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The young engineers and scientists of Africa: initiating the STEMI pipeline

This article focuses on the importance of initiating the Science, Technology, Engineering, Mathematics, and Innovation technology (STEMI) pipeline to facilitate the delivery of suitably qualified and motivated individuals for the national system of innovation. The Young Engineers and Scientists of Africa (YESA) programme is emerging as a national delivery vehicle for promoting creativity and innovation through a number of different school-based interventions. The heart of the process is the ability to track learner involvement in STEMI activities, events and competitions from Grade 1 to postgraduate level, with the expectation of identifying talented learners using social media on mobile phones.

Die jong ingenieurs en wetenskaplikes van Afrika: loodsing van die WTIWI-pyplyn

Hierdie artikel handel oor die belang daarvan om die Wetenskap-, Tegnologie-, Ingenieurswese-, Wiskunde- en Innovasiepyplyn (WTIWI) te bevorder met die oog op die verskaffing van toepaslik gekwalifiseerde en gemotiveerde individue vir die nasionale innovasiestelsel. Die program *Young Engineers and Scientists of Africa* (YESA) ontluik as 'n nasionale voertuig om kreatiwiteit en innovasie te bevorder en wel deur 'n aantal verskillende skoolgebaseerde tussenkomste. Die kern van die proses is die vermoë om die betrokkenheid van leerders te volg in WTIWI-aktiwiteite, geleenthede en kompetisies vanaf Graad 1 tot nagraadse vlakke in die verwagting om talentvolle leerders te identifiseer wat sosiale media en mobiele telefone gebruik.

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Science and technology are critical to the future of South Africa. The South African government recognises its key role in providing an enabling environment for innovation and research and in building the human capital required for the future knowledge economy. The National Research and Development Strategy motivates, first, the adoption of and funding for new technology undertakings for the promotion of economic and social development. These include biotechnology, information technology, technology for manufacturing, technology for leveraging knowledge from and adding value to the natural resources sectors, and technology for poverty reduction. Secondly, it motivates the development and transformation of Science, Technology, Engineering, Mathematics, and Innovation technology (STEMI) human resources and linkages with the higher education sector through the National Research Foundation (NRF), which is responsible for promoting and funding science in the higher education sector.

Positive steps forward reveal that there are new sets of challenges to which we must respond. Innovation is not equivalent to research and development. Innovation is the key process whereby products, processes and services are created, and whereby businesses generate jobs and wealth. In addition, in the social sphere, effective innovation has a strong impact on the reduction of poverty and the improvement of the quality of life of people. It is therefore critical to increase the rate and quality of innovation in South Africa (Ngubane 2002: 5). Innovation requires well-trained, effective scientists, engineers and technologists. There is increasing evidence that South Africa is not making satisfactory progress in producing scientists, engineers and technologists. We therefore require interventions to strengthen the transformation of our science and technology capacity in order to achieve increased numbers of people working in key fields that are important for the future (DST 2002: 5).

The National Research and Development Strategy describes the South African context according to four key points. The first two are highly relevant to the Young Engineers and Scientists of

Africa (YESA) programme. First, human resource development is required in order to exert maximum effort to train the necessary numbers of people in all fields required for the development, operation and management of modern economies. This should be a national effort in which obligatory expenditures should be viewed not as a cost, but as an investment in our future. Secondly, we must ensure that as many people as possible master modern technologies and integrate them in social settings, including education, the delivery of services, and economic activities. This relates, in particular, to communication and information technology (DST 2002: 3).

A method for companies that are serious about investing in their future is to make funds available in the form of bursaries, scholarships and internships. Such funding could be used to lure worthy candidates into pursuing tertiary qualifications to supplement skills shortages in key areas of the company's Human Capital Development (HCD) strategy. The search for quality future employees is a constant endeavour of allocating and replacing human capital in response to natural migration, immigration, retirement and stagnation in the workplace. However, it is important that forward-thinking organisations accept the challenges of adapting to the pressures of a changing economic environment by actively nurturing creativity and innovation in order to retain a competitive edge in the marketplace. Prospective students applying for such funding opportunities often fail to meet the stringent requirements of minimum grades in certain subjects at grade-12 level. They also need to attain sound academic records in the preceding grades, present a combination of certain major subjects, or display a variety of additional skills in terms of leadership, sport and social responsibility. Any such additional and relevant achievements may place the candidate at an advantage. Coupled with this are terms and conditions related to working for the company for a prescribed period of time.

