There is therefore a severe lack of sustained funding for research. Recently the Ministry has established a fund for science and technology, which will help. Very little money comes from students or self-generated income.

The biological sciences

Now we can consider in more detail the situation in one particular science, biology. We do this in order to identify the factors that are causing the difference between Egypt and the UK.

We collected data on 35 countries, including 11 muslim ones from North Africa, the Middle East, Arabia and Asia. The data contained measures of the effort countries put into educating their population in general (e.g. the average number of years spent at school, the proportion of school students who go on to university, etc), funding in general and for science in particular, the number of researchers, and whether the country was muslim or not. We then used these to see the extent to which they predicted the scientific (biological) output of a country, chosen to be represented by the number of publications per researcher.

The strongest predictor was the proportion of the GDP spent on science R&D, followed by the general wealth of the country: together these predicted more than 60% of the variation in the science output among countries. Three other measures made a small contribution. For example, the greater the number of researchers per million of the population, the lower the average output of publications. This is probably because good scientists are the first to be recruited, followed by others of lesser ability - therefore having a relatively large number of researchers reduces the average quality and hence their output. A higher proportion of students entering HE also influenced science output slightly. There was no effect of whether a country was muslim or not. The conclusion from this analysis is that the only issue causing the low science output of Arab countries is the level of funding for science. There is no detectable cultural barrier to science at all.

How is Egypt doing in biology ? If we look at the relationship between the number of publications per researcher, then the UK produces substantially *more* than expected for the amount of funding it gives to science, whereas Egypt produces substantially *less* than expected. Thus, even for the very low level of science funding in Egypt, it is doing poorly. Why is this ? We might have expected that the long and great tradition of HE in Egypt would mean that it would perform well relative to its funding - but this is definitely not the case. What is the reason for Egypt's poor performance ?

Part of the answer is obvious from the figures given above. Egypt has the worst of all possible worlds for research: an inadequate science R&D budget is spread over a very large number of researchers. Furthermore, most of the funding is directed towards applied research, which does not generate nearly as many publications per researcher as pure science, and arguably is less useful for the development of the field. It is one of the ironies of the history of science that the more a government tries to direct what science is done, the worse the science. It is important to allow scientists to pursue the avenues that *they* think are important to the field, rather than what someone else thinks is important.

But there are other reasons too, to do with how science and scientific careers are structured in Egyptian universities. The function of the PhD, for instance, needs overhauling.

In the UK, the research done for the PhD degree is often the career-best of a scientist, generating high-quality research and high-quality papers in top international journals. In Egypt the research itself is also often high in quality, but for the student the aim is training only, and all too often the research is never published. Why ? One reason is that in the UK, the publications belong to the student, and are always essential for the student's career. Although one of the stated aims of a UK PhD programme is 'training in research', in fact for a very long time in the UK as elsewhere in the developed world, it is the quality of the publications arising from the PhD that determine whether or not a student is able to carry on as an academic. Nowadays more and more, a PhD consists of a set of papers, often already accepted or submitted before the PhD itself has been submitted to the university.

Contrast this with the situation in Egypt, where the publications belong to the supervisor, and in fact are expressly discounted in the student's subsequent career development. Since supervisors are often already professors, it is also of no benefit to them to publish since after promotion to professor, there is nothing to be gained from publishing papers apart from one's own satisfaction. If it is in no-one's interest to publish, then it is not surprising that the majority does not get published. Furthermore, the 'book' format is always adopted in Egypt, rather than the PhD thesis as a set of papers. Scandinavian countries date their emergence as a dominant force in biology to their decision to change from the 'book' format to the 'set of submitted papers' format. These issues are slowly being addressed in Egypt, it is true, but only very recently, not in time to affect the numbers in the indicators. Recently the

Higher Education authorities have asked for publication before submission of theses, one published paper for an MSc, and two for the PhD: this is definitely a step in the right direction.

