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KNOWLEDGE MANAGEMENT AND INVESTING IN HUMAN CAPACITY DEVELOPMENT FOR AQUACULTURAL EDUCATION AND TRAINING IN AFRICA

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Abstract

The rapid growth of the aquaculture industry, whilst driven by emerging market opportunities, has been enabled through developing knowledge and application of new scientific and technological innovations supported by private and public investments. While there are numerous initiatives directed at accessing, managing, documenting, publishing, communicating and disseminating research information and data, the present scale of 'knowledge management' is insufficient to achieve wide accessibility and use, particularly in Sub-Saharan Africa. Paradoxically, too much potentially valuable knowledge produced by committed researchers languish in libraries, unused by society; and too many of society's greatest needs for new knowledge remain relatively unexplored by researchers. In this paper, we review recent initiatives to promote sustainable aquaculture development through improvements in education and training capacity, and innovations in the use of new web-based technologies, with emphasis on use of digital e-learning tools. At the broad level, we present three development trends likely to shape the sector: educating for global competencies; knowledge sharing via use of Web 2.0 technologies and open learning resources; and emerging role of flexible and lifelong learning. The paper also present use of various digital e-learning platform tools and websites that are expected to change aquaculture education and knowledge exchange. Finally, we offer four recommendations to increase aquaculture knowledge exchange and human capacity building in Africa: (1) promote networking and mobility in aquaculture education and research; (2) develop new generic skills and competencies approaches; (3) continued professional development via eLearning and other innovative approaches; and (4) position lifelong learning in aquaculture studies.

Keywords: Aquaculture, Knowledge management, capacity development, education, training, e-learning

GESTION DES CONNAISSANCES ET INVESTISSEMENT DANS LE DÉVELOPPEMENT DES CAPACITÉS HUMAINES POUR L'ÉDUCATION ET LA FORMATION EN AQUACULTURE EN AFRIQUE

Resume

La croissance rapide de l'industrie de l'aquaculture, stimulée par les débouchés émergents, a été facilitée par le développement des connaissances et l'application de nouvelles innovations scientifiques et technologiques appuyées par des investissements privés et publics. Bien qu'il existe de nombreuses initiatives visant à accéder, à gérer, à documenter, à publier, à communiquer et à diffuser les informations et les données de la recherche, le niveau actuel de la « gestion des connaissances » n'est pas suffisant pour permettre une large accessibilité et une utilisation accrues, en particulier en Afrique subsaharienne. Paradoxalement, une importante partie des

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connaissances potentiellement précieuses produites par des chercheurs engagés languit dans les bibliothèques, inutilisées par la société ; et un trop grand nombre d'importants besoins de la société en matière de connaissances nouvelles demeurent relativement inexplorés par les chercheurs. Dans cet article, nous examinons les initiatives récentes visant à promouvoir le développement durable de l'aquaculture par l'amélioration de la capacité d'éducation et de formation et les innovations dans l'utilisation de nouvelles technologies basées sur l'Internet. Au niveau général, nous présentons trois tendances de développement susceptibles de façonner le secteur : l'éducation pour les compétences globales ; le partage des connaissances grâce à l'utilisation de technologies Web 2.0 et de ressources d'apprentissage ouvert ; et le rôle émergent d'un apprentissage flexible et durable (tout au long de la vie). Le document présente également l'utilisation de divers outils de plateforme d'apprentissage numérique en ligne et de sites internet susceptibles de changer l'éducation aquacole et l'échange de connaissances. Enfin, nous proposons quatre recommandations visant à accroître l'échange des connaissances en aquaculture et le renforcement des capacités humaines en Afrique : (1) promouvoir la coopération en réseau et la mobilité dans l'éducation et la recherche en aquaculture ; (2) développer de nouvelles approches génériques de connaissances et de compétences ; (3) poursuivre le perfectionnement professionnel via l'apprentissage en ligne et d'autres approches novatrices ; et (4) le positionnement de l'apprentissage tout au long de la vie dans les études de l'aquaculture.