The assumption is that information regarding the funding options will be made available to all learners throughout the country through a variety of channels to ensure that the talent search is

cast as widely as possible. All companies strive to identify the best possible talent in order to select only the top candidates for the limited available bursaries. The current general standard for comparing students' achievements is the national exit examinations at the end of Grade 12. When presented with this information, the company supplying the bursary has the task of shortlisting candidates with the expectation of interviewing them for final selection. Authenticating this information is essential to the process. Finally, there has to be return on investment to the company in the form of productive years of service.

However, the dilemma is that many candidates come from diverse educational backgrounds and there is substantial range in the quality of teaching, from unqualified and underqualified teachers at poorly resourced schools to highly qualified and experienced educators at well-resourced institutions. Talented individuals from poor teaching environments could be disadvantaged through no fault of their own, resulting in average results, whereas the converse may also be true. There is no way of differentiating between learners with similar results other than by finding alternative and appropriate indicators.

This article proposes the concept of a national portal in the form of the My YESA Passport. YESA was incubated within the African Advanced Institute for Information and Communication Technology, commonly referred to as the Meraka Institute. YESA is in the process of emerging from the Meraka Institute as a not-for-profit organisation. YESA aims to initiate and nurture a pipeline for STEMI from an early age by introducing various interventions. It aspires to engage as many learners as possible while developing their innate creative and innovative talents. Individuals exposed to, and emerging from, the various YESA interventions will therefore be better equipped with the appropriate knowledge, skills, attitudes and values to operate effectively in the present and future digital and technological world. The skills required cover a broad range from basic technology education to PhD levels, and relate to everyday skills such as reading, writing, arithmetic and ICT skills. A key component of YESA is the My YESA Passport, which

is designed to track learner involvement in STEMI-based events, competitions and olympiads in order to identify individuals with talent.

The My YESA Passport is informed by the YESA skills grid; human capital development; the national system of innovation; twenty-first-century skills development; creativity and innovation, as well as STEMI.

During the incubation phase of YESA, a number of interventions were conceptualised to address specific skills gaps in the development of individuals (*cf* Figure 1):

- FabKids

  Learners are introduced to the high-tech rapid-prototyping environment of a fabrication laboratory or FabLab, where they are expected to apply the principles inherent in the design process to solve set challenges in teams (Beyers 2010a).

- Digital Kids

  Computer literacy is assumed in order to convey the principles of digital literacy through the use of open source software in technology clubs. Participants are taught to generate 2D and 3D graphics, animations, video editing and web page designs, and receive an introduction to programming.

- Fab Teachers

  The principles of FabKids are applied to the Fab Teachers, the only difference being that participants are exposed to the pedagogy of the design process.

- Information leadership conferences

  Through this intervention, teachers are encouraged to become knowledge producers and to share best practices within such forums.

- Developing technology clubs

  This intervention is initiated through Digital Kids and is expanded to include a host of additional relevant STEMI activities wherever possible.

- Ulwazi project

  Through this project, virtual interactive classrooms are created using wireless broadband connections, interactive whiteboards, webcams and microphones for digital sharing among teachers (Beyers 2007).

- South African School of Space and Aeronautical Technologies

  This concept aims to initiate a cost-effective method to attract the youth to careers in space and aeronautical technologies (Beyers 2008).
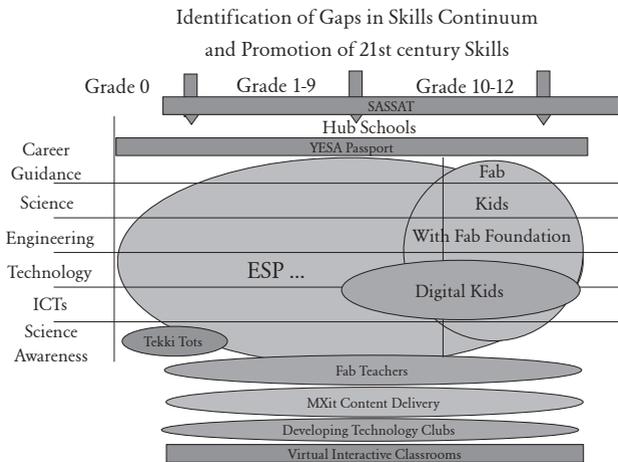