In the UK, it has been many years since there was an ‘Entomology Department’ in any university. This is because discipline boundaries are a serious hindrance to the collaborative multidisciplinary research that characterises successful science today. Egyptian universities have serious boundary problems, and there is no Biology Department in any Egyptian university: the system tends towards splitting rather than merging, perhaps because Professors are more motivated to hold senior administrative positions rather than to integrate their research with others. A recent Egyptian PhD on pollination had half the chapters on the plant, and half on the insect pollinator, and there was a serious issue about what part would ‘count’ for the PhD because it could not be placed in Botany or Zoology. This kind of attitude makes no sense from a scientific point of view.

A crucial difference between the UK and Egypt is that in the UK the whole aim of the PhD training is to produce an independent researcher at the end, someone who can devise, plan, implement and publish their own research programme. The supervisor helps, but does not direct the research except when it is essential to help the student get on their feet. In Egypt, there is no independence from the supervisors since the research plan is devised entirely by them, and the job of supervision and eventually of assessment by the examiners consists of making sure that the plan has been carried out. Deviations from the plan are not allowed at all, or it is very difficult to get them accepted by the supervisors - this is exactly opposite to the flexible ‘follow-your-nose’ approach of British research. There is a serious issue about the role of supervisors in Egypt: each supervisor wants a share of the work, whether or not their specialist subject fits with the topic of the thesis: this leads to nonsensical combinations of subjects being asked for by the supervisory committee (such as taxonomy and the effect of gamma radiation on insects). The task of publication in Egypt also does not belong to student, but to the supervisors. These aspects of Egyptian practice do not foster the kind of independence that is required for the student’s future career. Of course, publishing in English demands of Egyptian scientists the additional skill of language: UK scientists are simply very lucky in having the language of science their own native tongue.

Most UK universities, like their counterparts elsewhere in the developed world, see it as their priority to provide their academic staff with a great deal of support in the form of non-academic staff with various skills, and easy free access to the scientific literature, so that academics can keep up with their field and do their teaching and research jobs properly. In Egypt, relatively little staff support is present, and no access to the literature is provided in any university: individuals must pay for such access themselves. This by itself would be enough to hamper seriously the efforts of scientists of any nation.

In academic careers as a whole there are also some very striking contrasts. In the UK, staff move among universities for their career because they have no secure job for a period of at least 10-15 years after their first degree. Many of them fail to achieve a secure job at all, and are lost to academia and also sometimes to science. Achieving a secure job and promotion are very hard, and always depend on the quality and quantity of one’s lifetime publication and grants record. Staff are only recruited when the teaching or research portfolio of the department requires it, and the university can afford it.

In Egypt, in contrast, jobs are not decided mainly on a needs basis but on having a number of the best graduates every year, the "top firsts": therefore staffing levels are accumulative rather than steady-state. The top undergraduate student(s) are recruited into the Department, and have a secure job for life from the first day, before they have even registered for their MSc. The departments receive new staff every year with no fund to support them, or even no space to accommodate them, and the result is very crowded departments: it is impossible for such a system to continue. The top graduates not necessarily the best researchers, since they have never done any research, so the departments are trapped with employees who may not be capable of doing research for a whole variety of different reasons. Another important issue is about whether the top graduate students are women (which in biology is almost always the case): then it is almost certain that in many departments a large proportion of the staff are away for long periods of time on maternal leave, and the net result is a huge number of employed demonstrators but with few people actually doing the work.

In Egypt the number of staff members who leave a department for various reasons (e.g. not interested any more, not doing very well, fired or retirement) is very small, and the consequence is that a hierarchical system builds up, with a major professor in a specific topic, and a number of their students as staff members who are required to respect and appreciate the senior scientist. This implies a lack of mobility, and usually in fact there is no mobility at all - there's no need. Promotion is relatively easy: it depends purely on achieving a relatively low number of recent publications, only some of which need to be of high quality. The Egyptian situation does not stimulate an active scientific research career: instead, people are interested in publishing mainly when the rigid timescale of promotion dictates.

The fierce competition among scientists in developed countries for grants is instrumental in ensuring that the results of the research get published, because otherwise there is little chance of obtaining the further grants upon which one's career depends. In Egypt there are usually no grants and those that exist (the recent plan) are not enough to identify and encourage a reasonable number of good researchers: thus as before the only available funds are those from foreign-funded projects not accessible to the majority of staff members.