Mots-clés : aquaculture, gestion des connaissances, développement des capacités, éducation, formation, apprentissage en ligne

Introduction

Aquaculture is the fastest growing food-supply industry in the world with an annual average growth rate of 8.6 percent over the last three decades (FAO, 2014; Troell *et al.,* 2014). The Food and Agriculture Organisation of the United Nations (FAO) defines aquaculture as "the farming of aquatic organisms such as fish, crustaceans, molluscs and aquatic photosynthetic organisms" (FAO, 2002). Global aquaculture production reached 73.8 million tons in 2014, nearly 50 percent of global fish production, with an estimated value of US$ 160.2 billion (FAO, 2016b). This share is projected to rise to 62% by 2030 as catches from wild capture fisheries level off and demand from an emerging global middle class substantially increases (World Bank, 2013; Kobayashi *et al.,* 2015). A milestone was reached in 2014 when the aquaculture's contribution to the supply of fish for human consumption overtook wild-caught fish for the first time (FAO, 2016b; Golden *et al.,* 2016). Given this milestone, and the fact that world population is projected to reach 9.6 billion in 2050 (UN 2015 Revision of World Population Prospects), aquaculture is understandably receiving considerable attention as a source of food and economic development (Hall *et al.,* 2013). Aquaculture's rapid expansion is often referred to as the 'blue revolution'. Currently, governments and international organisations worldwide are responding to the blue revolution by becoming increasingly interested in expanding aquaculture to foster food security, nutrition and income generation (Krause *et al.,* 2015). The rapid growth of the aquaculture industry, whilst driven by emerging market opportunities, has been enabled through developing knowledge and application of new scientific and technological innovations supported by private and public investments (Bostock and Seixas, 2015; FAO, 2015b).

Several studies have been conducted in the field of aquaculture, fisheries and aquatic resource management to support processes of knowledge creation, knowledge exchange and innovation (collectively known as "knowledge management"), particularly through the processes of education, training and skills development in Europe (Bostock and Seixas, 2015; Eleftheriou and Seixas, 2015; Pita *et al.,* 2015; Seixas *et al.,* 2015). The

practice of engaging knowledgeable and skilled individuals within the aquaculture sector and investing further in developing their capacities is referred to as "investing in human capacity development". Capacity, as we use the term here, includes the capability to act and the competence to do so effectively (van Kerkhoff and Lebel, 2015). Capacity development is a related concept in development that refers to "the process of unleashing, strengthening and maintaining such capacity" (Aerni *et al.,* 2015). Capacity development has become a core aim of development more broadly, reflecting a shift from more technical, top-down "knowledge transfer" approaches to more supportive, bottom-up, endogenous development strategies (van Kerkhoff and Lebel, 2015).

As aquaculture develops and matures, greater emphasis on knowledge management is likely to generate further innovations in education and training in response to technological and social developments (Bostock and Seixas, 2015). Another important concept is "knowledge governance" (as a scale above knowledge management) concerned with the formal and informal rules that govern knowledge processes, including production, sharing, access, and use (van Kerkhoff, 2013). While there are numerous initiatives directed at accessing, managing, documenting, publishing, communicating and disseminating research information and data, the present scale of knowledge management and governance is insufficient to achieve wide accessibility and use, particularly in Sub-Saharan Africa (SSA). Paradoxically, too much potentially valuable knowledge produced by committed researchers languish in libraries, unused by society; and too many of society's greatest needs for new knowledge remain relatively unexplored by researchers (Clark *et al.,* 2016; Tella *et al.,* 2009). A transition toward sustainable intensification in aquaculture is an urgent task that requires mobilizing more and better knowledge of ways to secure and sustain inclusive improvements in human well-being.

In this paper, we review recent initiatives to promote sustainable aquaculture development through improvements in knowledge management, education and training capacity, and innovations in the use of new internet-based technologies, with specific consideration on use of digital e-learning tools. The paper is intended for higher education teachers, administrators, informal educators, policymakers, researchers, graduate students, and all other stakeholders interested in preparing our next generation for the 21st digital century. Becoming better at educating and teaching for global competence involves rethinking practices and recognizing that there are no simple recipes for success. The next section reviews literature on aquaculture status and dynamics at global and regional scales. This is followed by broader analysis of recent trends in tertiary education and training that is expected to shape specific needs of the aquaculture sector. Finally, we offer some perspectives on areas of interest to promote sustainable aquaculture development through improvements in education and human training capacity in Africa.