Figure 1: YESA skills grid

- Hub School concept

  This concept is based on the integration of the foregoing projects as value-added services in addition to an existing information communication network (Beyers 2010b).

- My YESA Passport

  This system tracks learner involvement in STEMI events, olympiads and competitions while delivering additional service through a variety of channels.

1.   Human capital development

Since the Second World War, many defining moments have had a cumulative effect on the emphasis and direction of the economies of major global superpowers. This, in turn, has shifted the focus from short-term decisions affecting economic growth to long-term education decisions. Hagen, a senior scientist with the USA Naval Research Laboratory, headed the American effort to launch a satellite code named Project Vanguard in the late 1950s. His concerns and those of others were raised on Sputnik Night, exacerbated by later Soviet accomplishments in space flight, and enjoyed a long gestation period. For much of American history, and certainly throughout the twentieth century, if there is one hallmark of the American people, it is their enthusiasm for technology and what it can help them to accomplish. They used technology to transform a wilderness into their "city upon a hill". Since that time, the USA has been known as a nation of technological system builders who were able to use this ability to create great machines and the components of their operation of wonder (Launius 2005). J F Kennedy's presidential campaign revolved around getting America moving again on all fronts: militarily, technically and economically (Thurow 1992: 12). The desire to maintain a competitive advantage has persisted to the present, with America's political and economic leaders urging radical changes in their education system (Hershberg 1996: 1). The National Adult Literacy Survey in the US in 1993 highlighted the fact that half the American workforce (approximately 90 million adults) were ill-equipped for the jobs of the twenty-first century economy (Hershberg 1996: 5). The significance of human capital development is related to the concept of "human capital", or the education, skill levels and problem-solving abilities that will enable an individual to be a productive worker in the global economy of the twenty-first century (Hershberg 1996: 1).

Failing to invest in the education of the future generation can have dire consequences for the long-term success of a country through lack of developing the throughput for HCD. This will ultimately have a direct effect on achieving the Millennium

Development Goals (United Nations Millennium Summit 2000), which touches the lives of every member of society that is influenced by the success of the educational reforms initiated. In post-apartheid South Africa, the implementation of educational reform processes depends on who occupies the vital post of Minister of Education in the ruling party.

HCD also forms part of the Department of Science and Technology's (DST) Ten-year Strategic Plan. Integral to this is the national system of innovation, which is focused on increasing the pool of innovators and increasing the number of PhD graduates who can compete on an equal footing with the rest of the world. This is closely supported by the DST's Youth into Science Strategy (YiSS) as part of its goal to promote youth empowerment in science, technology, engineering and mathematics (DST 2006). This is expected to ultimately close the skills gap by supporting all efforts to improve the development of high-level researchers, scientists and technologists. The My YESA Passport will also capitalise on the Schooling 2025 programme, which is long-term plan for the basic education sector, allowing for the monitoring of progress against a set of measurable indicators.

2. National system of innovation

It is important to consider the impact of the formative years on the number of doctoral students that South Africa can produce. The yardstick for the National System of Innovation (NSI) is generally the number of PhDs that a country produces. To increase capacity in the pipeline, it is necessary to return to the source and make a long-term investment from as early an age as possible in the hope of increasing the human capital feedstock. YESA is the start of such an initiative and will feed into the South African government's awareness of the need to stimulate entrepreneurship, innovation and growth among knowledge-intensive businesses (Comins 2006). Science and technology education, innovation and commercialisation are integral components of the NSI. The key challenges are adequate funding; skilled human resources; improved private sector research and development; protecting and exploiting intellectual

property, and integrating a fragmented government science and technology system (Comins 2009).

