Developmental education for innovation: lessons from an experience in Kenya

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Abstract

Promoting innovation through education is a challenge for both advanced industrial and developing economies. The linkages between public and private investment in education, the kind of education that is needed and sources of social and economic dynamism are all-important. These linkages are particularly challenging in the Global South, where many types of dynamism and social need are 'below the radar'. This is the backdrop to a practice-based project that used training in technology policy and innovation research to promote employability and innovation capability in key sectors in Kenya. We use findings from surveys, interviews, workshops and stakeholder meetings to rethink the role of education and training in supporting innovation that focuses on social need. We contribute to debate by arguing for a developmental education system based on a multi-sector and multi-organisational approach, and which combines different types of education, training and learning in collaboration with public and private sector enterprise.

Key words: Kenya; science, technology and innovation studies; reflective practitioners; critical thinking; education and training; developmental education system

1. Introduction

At the beginning of 2012, Kenya was finalising negotiations on its Science, Technology and Innovation (STI) bill. The bill was being discussed by a high-level taskforce of politicians, academics and private sector stakeholders in conjunction with a series of bills related to vocational education and training, university education, the Kenyan constitution and Kenya's overarching development strategy known as 'Vision 2030'. Science, technology and innovation is a key pillar of Vision 2030. A key question being addressed by the taskforce was how best to promote STI activity and what role should be played by vocational and university training.

A similar issue underpins a practical research project undertaken by the authors. The project aimed to assess the value of professional development in technology policy and innovation research for graduates in key sectors of the Kenyan economy (agriculture, energy and health). The underlying rationale was prompted by the need for capacity development to promote innovation in the areas of policy, processes and research, and to enhance and promote employment in these domains. The project, which was carried out by the UK Open University (OU)[i] and the African Centre for Technology Studies (ACTS)[ii], consisted of three overlapping activities. The first was to provide a small cohort of professionals with training in

technology policy and innovation research in order to promote their understanding of STI and the value and importance of innovation (October 2009-April 2010). The second was to enable this cohort to adapt its learning and be able to train others (May–September 2010). The third was to use the outcomes and a review process to help shape future training efforts by ACTS and other education and training providers, in consultation with public and private sector stakeholders (October 2010-July 2011).

As we outline in Section 2, the discussion about the relationship between innovation and education and where best to promote STI activities is longstanding. In particular, there is recognition that STI activities often occur outside formal research and development (R&D) settings, and that STI activities are essential ingredients of successful economic development required throughout all sectors and working environments. The Kenyan policy documents (Government of Kenya, 2007; 2010a, 2010b) recognise these processes and emphasise the need to promote innovation throughout society and from the earliest education efforts. Such processes were also evidenced during our project, from the way participants engaged with the materials they studied, utilised the learning they received and incorporated it into their working practices. The review of the project's activities outlined in Section 3 highlights in particular that participants took, and used, different things from the learning materials because people innovate in a wide range of contexts. As such, as outlined in our discussion in Section 4, there is a strong argument for an expanded definition of, and approach towards promoting, STI activities and different types of education and training. To encapsulate this view, we add to, and to some extent reframe, the conceptualisation of a science innovation system outlined by Conway and Waage (2010, p.6), for steering such an approach nationally, while acknowledging the need for accompanying processes, such as continuous improvement methodologies (Bessant, 2000), within organisations.

2. The relationship between innovation and education

There has been considerable discussion in the last decade about the need for greater awareness of the role of innovation in development, amongst social and economic sectors as well as scientists and policy makers. This discussion was taken on board by Kenyan policy makers in the STI and education related bills and strategies referred to above (Government of Kenya, 2006; 2007; 2009; 2010a; 2010b; 2010c). In these documents there is a well understood and articulated understanding of the importance and potential of promoting STI for Kenya. The documents highlight specific key sectors of the economy (such as agriculture and manufacturing) and the promotion of social wellbeing (through strategic emphasis, for example, on natural resource management, animal and human health security). There is also a desire to integrate STI into all areas of education and training, including the youngest of students, and to promote a participatory model of learning that allows for creativity, learning by doing and experimentation. Linkages between training and teaching institutions and the private sector, and the promotion of open and distance learning to support a wide range of learners are emphasized, as is a need to increase awareness and understanding of the importance of STI amongst the general public.