Aquaculture Status and Dynamics at Global and Regional Scales

The total world fishery production (capture plus aquaculture) is projected to expand over the period 2016–2025, reaching 196 million tonnes in 2025 (FAO, 2016; OECD and FAO, 2014). Surging demand for fish and fishery products will mainly be met by growth in supply from aquaculture production, which is expected to reach 102 million tonnes by 2025. Globally, aquaculture production has doubled every decade for the past 50 years, representing the fastest growing food sector (Bostock and Seixas, 2015; FAO, 2014; Samuel-Fitwi *et al.,* 2012). In the period from 1983 to 2013, capture fisheries production increased from 71.1 to 92.6 million tonnes. Aquaculture production meanwhile expanded from 6.2 to 70.2 million tonnes (FAO, 2015a). Global aquaculture outlook reports by the World Bank projects the total fish supply will increase from 154 million tons in 2011 to 186 million tons in 2030, with aquaculture entirely responsible for the increase (Kobayashi *et al.,* 2015; World Bank, 2013). The FAO and OECD

state that capture fisheries output will rise at lower rates with a projected 5 percent growth by 2022 while the output from aquaculture will increase by 35 percent (OECD and FAO, 2014). However, this global figures masks some important regional distinctions. Asia accounts for nearly 90 percent of global production, with 62 percent coming from China alone (FAO, 2014). Recent statistics reveal that annual aquaculture production growth during 2000–2012 was fastest in Africa (11.4 percent), Latin America and the Caribbean (10 percent) (FAO, 2015). Thus, it can be foreseen that aquaculture will be the main source of fish for human consumption in the next years (Béné *et al.,* 2015).

Although Africa has the fastest growing industry by rate of growth—at more than 20% per year between 2007 and 2014—this is from a low baseline, as the region currently contributes less than 2 percent of global production (FAO, 2016b; HLPE, 2014; Waite *et al.,* 2014). However, the situation is different in Egypt, Africa's largest aquaculture producer, and a major contributor to the higher production volumes reflected by this continent (Ottinger *et al.,* 2016). Africa, however, has large natural resources that offer great potential for aquaculture development in the coming years (AUC-NEPAD, 2014; Brummett *et al.,* 2008; Ottinger *et al.,* 2016). The latest estimate for total aquaculture production in Africa is 1.6 million tons (AUC-NEPAD, 2014). In 2012, FAO reported that ten of fastest growing aquaculture sectors were in Africa (Egypt, Uganda, Kenya, Zambia, Ghana, Madagascar, Tunisia, Malawi and South Africa) (FAO, 2014). African aquaculture production is projected to expand over the projected period by 35 percent (reaching 2.3 million tonnes) due partly to the additional capacity put in place in recent years, but also in response to rising local demand from higher economic growth, and local policies promoting aquaculture (FAO, 2016b).

Trends and Drivers in Tertiary Education and Training

Tertiary education sector, i.e. post-secondary education, is often divided into further education (focusing on technical skill-based training) and higher education (focusing on academic subjects and research-led curricula). Higher education is classed as formal education as it is built around planned programmes involving assessment and accreditation of learning outcomes (e.g. the awarding of degrees, diplomas or certificates at the end of the study period). Formal education may be complemented by non-formal learning (structured/programmed but usually not assessed or accredited) and informal learning (unstructured/non-programmed) which can be particularly important for life and work skills (Bostock and Seixas, 2015). Recognising the role and significance of each type of learning throughout an individual's life and career is important to find ways to better integrate formal and informal learning or forms of instruction. The future of aquaculture education and training, whilst influenced by the specific needs of the sector, will be heavily shaped by broader developments in educational policy, practice and organisation (Bostock and Seixas, 2015). In particular, we present three broad development trends likely to shape the sector: (i) educating for global competencies; (ii) knowledge sharing via use of Web 2.0 technologies and Open Learning Resources; and (iii) promoting flexible and lifelong learning.