3.   Creativity and innovation

Innovation is not new. Arguably, it is as old as mankind itself. There seems to be something inherently "human" in the tendency to think about new and better ways of doing things and to try them out in practice. Innovation, according to Finland's new national innovation strategy (Lemola 2009), is also an interactive process that is made possible through collective and collaborative processes involving a range of actors (including firms, users and researchers), but people are at the heart of any innovation process. Without innovation, the world in which we live would be very different. Imagine a world without aircraft, automobiles, telecommunications and refrigerators, to mention but a few of the more important innovations from the not-too-distant past. Taking a longer perspective, where would we be without such fundamental innovations as agriculture, the wheel, the alphabet, or printing (Fagerberg *et al* 2006: 1)? We can no longer rely on traditional pedagogical approaches to solve the problem of a lack of skills needed by an emerging economy or to promote creativity and innovation together with other twenty-first-century skills. The strategic deployment of a large number of fabrication laboratories, or FabLabs, is envisaged as the delivery vehicle for initiating the processes based on the lessons learnt from the six pilot projects over the past three years. The FabLab concept originated as the educational outreach component of the Massachusetts Institute of Technology's (MIT) National Science Foundation-funded Center for Bits and Atoms.

A FabLab consists of a suite of off-the-shelf, industrial-grade, digital fabrication tools, an electronics workbench, as well as computers and programming tools, and is supported by open source design software and CAD and CAM experimental freeware. It is designed for community-based, peer-to-peer, informal technical education and invention (Lassiter 2009: 5). Emerging technologies and the industries based upon them are very often accompanied by a widening of the socio-economic gap. People and places with

resources are the first to reap the intellectual and financial benefits of their development. Closing that gap is essential to the general economic prosperity of a society and for the more equitable distribution of wealth.

Chesbrough (2003) views innovation as quite different from invention. "Innovation" means invention implemented and taken to market. Beyond innovation lies "disruptive innovation", which changes social practices (the way we live, work and learn). Really substantive innovation (the telephone, the copier, the automobile, the personal computer, or the internet, for example) is quite disruptive in that it drastically alters social practices (Chesbrough 2003: ix).

It is against this background that the My YESA Passport is set to operate.

4.   Features of the My YESA Passport

In order for the My YESA Passport system to function effectively, it was established as a national portal with access through a variety of technologies. Figure 2 displays the introductory screen of the *alpha* version of the web portal, and Figure 3 shows a mock-up of the My YESA Passport on a MXit platform. Seed funding for this phase of the project was provided by the South Africa-Finland Knowledge Partnership on ICT (SAFIPA 2011). The *alpha* version provided some functionality to highlight basic features of the Passport. The new version that will appear early in 2011 is based on MXit (pronounced "mix it"), a free instant messaging application developed by MXit Lifestyle (Pty) Ltd in South Africa. The implications are that the My YESA Passport will be accessible, constantly available and more affordable on a number of mobile devices and computer platforms reaching a far wider audience, even from the back seat of a taxi.
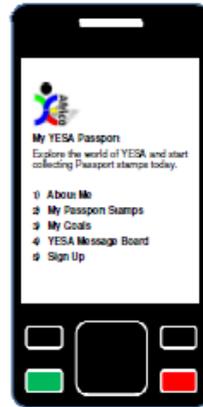
Figure 2: The My YESA Passport website

Figure 3: A mock-up of the My YESA Passport on a MXit platform

The planned capabilities of the My YESA Passport service can be summarised as follows:

- National delivery vehicle for STEMI events, competitions and olympiads in collaboration with other stakeholders (including a public relations channel and shared event booking service)
- Passports and visas
  - Real and virtual passports
  - Access via Web, WAP and mobile phones (MXit)
- Career planner
  - Setting personal vision and mission statements
  - Delivery of relevant STEMI career information
  - Presentation of specific tertiary institute entry requirements
  - Revisiting of personal goals
  - Job opportunity adverts for STEMI