In the academic literature, a similar recognition has called for changes in education to promote innovation in development. For example, Kearney (2009) argues for diversification within education: learning by doing, widening access through face to face and open learning, engagement with local and regional priorities, and the generation of a research agenda (ibid., p.14). These elements echo in part the findings of earlier research into the role of universities in societal transformation (Brennan, King and Lebeau, 2004). In a similar manner, the UN Millennium Development Goal Task Force on Science and Technology also suggests change is needed in the education system. The report notes that 'having knowledgeable people is not enough' (UN, 2005, p.92): people need to be able to apply what they have learnt as 'inseparable parts of the learning process' (ibid.). However to achieve such an outcome requires 'reshaping universities to perform development functions [which] will include modifying their curricula, changing schemes of service, modifying pedagogy, shifting the location of universities, and creating a wider institutional ecology that includes other parts of the development process' (ibid., p.95). The report outlines a number of ways in which universities can be reshaped. One is by making partnerships with non-governmental organisations, as in the case of Colombia, where the Foundation for the Application and Teaching of the Sciences (FUNDAEC) aims to 'extend high-quality education beyond the walls of the traditional university' and has led a successful trajectory in this respect since the 1970s[iii] (ibid., p.98).

These arguments for an alternative and innovative approach to education and learning, building partnerships with a range of stakeholders and engaging in local and regional innovation, have been discussed in other fora. The need for successful collaboration between universities and other stakeholders, particularly business and government, has been promoted by the 'triple helix' model of innovation studies (c.f. Etzkowitz, 2003; Leydesdroff and Etzkowitz, 1998). South American scholars have discussed the importance of ensuring university education meets the needs of users, and is more practice- and context-driven (Arocena and Sutz, 2005; López Cerezo and Verdadero, 2003; Velho, 2005). In particular, Arocena and Sutz (2003) make the case for 'learning societies' and 'developmental universities'. Learning societies are 'where a fair proportion of the population and the social and economic organizations permanently perform knowledge-demanding activities, where many actors need and are able to upgrade systematically their individual and collective skills as well as their awareness of scientific and technological changes' (ibid., p.177). Developmental universities are 'characterised by the joint practice of three missions: teaching, research and cooperation for development with other institutions and collective actors…developmental universities can only exist as active partners in innovation systems' (Arocena and Sutz, 2010, pp.14-15). Similarly, López Cerezo and Verdadero (2003) discuss the need for South America to develop science and technology studies education that has a practical value and for a participatory R&D system oriented to the social needs of local populations. Velho (2005) argues that this type of approach is needed because often universities and public research institutes are not meeting users' needs and firms are not demanding R&D for products and services that the majority of the population require.

A similar argument with respect to Africa argues for more context-based thinking around innovation and the teaching of STI in universities. One reason is the recognition that learning takes place in both formal and informal ways (Lorenzen, 2010; Lorenzen and Mohamed, 2009). In addition, innovation often occurs as a result of scarcity induced conditions (Sutz and Hanlin, 2010; Sutz and Srinivas, 2005). Rather than resulting from traditional R&D processes in formal institutions, it occurs 'below the radar', and is given insufficient recognition by businesses and policy makers (Kaplinsky et al., 2009).

Finding figures on R&D expenditure in African countries is challenging. The World Bank only provides figures for South Africa and Mauritius (http://data.worldbank.org/indicator). The latest R&D figures in relation to agriculture, the biggest business area in Sub-Saharan Africa, are from 2000, when Africa was spending 0.70 US$ on agriculture R&D per every 100 US$ of agricultural output (World Bank, 2008). In Kenya, despite being the largest business sector of the economy, agricultural R&D expenditure was only 1% of total R&D expenditure in 2000 (UNCTAD, 2005). These figures, while dated, highlight the lack of R&D in key economic areas.

However these figures only show formal R&D activity and do not show the amount of innovation that takes place every day in Kenya. M-Pesa money transfer services and UShahidi, an open-source crowdsourcing software, are perhaps the two most internationally well-known examples of innovations from Kenya which started with small beginnings but have gone on to transform money transfer and crowdsourcing activities around the world. However, small scale innovations are frequently occurring in the informal sector (Daniels, 2010) as well as in formal sectors such as electronics and information technologies (Kevitt Desai, 2010, personal communication), agriculture and energy (Theobald et al, 2011).

Although there are examples of Kenyan universities commercialising products and services or providing training and education that is directly relevant to industry (see World Bank, 2008), many innovations are not the result of these initiatives, hence their 'below the radar' status. Many Kenyans may be able to develop inventions but few are able to successfully innovate: i.e. to commercialise or put into sustained practice and use their invented product or service. As the UN (2005) has argued, a conducive 'institutional ecology' is needed.