Educating for Global Competence

The emergence of a knowledge based economy has put higher education at the centre of policy development in many parts of the world since the beginning of the 21st Century. Globalization, the digital revolution, mass migration, and the prospect of climate instability are triggering new concerns and demanding a new kind of graduate (Mansilla and Bughin, 2011; Mansilla and Jackson, 2013). There is an increasing call for a more powerful and relevant learning in response to these new demands and opportunities (Mansilla and Jackson, 2013; Reimers, 2010). The definition of "Global Competence" proposed by the Economic Co-operation and Development (OECD) encompasses a complex learning

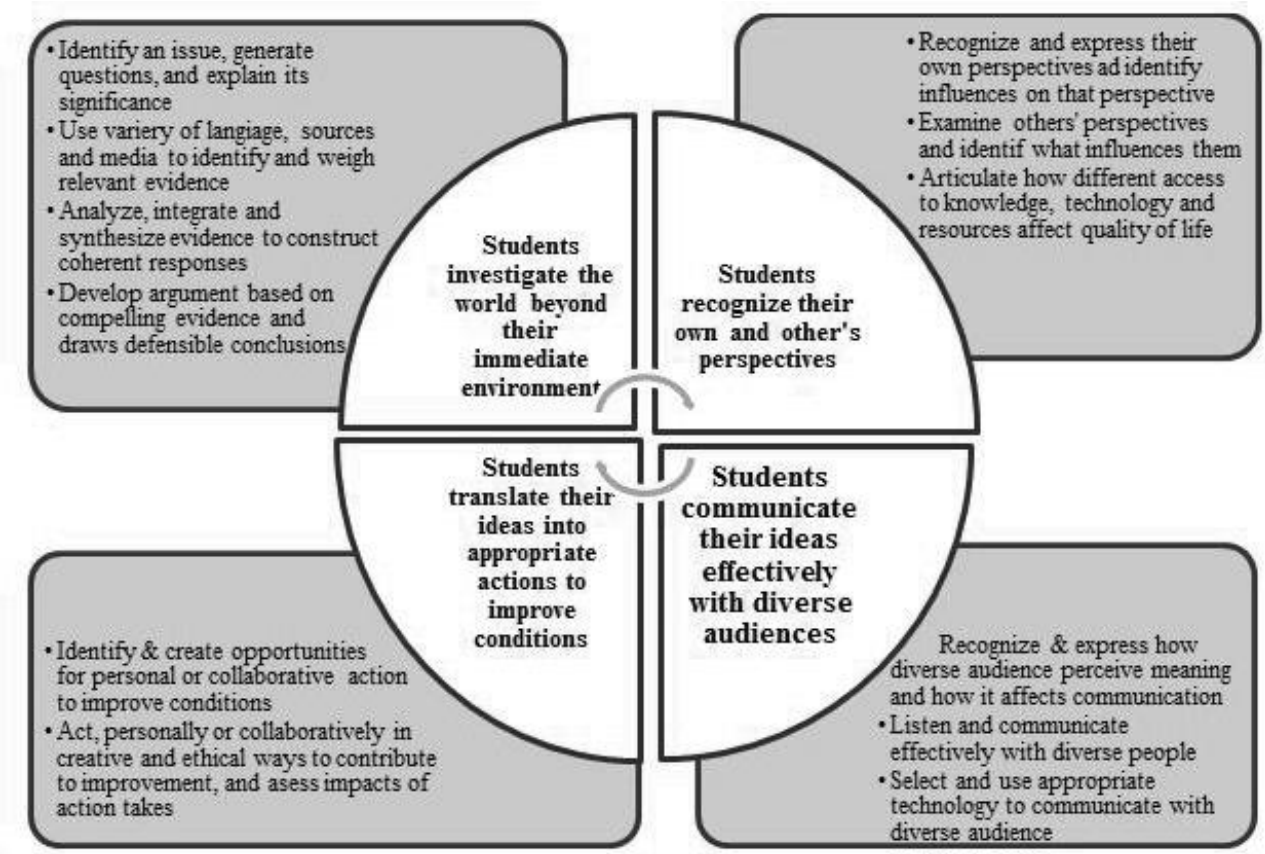

Figure 1: Framework for Global Competence. Modified from: Mansilla and Bughin, 2011

goal: Global Competence (OECD, 2016). is the acquisition of in-depth knowledge and understanding of global and intercultural issues; the ability to learn from and live with people from diverse backgrounds; and the attitudes and values necessary to interact respectfully with others" (OECD, 2016). Specifically, globally competent students are able to perform the following four competences (Figure 1):

i. Investigate the world beyond their immediate environment, framing significant problems and conducting well-crafted and age-appropriate research;
ii. Recognize perspectives, others' and their own, articulating and explaining such perspectives thoughtfully and respectfully.
iii. Communicate ideas effectively with diverse audiences, bridging geographic, linguistic, ideological, and cultural barriers.
iv. Take action to improve conditions, viewing themselves as players in the world and participating reflectively.