- My Personal Passport Space
  - Customisation by the user
  - Personal and shared calendars
  - A range of additional widgets, portlets and games to promote access to STEMI information and collaboration within the YESA community
  - Announcement of STEMI competitions, events and olympiads
- Supplementary STEMI content
  - Lab- and fieldwork exercises that can be conducted using household equipment
  - Opportunities to accumulate informal YESA stamps for real and virtual passports
- Issuing authorities
  - Federation of Engineering, Science and Technology Olympiads and Competitions (FESTOC)
- Populating information to personal calendars
- Registering events
- Issuing real and virtual stamps
- Capturing post-event data
  - Technical colleges, universities
  - Private sector training providers
  - Industry
- Reporting and tracking
  - Generation of dynamic reports customised to meet the needs of clients
  - Longitudinal reports on individual learners over a period of time
  - Vertical statistics on events, geographical concentration, gender and age differences, for example

- Research opportunities for further high-level investigations into
  - Human capital development
  - Tracking of learners
  - Efficacy of the system
- Events management of almost any national or local event.

It is not possible to provide detailed explanations of all the components of the system in this instance; a few key elements are thus highlighted. The original Passport was envisaged as a physical document issued to learners on application through schools or the various issuing authorities. The latter could electronically issue uniquely numbered stamps for specific activities and events, and such stamps could be added to a user's paper-based passport.

The introduction of the MXit version will open up the possibility of reducing the costs of managing a complex paper-based environment by issuing virtual stamps onto an individual's virtual passport as a permanent record of their STEMI activities, events and competitions. MXit IM, a next-generation mobile instant messenger and social networking software application, allows users to chat anywhere from a mobile phone or PC at no charge, using Yahoo, ICQ, Google Talk, AIM or Windows Live Messenger contacts (MXit 2009).

MXit (MXit 2009) and metaLAB (2011) are striving to ensure that appropriate educational content and services are made as widely available as possible, at no charge to the end user, across Africa and beyond via MXit's mobile instant messaging channel (IM). BSmrt (pronounced "be smart") is a new portal live on MXit that is devoted exclusively to achieving large-scale, systemic, social impact, using education as the point of reference for stimulating sustainable livelihoods. BSmrt's educational approach is rooted in the idea that young people have the inner resources to solve their own problems and that all they need is access to information, skills, support and platforms through which to communicate. Using BSmrt and MXit can provide an invaluable service to the My YESA portal in providing supplementary educational content

as well as a conduit to the portal itself from the comfort of a mobile phone.

The My YESA portal allows for the generation of two types of records. First, there is an externally verifiable set of data generated from an individual participating in a formal event such as a mathematics olympiad, a technology olympiad or a regional science Expo. Long-term records will be available of the individual's participation as well as the outcome of such events. Secondly, it will be possible for individuals to participate in informal events based on the completion of low-level tasks, similar to Scout Badges (World Scout Bureau 2010). These activities are focused on the promotion of science and technology awareness accumulated through the completion of prescribed activities, which are not reliant on mass participation in a competition-type environment. The lab- and fieldwork sections of the portal make provision for individuals using common equipment found in the home.

The portal will also include the development of a wide range of compelling content and micro-services that are both magnetic and sticky. Their aim is to avoid churn. This will provide a vital channel of information, including interactive science and technology multimedia curriculum content to supplement the work done in classrooms. A paper-based system would severely curtail the impact of the Passport system by limiting access to vital sections of the portal. Given the maturity of mobile technology platforms, it is now possible to deliver multimedia content to individuals in deep rural communities at affordable rates. This will go a long way towards digital inclusion of individuals who find themselves disadvantaged by the digital divide. Major advantages of the portal system include:

• Horizontal analysis

The ability to track an individual's involvement in STEMI from grade 1 to doctoral level. This affords the opportunity to conduct large-scale longitudinal national studies. FESTOC members can provide statistical information on the annual number of participants and, in some cases, identify an individual's involvement over a number of consecutive years. There

are, however, no records available for individuals participating in multiple olympiads and competitions over a number of years.

- Vertical analysis

    The Federation of Engineering, Science and Technology Olympiads and Competitions (FESTOC), for example, was established to coordinate the national STEMI events. However, there is a paucity of information to identify critical geographical information on, *inter alia*, the location of hot spots in the country or where to focus future efforts. The existence of the MY YESA Passport portal will provide an opportunity to datamine a common data source in order to take decisions on national initiatives in the longer term, in particular for various government departments, including Education, Science and Technology, and Labour.