Moreover, despite recognition that innovative activity does not necessarily require university collaboration, there is still a propensity within the literature to emphasize the role of universities, and to see an innovation system as focusing primarily on the formal organisations and institutions of government, universities and laboratories. For example, Conway and Waage (2010), although acknowledging the multi-actor and non-linear nature of science innovation systems, focus primarily on universities in their science innovation system model (redrawn in Figure 1, below).

[Figure 1 here]

A complementary strand to the discussion of the link between education, learning and innovation is how learning and innovation occur within organisations. One example is the research of Bessant (for example, 2000; 2003) on 'continuous improvement' in industry, research that developed into a methodology (or soft technology) for promoting continuous improvement in organisations more generally. A fundamental idea behind continuous improvement is that all employees have something to contribute to organisational performance. Bessant is particularly keen to emphasize that it is people rather than organisations who learn, so one of the basic challenges is how to unlock the willingness and potential to change. Although Bessant's focus is on internal processes and, generally, on established companies, the questions he raises, and the learning dynamics he exposes, resonate with the themes of this paper.

Our findings, discussed in Section 3 below, highlight innovation as needing a wide set of learning opportunities within an outward looking and networked education system as a whole, not only in or through universities. In other words, what is needed is a 'developmental education system', not only 'developmental universities' (Arocena and Sutz, 2010). A developmental education system would not only include alternatives to conventional, qualification-based education, such as continuing professional development (CPD) (despite our own project's emphasis on CPD). Our empirical evidence rather highlights the importance of an enabling institutional environment for supporting the promotion and embedding of a wide range of learning processes for innovation. We would therefore argue that building a mutually reinforcing relationship between education and innovation requires a multi-sector and multi-organisational approach that combines many types of education, training and learning in collaboration with public and private sector enterprise: what we might call an inclusive and integrated pedagogy. The approach of the Kenyan policy documents referred to earlier goes a long way towards providing the building blocks for ensuring a wider appreciation of STI activities and the requirements for their support. However there are considerable implementation challenges, which our project illustrates.

3. Technology Policy and Innovation Research: an example of learning for innovation

Our argument is based on data from the project, outlined in the Introduction, to promote education and training in technology policy and innovation research for graduates working in the fields of health, energy and agriculture in Kenya. The project was called: 'Training for occupations in agriculture, health and sustainable energy innovation in East Africa'. Between October 2009 and July 2011, this project aimed to enhance skills and future employment prospects, focusing on those either already working in or aiming to work in agriculture, health and energy in private and public sectors. In particular it targeted people working in intermediary organisations or acting as middle managers and working at the interface of policy and action.

3.1 Project activities

The project had two phases. The first phase centred on a group of 20 graduates who studied a module on technology policy and innovation research on a part-time,

distance learning, basis over six months. The module had as its aim: 'to develop a critical and evaluative understanding of research approaches to the shaping and social implications of technology and innovation' (Spear, 2003, p.2). It had four blocks of work, covering a wide range of technologies and a North-South perspective, which focused on innovation and design, shaping technology, making policy (including in environment and development) and the role of organizations and institutions in innovation.

Module participants were formally recruited and selected through OU procedures. Participants were provided with the teaching materials as well as additional tuition and marking of assignments, which took place electronically. After each section of the module students were asked to feed back their views on the teaching materials and learning process. At the end of the module, an evaluative workshop was held (June 2010) on the value of the materials, the kinds of learning that took place, and on how participants could support other distance learners, initiating a discussion about how the materials could be adapted for wider use and with whom.

The second phase worked on activities to enhance the use of the materials in the longer term with a view to embedding them into existing activities to promote innovation. As such, we conducted a second workshop (October 2010) to review the materials with the module participants, their employers and a range of other stakeholders from the education, training and private business sectors. We revised the materials, adding East African case studies, and put the materials online (using the OU's Open Educational Resources web-site, OpenLearn[iv]) so that they would have universal access. In addition to interviewing a sample of module participants about how they used the materials and their learning in their organisations, we conducted one-to-one meetings with key stakeholders to discuss the potential embedding of the materials into existing activity to promote different types of innovation. The online resources were used by ACTS in a short course (November 2011) with plans to make the materials central to their training programme – the beginning of a third phase, focusing on the potential for wider uptake.