The OECD recognizes that the development of Global Competence can also support graduate student employability. Effective and appropriate communication and behaviour, within diverse teams, is already a component of success in the majority of jobs, and will become an even bigger component over the years ahead. Rapidly advancing technologies and global economic and social integration are redefining the scope of communication skills at the workplace. Students thus need to acquire the skills and develop the attitudes to interact effectively and appropriately with people in different countries and with people of different cultures in their local context (OECD, 2016).

Web 2.0 Technologies and Open Educational Resources

In recent decades, the widespread use of the Internet and ubiquitous presence of portable digital devices e.g. computers, laptops, tablets, mobile phones, and digital assistants paired with the evolution of Web

2.0 technologies has opened new avenues for the application of digital e-learning tools, which are expected to change both the teaching and learning experiences (Gaebel, 2014; Seixas *et al.,* 2015). Tella et al. (2009) explore the wealth of literature to exploit the potentials of emerging technologies such as wiki, blog and social networking site (SNS) for knowledge sharing in higher education institutions (HEIs). Seixas et al. (2015) analysed the current status of the use of e-learning and information and communication technologies (ICT) to support learning in aquaculture and aquatic sciences education. The social Web 2.0 technologies and platforms used for knowledge management in aquaculture include social networking sites, blogs, online forums, podcasts, wikis, multi-media platforms, Voice over Internet Protocol (VoIP) systems, games/ simulations, electronic portfolio and social media (Seixas *et al.,* 2015). One notable trend has been the rise of social networking, and in particular professional networking through the Internet (Bostock and Seixas, 2015). The best-known service is probably LinkedIn which has thousands of special interest discussion groups and promotes networking across the usual barriers of organisations, ages and location. For our purposes, we briefly describe some of the new information technologies that offer opportunities for aquacultural education and learning in Table 1.

Open Educational Resources (OER) aim to promote open access to digital educational resources "that are available online for everyone at a global level" (Caswell *et al.,* 2008). The term was introduced by UNESCO (2002), which defined OER as the "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes." OER can be full courses, course materials, modules, textbooks, streaming videos, tests, software, and other materials or techniques used to support access to knowledge (McGreal *et al.,* 2013). The use of OER to facilitate the efficient creation, distribution and use of knowledge and information is a recent innovation. Massive Open Online Courses (MOOCs) are one among a wide range of OER that may bring transformation in teaching and learning in HEIs. Although MOOCs have gained popularity in other parts of the world, focus is still in the United States of America, with providers such as Coursera, edX and Udacity not only growing in size, but also developed distinct profiles (Gaebel, 2013, 2014). There are a number of MOOC providers, the four major players are presented in Table 2. So far, the vast majority of MOOC participants are higher education students, former students or upper secondary schools pupils, who are likely to enter higher education (Gaebel, 2014).

The implications of MOOCs for learning and teaching is still unclear, partly because MOOCs are a relatively new development, their use is still in experimental phase and not much research has been published. Since MOOCs generally do not award credits or grades, and therefore no degrees, MOOCs do not replace institutional higher education provision, but supplement it. For example, MOOCs can be used in blended learning within universities, as individual lifelong learning opportunity (predominantly during or after higher education studies) or as a means to reach out to new target groups through continued professional education (Gaebel, 2014). Overall, online learning has not replaced face-to-face instruction, but offers an alternative for learners who are not able to attend "brick-and-mortar" institutions and allows flexibility in teaching and learning.

For students in aquaculture, fisheries and related aquatic resource management courses, the increasing amount of information available requires more effective information management. To find the right information quickly and at the right time, it is necessary to be aware of available and accessible sources of scientific and technical information that are useful for their projects (FAO, 2016a). Scientific and technical information includes all information produced by research and necessary for scientific activity. The main sources of scientific and technical information, including those related to aquaculture and fisheries sectors include: Web of Science

Table 1: Web 2.0 Technologies and platforms used for knowledge sharing in education and online learning. Source: Synthesis of information from (Ajjan and Hartshorne, 2008; Grosseck, 2009; Seixas *et al.,* 2015; Tella *et al.,* 2009 and Wikipedia)