The availability of a verifiable long-term record of an individual's journey is viewed as an invaluable indicator of their interest and commitment to a potential career in STEMI. The current indicators available to prospective employees and to companies wishing to secure top students through the allocation of bursaries are limited essentially to the student's internal academic records and a final exit examination at the end of Grade 12. Given the presence of a verifiable source of data, it is believed that potential employees would be interested in data-mining the Passport data bank for potential candidates, especially as the system matures over time.

It should be borne in mind that education deals with the learner holistically, and not merely with the left side of the brain. In general, schools tend to favour left-brain modes of thinking, while down-playing right-brain ones. Left-brain scholastic subjects focus on logical thinking, analysis and accuracy (Riedl 2002: 9). There is a need to promote creativity and innovation at school level through the use of subjects such as art that develop the right side of the brain. Academic subjects tend to cater for the more mentally adept left-brained individuals, while technical subjects cater purely for the development of psychomotor skills. The recent introduction of technology education into the South African national

curriculum up to Grade 9 provides an opportunity for nurturing the capabilities of creative right-brained individuals if the subject is taught correctly. This is dependent on the background of the individual appointed to teach the subject.

The success of the My YESA Passport is heavily reliant on the promotion of the system to as many users as possible. A number of scenarios for marketing are envisaged. Direct marketing will be employed using print media, contact with schools and other broadcast media. Additional promotion opportunities will be sought through mass school events and channels such as the SciFes, Sci Bono Centre and MTN science centres. This will entail banner advertising inviting learners to register through either MXit or e-mail to gain access to the entry-level components of the system. Once registered, a second level of promotion can be achieved through permission-based marketing as well as viral marketing through social networks such as Facebook and Twitter. This is in contrast to spam, which is unsolicited commercial e-mail.

The portal service will guide learners through the process of compiling their own *curriculum vitae* for submission to prospective employers. They can also build their own e-portfolio recording the extracurricular events they have attended, YESA experiments they have conducted and fieldwork they have undertaken. This will allow learners to develop a more comprehensive e-portfolio of both formal and informal participation in STEMI activities for their YESA Passports.

5.   Potential outcomes

This initiative will build on the lessons learned during the successful prototype phase, which was funded by the South Africa-Finland Knowledge Partnership on ICT (SAFIPA) early in 2009. The original intention of the prototype was to demonstrate a simple system to track learners over a number of years. Based on conversations with various stakeholders, the prototyping team was able to mature the approach into one that combined tracking capabilities with other imaginative yet practical ways of supporting the HCD

work required to create next-generation scientists for Africa. The MY YESA Passport and Journey Planner Service are the beginnings of a community of interest for young people with the potential for even greater social impact in STEMI. One of the characteristics of the "net generation" is that they use technology extensively to network and socialise (Oblinger & Oblinger 2005: 2.12). The My YESA Passport aims to capitalise on this characteristic of modern youth and to engage them by making use of the tools they utilise on a daily basis. However, it is essential to develop an inclusive solution that will reach learners across the country, from top private schools to deep rural communities, in order to track, guide and support them as they explore the world of science, engineering and technology.

As the system matures, the goal is to develop a pan-African approach. The portal is based on the LifeRay Enterprise open source *portal*, collaboration, social networking and content management (Liferay 2009). This product is both scalable and highly portable to other languages, making it suitable for translation into almost any language while retaining most of the features of the Passport system. To push back the barriers for all the youth in South Africa in this way requires YESA to make use of any device that learners can access on a daily basis. A key element of the service will be the promotion of peer-to-peer collaborative learning to encourage users to seek out like-minded colleagues within the YESA community. The objective is to provide a service that will enable approximately 100 000 potential scientists, mathematicians, technologists and engineers to join YESA each year for a period of five years. In South Africa, the estimated mature YESA community would consist of approximately 500 000 learners between the ages of 10 and 25. Assuming a 10% return on investment in encouraging more learners to pursue STEMI careers, there is the potential to increase support for the national system of innovation by an additional 50 000 learners. Table 1 indicates the YESA targets for the number of learners joining, leaving and graduating in the first five years.