While the project was intended to promote capacity development and employment enhancement, the underlying rationale was prompted by the need for particular types of capacity development that would promote innovation in policy, processes and research. Thus the interest of the project was not simply individual capacity development but also how capacity development could be embedded institutionally and what type of 'institutional ecology' was needed to enable that to happen. As implied above, the materials taught both innovation management and research methods to give participants an understanding of the importance and function of innovation and how best to promote it.

In addition, the project aimed to promote or enhance critical reflection. In this sense, the project echoes Winberg (2006, p.161) whose work on South Africa argues 'for teaching and learning in the higher education sector to be seen to be knowledge producing and contextual, rather than knowledge 'reproducing' and discipline-bound'. The teaching and learning approach used by the OU is informed by a constructivist perspective (new knowledge building on and challenging prior knowledge, leading to reflection and action), and is designed to be interactive and to create 'reflective practitioners' (Atkins et al., 2002). In this sense, then, we hoped

that participants would be challenged by the learning experience, that it would influence their thinking (and even potentially contribute to 'continuous improvement' [Bessant, 2000; 2003] in their own organisations).

3.2 Findings

As implied above, the project combined practice and application with research and evaluation. We were interested particularly to find out about participants' reactions to and use of module content, whether and how the content was relevant for innovation in Kenya, and what kinds of institutional and organisational settings could use it. Data were therefore collected as the project progressed, including a component of 'real time evaluation' (Ling, 2012) carried out through questionnaires and workshops, as well as interviews with project participants and meetings with officials in the public and private sector. In addition to understanding the learning experience and use of it by participants, key issues were the policy challenges of promoting a 'learning society', and how space could be created within and between organisations to promote the capacities, skills, resources and employment opportunities needed for innovation and development more widely.

To analyse the data, we developed a thematic framework which referred to key themes in the literature as well as identifying emerging themes from the Kenyan context. The major themes that emerged combined: (i) notions of individual and collective learning and awareness of developments in science and technology and sci-tech policy (Arocena and Sutz, 2003); (ii) the need for opportunities to apply learning and an institutional setting or ecology (UN, 2005) that enables education and training to be diverse, context-based and knowledge producing (Kearney, 2009; Winberg, 2006); and (iii) links to collective action and the prospects for very different kinds of universities, curricula, pedagogies and research agendas (Arocena and Sutz, 2010; Kearney, 2009; López Cerezo and Verdadero, 2003; UN, 2005).

3.2.1 Learning and awareness of science and technology

Overarching findings on themes (i) and (ii) are outlined in Table 1. For example, project participants noted both the positive reinforcement of particular skills (rather than substantive content) as well as how they hoped to use their new knowledge and skills in the workplace. It will be seen that many of these comments were about learning dynamics and enhanced confidence to work with others on similar issues.

However an issue for the project was how participants would use their learning in their own professional arenas. Two illustrations in Section 3.2.2 below demonstrate how learning could be adapted to context.

[Table 1 here]

3.2.2 Applying learning to context

At the end of the first phase of the project, module participants were invited to use their new knowledge and the materials to organise a workshop or other type of session within their own organisation or group of stakeholders. Two workshop reports reveal the different dimensions of innovation in which each organisation was

engaged (and hence the need to enable learning processes in many different environments, as argued above).

One workshop, held in the Ministry of Higher Education, Science and Technology, was organised by two of the participants who worked there. They carried out presentations using the module materials and held discussions with a collegial audience of 20 people. Highlighted in the report of the workshop was, first, their colleagues' desire for greater theoretical conceptualisation and understanding of innovation: 'They expressed interest in usage of terminologies – innovation, technology, invention and others – in common speech and by specialists in technology policy and innovation policy studies.' Second were other absences in knowledge that colleagues wished to improve: 'Whilst the group that was targeted was largely comprised of research scientists of different specialities, it emerged that technology and innovation policy studies has not been widely studied per se as a discipline by colleagues. What emerged was that there was room for learning, especially in harnessing of qualitative techniques for policy research; terminology usage in innovation and technology studies; and triangulation for better research outcomes in policy studies.' Third were plans for further dissemination: circulation of definitions of key terms in innovation studies; the possibility of having another workshop with a wider stakeholder base 'to ensure that policy makers from non-science professions be brought to know the meaning of key concepts in science, technology and innovation as they apply to policy'. Finally, was the observation that 'information dissemination in science is an *art* that is not mastered among many in the science arena. We need clear communication of concepts to expert as well as lay audiences.' These observations echo sentiments in much of the literature – the institutional settings are not however always conducive to realising these aspirations, a point we return to in Section 4.