Web 2.0 Technology	Characteristics
Social and professional networking sites	In their simplest form, social networking services have three main components: a profile page where information is posted, a network of relationships that categorizes and connects profile page to contacts (for example, friends, colleague, business associate), and a messaging system that allows communication with profile contacts. Popular social networking sites include Facebook, Twitter, Google+, Instagram, Snapchat, WhatsApp, LinkedIn (for business and professional networking).
Learning Management System (LMS)	LMS are software applications for the administration, documentation, tracking, reporting and delivery of e-learning education courses or training programmes. Digital LMS were mainly created to manage learning content in a central location. Teachers and students can upload and download learning resources and can use collaborative tools. The most common LMS are Moodle and Blackboard.
Blogs	Blogs (abbreviated from weblogs are online user's journal entries or "posts" typically displayed in reverse chronological order (the most recent post appears first) on webpages. In education, a blog can be used to publish articles for discussion, including links to other sites of interest, and others can leave responses. There are many free applications available, such as WordPress, Blogger, which can be used to create a blog.
Podcast	The word "podcast" derives from "POD" (play on demand) and "broadcast". A podcast is a digital medium consisting of an episodic series of audio, video, PDF, ePub, files that end users can subscribe to through web syndication or using special software known as a podcatcher (e.g. iTunes, Feedbook). A podcast can be played online or alternatively downloaded to a computer or a mobile device for on-demand offline playback. The success of the iPod? device popularised the term podcast, as audio podcasts are often listened to on portable media players. One well-known open access application to produce audio podcasts is Audacity.
Mobile handheld devices	Handheld devices can store, process and access data, such as smartphones, conventional mobile phones, tablet computers or personal digital assistants (PDAs).
Wiki	A wiki is usually a web application which allows people to add, modify or delete content in collaboration with others. While a wiki is a type of content management system, it differs from a blog or similar systems in that the content is created without any defined owner, and wikis have little implicit structure, allowing structure to emerge according to the needs of the users. For example, Wikipedia allows users to modify entries by creating a reviewer and editing structure.
Voice over Internet Protocol (VoIP)	VoIP is a category of technologies for delivery of voice communications and multimedia sessions over Internet Protocol (IP) networks, such as the Internet. One of the most extensively used applications is Skype.

Web 2.0 Technology	Characteristics
Multimedia-sharing platforms	These are online applications that allow authors of multimedia materials to share them with other users. They usually offer several levels of accessibility, i.e. materials can be made available to the general public or they can be restricted to smaller audiences. Numerous applications are available on the web to share digital pro- ducts such as photos, videos, sound clips and slide presentations, either with the wider public or with closed user groups where access is provided upon invitation. These applications can, e.g. be used by teachers to share learning resources with students or for exchange of learning materials among the student community. Some of the best-known platforms are video portals—YouTube, photo sharing portals—Flickr and slide presentation-sharing portals—Slideshare.

Table 2: Brief description of major providers of MOOCs and online sources. Given the rapid development, it is impossible to keep up-to-date even in the processes of writing, and only MOOC development up to July 2016 were taken into consideration.

MOOC Provider	Description	Online Sources
Coursera	• Education platform launched in April 2012 that partners with top universities and organizations worldwide, to offer courses online for anyone to take. • As of January 11, 2016 Coursera offers 1,563 courses from 140 partners across 28 countries. • All Coursera courses are "accessible for free"; some have an option to pay a fee to join the "Signature Track". Students on Signature Track receive verified certificates, appropriate for employment purposes.	*https://www.coursera.org/ https://en.wikipedia.org/wiki/Coursera* Accessed on 21/07/16
edX	• Founded by Harvard University and MIT in 2012, offering high-quality courses from the world's best universities and institutions to learners everywhere. • The edX consortium currently comprises more than 90 global partners, including the world's leading universities and non-profits as members. • As of 24 March 2016, edX has more than 7 million students taking more than 700 courses online. • EdX courses consist of weekly learning sequences. EdX offers certificates of successful completion, but does not offer course credit.	*https://www.edx.org/ https://open.edx.org/ https://en.wikipedia.org/wiki/EdX* Accessed on 21/07/16
Udacity	• Udacity is a for-profit educational organization founded in February 2012 to offer MOOCs. • As of 28 April 2014, Udacity had 1.6 million users in 12 full courses and 26 free courseware.	*https://www.udacity.com/ https://en.wikipedia.org/wiki/Udacity* Accessed on 21/07/16