Thus in the end the career paths of UK and Egyptian scientists differ greatly. Successful scientists in the UK are encouraged to expand their research groups by obtaining more grants, and producing more publications. In Egypt, the only route to success after having been promoted to professor is to become an administrator, via Head of Department, Dean of the Faculty, etc. The energies of Egyptian scientists are thus absorbed not in doing science, but in other avenues.

In our own discipline of field-based biology, which is vital for environmental and biodiversity protection, there are special problems for Egyptians. The solid basis of the subject in Darwinian evolutionary biology is hardly taught at all in Egypt, neither is natural history a major part of the school curriculum and television output, as it is in the UK. The field-based testing of hypotheses in ecology is always part of a university undergraduate degree in the UK. In Egypt, fieldwork is mainly confined to collecting: there are extremely few well-designed experiments carried out in Egyptian environments. Why is this? Part of the reason is that Egyptian cultural traditions make spending long periods in the field very difficult - it is viewed as some kind of punishment. Many British people do not have any problem in living for months in the field - indeed, many enjoy it very much.

The Ministry of Higher Education is adopting the two measures used by the UK to assess quality in HE: Quality Assessment Assurance (QAA) for teaching, and the Research Assessment Exercise (RAE) for research. Are these a good idea ?

For the QAA there is no question but that it is a good idea. QAA encourages departments to think about what a graduate ought to be able to do, and to design its curriculum around delivering the appropriate courses. This kind of overall planning is needed in every university in the world. The way QAA is implemented will affect how seriously it is taken. In the UK, no extra funding can be gained from achieving a high score for the QAA, and hence universities take it less seriously than the RAE. In Egypt, the way that QAA has been introduced into Egyptian universities for some reason creates resistance rather than being welcomed in order to achieve the admirable goal of assuring the quality of teaching in Egyptian universities. The authorities should tackle this issue first. Why do staff members resist the Quality Assurance activities? This would be a good topic to research.

It is not so clear whether it would be a good thing or not for Egypt to have an RAE. The RAE exists in the UK in order to concentrate funding in so-called ‘centres of excellence’. The reasons why this is supposed to be a good idea are several. The first argument is that concentrating funding is needed in order to compete internationally, because of globalisation and the rapidly increasing cost of doing world-class science (much greater than the inflation rate). A second argument is that universities have been insulated from market forces, and this is a way of making them compete and hence (so the argument goes) become more efficient and productive. Finally, it enables the UK government to avoid increasing the science budget too much: although they have increased it substantially, they cannot fund every university to the same extent.

This how the RAE works. Every 5-7 years, the quality of the research of each department or ‘centre’ is assessed on a simple 7-point scale. The assessment is done by totting up the outputs (mainly the number of grants and publications, including where they were published using journal Impact Factors, a number derived from citations) together with some other indicators, and putting them all into a formula to arrive at the RAE score. Crucially, however, the RAE score makes a huge difference to the amount of funding that the university will received for the department (the block grant for research), and to the chance a staff member has of getting more grants. In addition, the government is increasingly transferring research support money from the block grant into the competitive grants, so in fact the dual-support system for research is being eroded. Soon many science staff members at many universities, recruited on the basis of their research abilities, will have no money at all with which to do any research. The long-term impact of this on the UK’s much envied success in science research is worrying many in the UK. Its effect is to force departments to choose between being mainly a teaching outfit, or to be a top-class research outfit: but they must beware of failure if they choose the latter, because a low RAE score makes closure an attractive financial option to the university. Already chemistry and physics departments have been closed down in some top universities. How can one have a proper university without such basic departments ?

Is the RAE a relevant option for Egypt ? Surely not ! The RAE is designed to concentrate an overstretched research budget in fewer ‘centres of excellence’. It would be nice if Egypt could merely identify the best researchers, and then put all the research money with them. Unfortunately this does not work. An analogy is with prospecting for oil: if we could identify exactly where oil was in the ground and just drill there, there would be no problem. But this isn’t possible - you have to put in the effort of drilling in lots of places in order to find some productive oil wells. In the same way, you have to have a critical mass of research being done before excellence is identifiable, and furthermore the same people do not always do good work. The RAE just isn’t appropriate, because Egypt has the opposite problem to the UK: how to increase basic scientific research from a low base. For this, it is crucial to have a good dual-support system of research support, and to reward good work.