A contrasting participant workshop was organised by a small private business for small-scale entrepreneurs working in the solar sector (in Uganda). The business was dedicated to finding solar solutions to energy problems that could be accessed and used by low income consumers. This workshop could be characterised as context- and practice-based in that the main concern was grounded in the entrepreneurial concerns of the participants, that is, innovation products and processes: 'to meet and exchange useful views, ideas and suggestions to improve the quality of the … solar products and services (i.e. solar phone chargers, solar charging controllers, the design and assembling processes etc)'. The main module tool used in the workshop was triangulation in research and investigation: 'this multidisciplinary approach ensures addressing challenges in a rather comprehensive manner'. Key dimensions that come through from the workshop report are that the workshop was highly interactive and participatory; participants improved awareness of issues and 'shared issues of mutual concern, established contacts with each other for future networking'; participants also made plans to visit each others' work sites. Whilst these aspects reinforce the principle of the importance of networks in innovation, the topics that participants wanted to pursue in future workshops were also highly grounded in the practice needs of innovators: 'leadership qualities for operators of solar-powered phone-chargers; record-keeping: an essential skill for operators of solar products and services; the importance of effective customer care in boosting

and sustaining the solar businesses/services; attractive product/service display for operators of solar products; and effective self-presentation for operators of solar products and services'.

These two, very different, accounts suggest that it does not take much to stimulate and motivate participants to think differently about the learning, knowledge and skills that are needed more widely for technology policy and innovation research. These participants readily applied the learning to their own contexts and practice and thought critically and reflectively about their place within the process of innovation. Their different backgrounds and the activities they undertook in their workplaces meant that innovation activities were applied or considered through a range of areas and not only in formal R&D settings.

As outlined above, the project involved university graduates and professionals working in key sectors. However the studies they undertook and the practical activities and applications challenged them in terms of ideas and critical thinking. They enabled them to see how the ideas and applications could enhance not only their own skills but those of others in their organisations – as well as wider stakeholders. For example, one interviewee, who had worked previously in science cafés[v], was very keen to use the ideas she had studied with school children.

These data are largely from self-reporting through the questionnaires, interviews and workshops. To validate them further it would be important to undertake additional interviews with line managers in the project participants' organisations. This is not something we were able to do in general, although we met with two line managers and others attended sessions in the workshops. However we do not think this undermines the general nature of the findings and of their contribution to the idea of an integrated and inclusive STIS education.

3.2.3 Collective action and innovation in education

The last point leads us to theme (iii) on 'links to collective action and the prospects for very different kinds of universities, curricula, pedagogies and research agendas', where the enabling environment required to support training was a particular focus in the second workshop (October 2010) and of discussions with public and private sector stakeholders (ministry officials and industry representatives). Although one subject of interest was the potential of accredited distance learning to reach people at scale, another significant issue was the need for sector-specific approaches and content. A range of businesses and requirements were noted, such as small businesses (kiosks) needing to engage with market innovation, banking for low income customers and the need for social innovation for a better quality police force. Discussions with a representative from one of Kenya's leading public companies highlighted the importance of mapping generic innovation training on to a company's specific portfolio, enabling colleagues to internalise the information more easily and use it effectively in the company.

Participants at the workshop also stressed the importance of policies that promoted supportive systems and processes: advocating innovation and innovative activity was not enough. Key, they argued, was the need for infrastructure such as internet access. An example was given during discussions with an academic stakeholder, who highlighted the government's support of a science park development at University of

Nairobi. Discussions with other stakeholders also identified the importance of support from key individuals and groups such as industry associations. The need for supportive policy and multiple stakeholders is best summed up by the message to policy makers, formulated by participants of an ACTS' November 2011 training workshop:

'Message to policy makers

- While science might be useful to address policy issues, it is still not clear about mechanisms through which such knowledge feeds into decision making. It is good to think of avenues for interaction between scientists and decision makers and the wider stakeholders.
- [Scientists and decision makers] should appreciate interdisciplinary approaches so that they can generate relevant policy issues from the research output coming from research organizations…
- … Promote participation of diverse stakeholders in policy making.
- Ensure that all stakeholders – beneficiaries of technology, experts etc are involved in policy formulation process…
- … Establish mechanisms by which policy formulation involves contributions made through scientific facts.
- Continuous research on policies affecting innovations and technology
- Form policies that will favour local innovation in respect to funding.'