Table 1: Targets for number of learners involved in the My YESA Passport system for the first five years

Number of learners	Year 1	Year 2	Year 3	Year 4	Year 5
New registrations on Passport system	100 000	125 000	150 000	150 000	150 000
Carried forward (from previous year)	0	65 000	162 500	282 500	372 500
Churn rate (losses – lack of interest)	-30 000	-20 000	-15 000	-10 000	-10 000
Accumulative total (year end)	70 000	170 000	297 500	422 500	512 500
Numbers graduating from YESA	-5 000	-7 500	-15 000	-50 000	-75 000
Stable community	65 000	162 500	282 500	372 500	437 500

In light of the potential number of involved learners, it is envisaged that a growing number of highly talented individuals will emerge who could draw benefit from the Passport system. It is important to identify these individuals at an early age and to monitor them while allowing them to be fast-tracked through additional support programmes. Data-mining the national repository for individuals with a broad range of twenty-first-century skills needed to contribute to innovative organisations will become an important value-added service to companies.

Students' success rate at secondary and tertiary education levels is unacceptably low, and the educational system has yet to produce the requisite kinds of skills required by society. This situation demands an urgent call to action. Urgent delivery is required on the South African government's Apex of Priorities of skills development, particularly in the area of scarce skills in the science, engineering and technology sector. In initiating a disruptive innovation programme of this nature, the focus will be on bringing about social change for the benefit of marginalised communities

through a multilevel selection processes. Given the strategic importance of increasing the number of suitably qualified scientists, engineers and technologists, it is imperative that a broad range of market sectors be targeted in order to identify and nurture talented youths from an early age through programmes such as YESA. Individuals exposed to, and emerging from, this intervention should be equipped with appropriate knowledge, skills, attitudes and values necessary to operate effectively in the future digital and technological world. The skills cover a broad range, from basic technology education to doctoral level, including twenty-first-century skills. These individuals could be traced and tracked through the My YESA Passport initiative as a longitudinal process of monitoring their involvement in STEMI-related activities. This information could also be used to channel individuals into STEMI careers through strategic placement and bursary opportunities with partner organisations.

HCD forms part of the DST's Ten-year Strategic Plan (DST 2007). Integral to this is the national system of innovation, which focuses on increasing the pool of innovators, leading to an increase in the number of doctoral graduates that can compete on an equal footing with the rest of the world. This is closely supported by the DST's YiSS as part of its goal of promoting youth empowerment in science, technology, engineering, mathematics and innovation (STEMI) and ultimately closing the skills gap by supporting all efforts to improve the development of high-level researchers, scientists and technologists in the country. However, the consequences of a lack of innovation are severe and are directly reflected in economic performance. For example, in the 1960s, South Africa accounted for 6% of world GDP. Curently, this figure is less than 0.5%, although the South African economy has not shrunk year on year. South Africa has simply been "out-innovated" by others who read the signs and acted fast. Half America's current economic growth comes from products that barely existed a decade ago. The degree to which this happens has become a key measure of a nation's success. Innovation has become the economic religion of the twenty-first century. Innovation is needed to outshine the

competition. To thrive in modern economies requires radical innovation. South Africa has not yet adopted this religion *en masse*, but there are exceptions. Innovation is about real people who take risks and set themselves outrageous goals, with nearly impossible odds (Grulke 2001: xv).

The power of the My YESA Passport lies in its ability to create a longitudinal profile of learners' involvement in a range of STEMI events and activities, which can be used to identify individuals with talent to create the feedstock for South Africa's national system of innovation. The Passport portal will contribute towards creating an inclusive, networked society that will constitute its own, self-centred world, characterised by a particular YESA temporal, spatial and cultural horizon. Castell indicates that inside a gatekeeper network, new possibilities are relentlessly created (Stadler 2006: 195).

Given the limitations of an article of this nature, it has not been possible to do justice to the interrelatedness of a system such as the My YESA Passport other than to describe a few examples of its potential in relation to many aspects of the educational process.

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