MOOC Provider	Description	Online Sources
	• Udacity used to issue certificates of completion of individual courses, but since May 2014 have stopped offering free non-identity-verified certificate.	
NovoEd	• NovoEd is a for-profit educational technology company, founded in April 2013. The company partners with universities, foundations, and corporations to offer MOOCs as well as small private online courses (SPOCS). • It offers over 400 courses (most of them for a fee) on management, design thinking, sales skills, and other business competencies. • NovoEd's unique selling point is that students can collaborate in small teams and submit assignments with classmates around the world. • In terms of global outreach, NovoEd has over 800,000 learners from over 180 countries formed over 100,000 teams.	*https://novoed.com/* *https://en.wikipedia.org/wiki/NovoEd* *https://novoed.com/corporate-learning* Accessed on 21/07/16

(https://www.webofknowledge.com/), Scopus (https://www.scopus.com/), Google Scholar (https://scholar.google.com/), ResearchGate (https://www.researchgate.net/) and Academia (https://www.academia.edu/). The last two sites combine professional networking with the sharing of research results and more academic discourse. Some of the websites are open archives that allow researchers to share and access scientific output, knowledge, and expertise, and grant an opportunity to access full text of their publications via hyperlinks.

Considering the growing public interest in aquaculture in Africa, professional networking platform—Sustainable Aquaculture Research Networks in Sub-Saharan Africa (SARNISSA) has greatly facilitated knowledge exchange and promoted research and learning among all value chain actors in aquaculture. This project, which was implemented for three years (2009–2012), is still active and draws it membership from all parts of the world, majority representing all major academic institutions and research organizations in Africa. The principle objective of SARNISSA was to strengthen the capacity of African researchers and development professionals by enabling them to have access to information. In addition to a mailing list, there is also a bilingual website for English and French speakers (https://www.sarnissa.org/) which serves as a repository for various information. SARNISSA has capitalized on modern information technology to disseminate knowledge over the Internet as well as in hard copy and by direct contact. For instance, the electronic outreach by the SARNISSA's Facebook page has over 3,330 followers (accessed on 21 July 2016) from among the general public, and the number is growing by the day.

Flexible and Lifelong Learning

The newly adopted Sustainable Development Goals (SDGs) are directly relevant to fisheries and aquaculture and to the sustainable development of the sector, and one goal expressly focuses on the education and lifelong learning. The SDG Goal 4 aims to "Ensure inclusive and equitable quality education and promote lifelong learning opportunities for all". In common with other sectors, there is a growing appreciation

within the aquaculture sector of the need for more responsive, flexible and collaborative approaches to learning and the accreditation of learning that properly respond to the needs of the industry and individuals (Seixas *et al.,* 2012). Concepts of defining lifelong learning (LLL) are gradually evolving from early versions based on learning that take place at all stages of life cycle (from the cradle to the grave) and, in more recent versions that it should be life-wide; that is embedded in all life contexts from the school to the workplace, the home and the community (Laal, 2011). Jarvis (2001) observes that LLL takes place throughout life and is the process whereby human beings create and transform experiences into knowledge, skills, attitudes, beliefs, values, senses and emotions. In general, two separate interpretations of the concept have emerged; (1) all provision of education is viewed in a lifelong perspective and includes all formal, informal and non-formal learning; and (2) LLL is a means of providing a series of activities such as professional upgrading, continuing education, distance education, university courses for junior, mature and senior learners, preparatory courses, and part-time education (Sursock and Smidt, 2010). This approach means that LLL enables students and adult learners to learn at different times, in different ways and for different purposes at various stages of their lives and careers (Omolewa, 2009).

Promoting sustainable aquaculture development through improvements in education and training capacity

The Bangkok Declaration and Strategy on Aquaculture Development (NACA/FAO, 2000), endorsed in 2000, provide the necessary guidelines to stimulate and promote the development of a sustainable and environmentally friendly aquaculture sector globally. Two of these guidelines are: (a) investing in people through education and training and (b) investing in research and development. The recommendations for education and training included:

- participatory approaches to curriculum development;
- co-operation and networking between agencies and institutions;
- multidisciplinary and problem-based approaches to learning;
- modern training, education and communication tools, such as the internet and distance learning, to promote regional and inter-regional co-operation and networking in the development of curricula, exchange of experiences and the development of supporting knowledge bases and resource materials; and
- a balance of practical and theoretical approaches to train farmers and provide skilled and innovative staff to industry.