(Kingiri, Rono and Adwera, 2011)

4. Discussion and conclusion

Our evidence underlines the importance of an approach to education and training that supports all types of innovation, including that which occurs 'below the radar' as a result of everyday activity. While taking as our empirical starting point a project that used postgraduate level professional development training, the types of learning that occurred as a result of the training emphasized the importance of innovation in different settings, not simply as the product of formal R&D. These findings resulted partly from the approach and content of the materials and partly from the creativity of the participants involved, the majority of whom were not involved in formal R&D activity as part of their 'day jobs', but were able to adapt their learning to their own organisational settings. The project provided evidence of how some participants have gone on to change the way they work or have voiced their desire to change the way others work, to induce an appreciation of innovation if not necessarily increasing innovative activity per se. As such the project highlights how education and training can be used to support a wider understanding of innovation and its key importance to societal development.

The data highlight a tension between focusing on generic understandings of innovation and the promotion of sectoral specific training. This aspect underlines the importance, raised in the literature, of thinking about practice and context. On one hand, key to our project was the ability of our participants to utilise the materials and modify them in their own settings, supporting the notion that learning is not simply about a linear and codified knowledge process but one which supports

learning by reflection, interaction, doing and using (Jensen et al., 2007; Johnson and Thomas, 2004; 2007). On the other hand, our interviews with stakeholders and feedback from the workshops highlighted how the materials would be easier to embed if contextualised and made sectorally specific.

Furthermore, as one of the project participants pointed out, innovation is an important element for teaching in schools. Looking at university-level education and professional development is necessary but not sufficient for creating a 'learning society', particularly in low and middle income contexts where there is often considerable invention and innovation 'below the radar' that could be – but is not – brought into markets at scale.

Our project and discussion of the literature do not enable us to conclude definitely that there is a better set of institutions or a different place for universities in an education or innovation system. However, it highlights the need for further research on how to make innovation pedagogy more inclusive to different forms of knowledge, sectors of the economy and types of people. It also needs to investigate how to create 'developmental education systems' that integrate innovation learning and knowledge production so that, as one of our interviewees stated, they no longer remain trapped in 'silos' as a result of 'day to day survival' activity.

In addition, there is an overall need for a more enabling environment to enable an inclusive and integrated pedagogy to gain ground. Vessuri (2003, p.264) notes that the place of science and technology in society needs to go hand in hand with political and economic change: 'scientific activities per se cannot achieve anything unless there is a long-term commitment to development'. It is important to consider education systems as a whole – the creation of critically reflective individuals at all levels who are able to link study and thinking (as well as research) to active, context-based problem-solving. However, as indicated above, the literature also notes that individual education, training and capacity development is not enough – conducive institutional and organisational settings and policies, and linking to wider collective action, are also needed. Furthermore these processes require recognising the importance of multiple players and networks. They require the development of public-private innovation networks with links upstream to governments and downstream to practitioners, professionals, innovators and communities, to enable dynamic thinking and practice to have a range of outcomes and spillover effects, particularly as 'innovation often occurs outside academic environments, as a result of inventive thinking and creative experimentation' (Kearney, 2009, p.7).

Recognising this need for a 'developmental education system' within a national system of innovation, would add to, and possibly somewhat reframe, the science innovation system model proposed by Conway and Waage (see Figure 2). In doing so we recognise two key 'below the radar' aspects of the innovation process. First, that innovative activity takes place in many different places and not simply in a formal 'science innovation system'. Second, by focusing on the processes as well as the types of institutions involved at each stage, we recognise the reality of everyday innovation where more than one organisation or institution can be involved in one or more of the processes or stages of innovation. Thus, although we agree that an enabling environment (policies, regulation, investment etc) as outlined by Conway and Waage is absolutely crucial, our model suggests that policy makers in emerging

economies should work towards a developmental education system and a national innovation system which engages horizontally as well as vertically. Such a system would involve:

(i) education from early school to graduates that promotes reflective and critical thinking and their application to problem-solving (development education);

(ii) close links with enterprise and non-governmental initiatives throughout the educational experience (for example, involving visits, hands-on activity and internships between industry and students, from small and medium to large-scale enterprises);

(iii) engagement that routinely includes those who are studying and innovating below the radar in low income communities as well as with schools and universities.