Conclusion

If science research is one of Egypt’s priorities, as President Mubarak has stated, then we need to acknowledge that the most successful countries support basic science with a reasonable level of funding, and have a dual-support system. Thus everyone gets some support at a level that is enough to be able to show what they are capable of, and scientists are left to do research on what they think is important to the field. Increasing the budget for basic science, and instituting an effective dual-support system is the best way of increasing Egypt’s science output. This means greatly increasing and ring-fencing a block grant for research so that all staff have a chance to do some research in the basic sciences. Then, every five years or so, one could assess how well *individuals* (not departments or institutions) have used these funds. The results could then be used to target selectively a set of research grants (which, however, should be open to all good ideas from anyone).

There are other measures that would be effective too. Alter the system of recruitment so that staff members are chosen not from those with BSc but with PhDs. Alter the rules of PhD research to encourage students more, especially in publishing (encourage the thesis to be a 'set of submitted papers' rather than 'book' format). Revise the rules and criteria for promotion system. Encourage multi-disciplinary and collaborative approaches in research rather than stay within the confines of single disciplines. Making available libraries or e-journals of the top international publications is a must. Sort out the issue of resistance to the quality assurance campaign. And find mechanisms to help staff to publish in international journals - lack of ability in English should not be such a barrier to publishing high-quality work.

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Further reading (all available on the Internet)

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الملخص العربى

بحث مقالى

البحث العلمى فى مصر – تقييم حالته؟ وكيفية تحسينه؟

فرانسيس جلبرت[1] – سامى زلط[2]
1- قسم العلوم البيولوجية – جامعة نوتنجهام – المملكة المتحدة.
2- قسم علم الحيوان – كلية العلوم – جامعة قناة السويس – مصر

إذا كان البحث العلمى هو أحد أهم الأولويات فى مصر "كما أشار الرئيس محمد حسنى مبارك"، لذا فعلينا أن نعترف بأن الدول المتقدمة قد دعمت أبحاثها الأساسية بكميات كافية من الدعم المادى من خلال خلق نظام الدعم الثنائى (ميزانية معقولة لجميع الباحثين تضمن إجراء أبحاثهم، بالإضافة إلى منح تنافسية تكون مفتوحة للجميع ويتم تقييمها وتوزعها من خلال نظام تقييم قادر وعادل).
يعتبر توفير الدعم المادى المناسب للعلوم الأساسية بالإضافة إلى خلق نظام الدعم الثنائى من أهم السبل لتطوير البحث العلمى فى مصر. هناك عوامل أخرى تعتبر هامة فى تحسين حالة البحث العلمى فى مصر منها: النظر فى نظام تعيين المعيدين والتفكير فى إستبداله بالتعيين بعد الحصول على درجة الدكتوراة، إيجاد سبل لتشجيع طلاب الدكتوراه لنشر أبحاثهم بصورة سريعة والتفكير فى أن تكون الرسالة على صورة عدد من الأبحاث بدلاً من الطريقة التقليدية الشائعة، مراجعة قوانين الترقيات ودراسة قواعدها بصورة متأنية وواعية، تشجيع الأبحاث الجماعية فى التخصصات المختلفة بدلا من التخصص الوحيد الضيق، يجب إنشاء مكتبة قومية (أو مكتبات متفرقة) تحتوى على أحدث الأبحاث فى مجال العلوم البيولوجية، مواجهة مشكلة مقاومة أعضاء هيئة التدريس لبرامج التطوير والجودة من خلال التعرف على أصول المشكلة ومحاولة حلها بدلاً من فرضها على الأقسام والكليات، مساندة أعضاء هيئة التدريس من خلال تقديم العون الفنى والمادى لهم لنشر أبحاثهم فى المجلات العالمية، حل مشكلة اللغة الإنجليزية والتى أحياناً تقف عائق ضد نشر أبحاث ذات قيمة علمية عالمية كبيرة.