[Figure 2 here]

Thinking about an innovation system in terms of such processes recognises the complex but everyday nature of innovation and provides a way of promoting practice-based and inclusive approaches to policy making. In particular, it encourages policy makers to consider how to support innovation processes as well as individual skills development in universities. In addition, as with Bessant (2000; 2003) our approach focuses on the unlocking of human potential. We are not suggesting that this is the only model - there has been significant and constructive development of thinking in this area in recent years, of which Bessant and colleagues are one example, and widespread recognition that that innovation is a non-linear process. However our argument proposes that innovation requires, as one important element, a different way of conceptualising education, noting with Bessant, that it is people who learn. There is some evidence in the Kenyan context to suggest this is starting to happen. Experience from South America also suggests it is possible to build policy more widely in this direction.

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Figure 1: A science innovation system (Source: Conway and Waage, 2010, p.6)

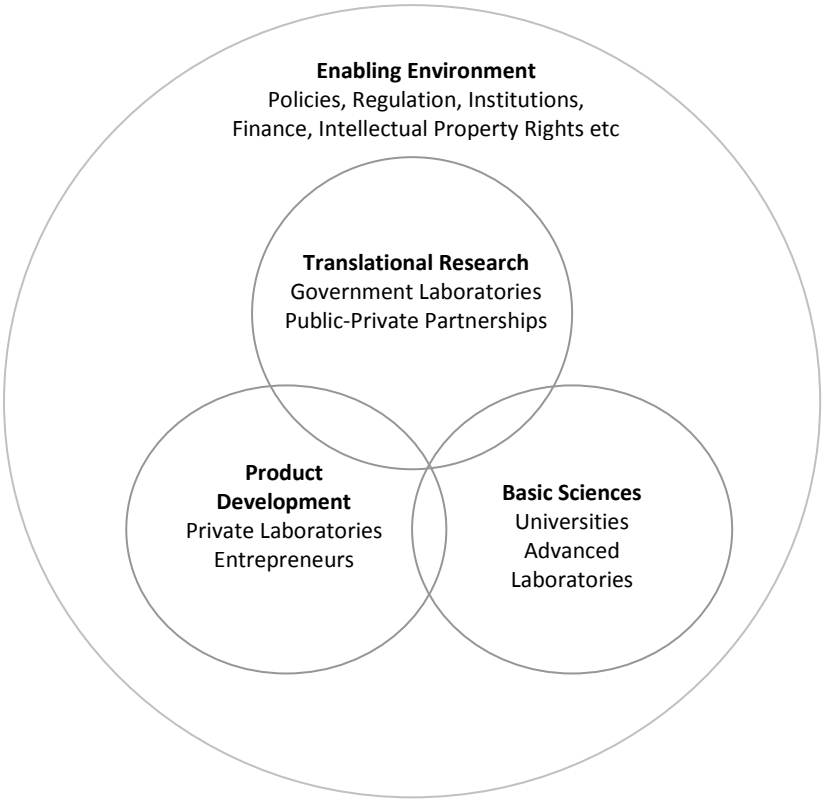
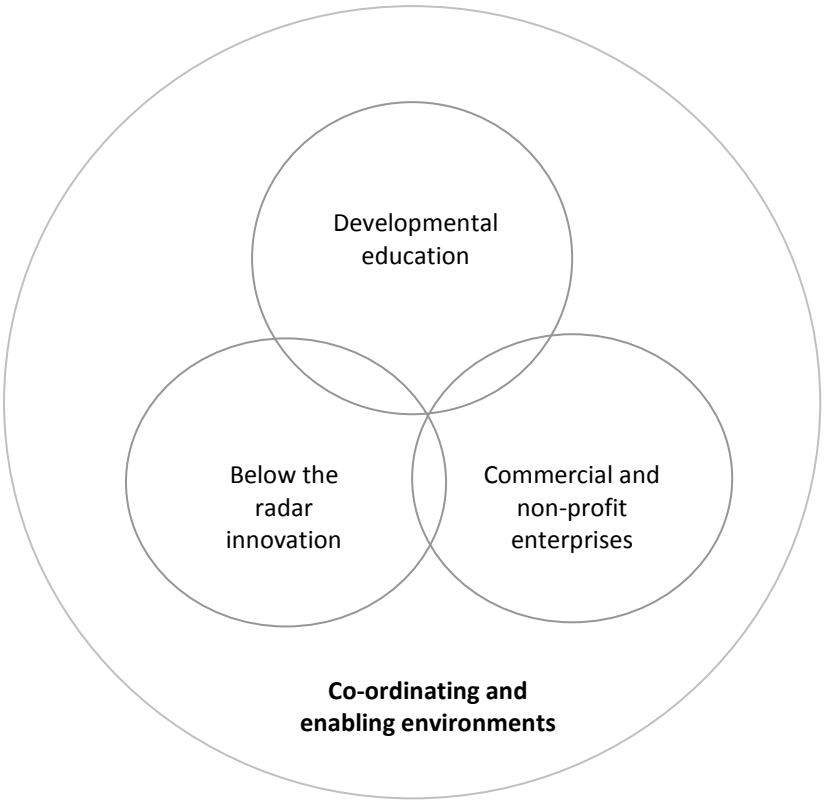


Table 1: Overview of findings relating to notions of learning and awareness, and opportunities to apply learning

Data source and timing of feedback	Data content
Participant questionnaires, January, March, May 2010	**Qualitative feedback on learning and awareness** 'All the material was relevant and useful. Innovation research, policy issues, economic, social, etc. I gained an in-depth knowledge of innovation as a whole (from all angles). I especially enjoyed critically reviewing methodologies and settling on the most appropriate approaches for given research projects/proposals.' 'The course was really beneficial to me and my work. […] below are some good parts: a) The research methods – a number of useful methods were explained and how and when to use them. This is very beneficial when it comes to undertaking research. b) Issues on policy – the way to go about it and ways to curb challenges. c) The reading on stakeholders and how to deal to involve them when going about one's work. They even help to give ideas and/or direction.' 'Overall I have learnt that before any project (technological/non technological) if it's to be implemented in the community, it is important that research is done first; at the same time the community (beneficiaries) should be engaged into the research.' 'I especially enjoyed critically reviewing methodologies and settling on the most appropriate approaches for given research projects/proposals.' 'Include more examples from each part of the world…' 'For future development of the course/study programme, I would suggest providing an opportunity to undertake a practical project integrating knowledge gained from the programme with an example of current practice/problem in a student's home country. This would enable a student to use his/her study experience [in] the analysis and application of a practical situation in any field or in any project. This can help one build other skills such as learning to plan, organize and carry out an independent project/research (preparing your initial project proposal; planning and managing your project to understand the nature of the research process and the strengths and weaknesses of various approaches; collecting, analyzing and using data reviews; and presentation of results and report-writing). When such studies/projects are carried out, documentation of findings (say a research report) can form part of the reading material for future students.'
Workshop at module end, June 2010	**Qualitative feedback on learning, awareness and potential application** ***What were the positive outcomes of this workshop for you?*** Enhanced capacity to organise workshops; refresher reminder on how to design one. Importance of logistics and workshop structure. Asking audience about expectations earlier enough so as to be able to meet them. Importance of engaging the audience.

	How to make learning more interactive; tools of presentation. How to work in a team. Gain in confidence and knowledge. Recap of appropriate research methods and tools; solving day to day research queries; learnt some research methods that can use for own organisation. Opportunity to network with others (including for collaborative research work) and meeting people that hadn't met before (including course facilitators). ***How do you hope to use these outcomes in your work/organisation?*** More confident to conduct a workshop in my work place and/or organising learning sessions for colleagues. Formulation of quality research proposals. Transfer of knowledge/skills to colleagues and others. Bring back workshop skills; useful do's and don't's. Organise a training workshop in my organisation; develop presentations and share with fellow staff; disseminate information to members of technical staff through organizational workshops. Present various aspects of the subject content in workshops and conferences. Introduce research methods to members of my organisation. Hope to disseminate research methods to (my) students.
Interviews 6 months after module completion	**Qualitative feedback on learning, awareness and potential application** Gained improved knowledge of innovation processes and research methods, including how innovation plays a role in development projects as well as in commercial activity; enhanced skills in critical thinking, document review and analysis, report writing, were also mentioned. Gained more confidence in engaging with issues around innovation and science policy in the workplace; one mentioned the practical application of cluster ideas in her area of work and, another, the use of stakeholder analysis. Thought that the policy dimensions and the research skills could be useful much more widely in their organisations; such skills did not only apply to those directly involved in innovation but also in monitoring and evaluating development projects; ideas about innovation were also seen as useful in long term, strategic planning in an organisation.

Figure 2: An alternative framing of an innovation system



[i] The UK Open University is a distance teaching and research university, based in Milton Keynes, UK.

[ii] The African Centre for Technology Studies is a policy think-tank, research and training organisation with a regional remit; it is based in Nairobi, Kenya.

[iii] See: http://www.fundaec.org/en/index.html

[iv] http://openlearn.open.ac.uk/

[v] Science cafés are informal meetings open to everyone where scientific issues are discussed (see www.sciencecafes.org, accessed 30/01/12).