Building on these guidelines, we offer four recommendations to increase aquaculture knowledge exchange and human capacity building in Sub-Saharan Africa: (1) promote networking and mobility in aquaculture education and research; (2) develop new generic skills and competencies approaches; (3) continued professional development via e-learning and other innovative approaches; and (4) position lifelong learning in aquaculture studies.

Networking and mobility in aquaculture education and research

Networking, diversity and mobility are essential components for global capacity building in education. Although there is an opportunity to establish close linkages between academic and research institutions in sub-Saharan Africa, significant challenges still remain. While SSA is home to several academic institutions with aquaculture research capacity, they tend to be geographically isolated with minimal networking and sharing of resources (FAO, 2015b). Recent attempts have been made to promote networking and human resource mobility between institutions to promote regional research and teaching capacity. For example, the NEPAD Regional Fish Node (RFN) was established in 2006 at Bunda College in partnership with University of Malawi to develop a regional aquaculture PhD

training programme. The programme supports the training of students from Eastern, Central and Southern Africa to build and strengthen a network of researchers involved in refining and implementing projects to enhance fisheries, aquaculture production and biodiversity. Building on this progress, the World Bank has approved Lilongwe University of Agriculture and Natural Resources (LUANAR) as a Centre of Excellence in Aquaculture and Fisheries Science (AquaFish) (LUANAR News, 2016). With the closure of the NEPAD fisheries desk, the African Union Inter-African Bureau for Animal Resources (AU-IBAR) has taken over the mantle for the Partnership for African Fisheries; with its Aquaculture Working Group (AWG) being a potential platform for coordination aquaculture research in the continent.

At the policy level, the African Union Agenda 2063 recognizes the need to "Catalyse an Education and Skills revolution and actively promote science, technology, research and innovation, to build knowledge, human resources, capabilities and skills for the African century".. To achieve this goal, the Agenda proposes "[…] faster movement on the harmonization of continental admissions, curricula, standards, programmes and qualifications and raising the standards of higher education to enhance the mobility of African youth and talent across the continent by 2025" (African Union Commision, 2014). To kick-off this movement, the Continental Education Strategy for Africa (CESA 2016–2025) was adopted by the Summit of Heads of State and Government of the African Union in January 2016 to provide the framework that links education to the human resource needs of Agenda 2063 and the Sustainable Development Goals (SDGs), as well as national development goals (African Union Commission, 2015). Notably, the Association of African Universities has identified the need to upgrade curricula of African universities to ensure they deliver professionals with skill sets required by the labour market (FARA, 2014). The African Union Policy Framework and Reform Strategy for Fisheries and Aquaculture in Africa also emphasized awareness enhancing and human resource capacity development in the sector as a key policy pillar and is noted that Capacity development is a key building block for creating knowledge, empowerment and enablement for effective participation in decision-making and for improved governance of the fisheries and aquaculture sector. Another laudable attempt that can facilitate intra-Africa mobility and academic integration is AU's recent announced plans to introduce single passport to create a 'continent without borders' by abolishing visa requirements for all African citizens in all Africa countries by 2018. All these efforts can "unlock the gates of higher education" and promote the skills revolution that is required for Africa to harness its youth demographic dividend and build prosperity through building value chains for expanding productive aquaculture sector.

Developing new generic and competencies approaches

The dynamic world faced by new graduates from aquaculture, fisheries and aquatic resource management degrees presents them with new demands and challenges for employability. According to Dearing (1997) key generic skills consist of four components: communication, numeracy, information technology and learning how to learn. Pita et al. (2015) identified additional generic skills relevant to the needs of for graduate employment in fisheries, aquaculture and marine sectors, such as scientific methods, management, career development and practical skills in Europe. The various respondents (employers, students, post-graduates, and university teachers) identified 39 generic skills under investigation as important, with none classified as unimportant (Pita *et al.,* 2015). Additionally, Pita et al. (2015) argued that there remains a need to place generic skills and employability attributes and attitudes at the centre of higher education curriculum. Since most aquaculture production growth is expected to be highest in African countries in the coming years, initiatives should focus on developing generic skills and human capacity to drive the changes via vocational and university

education.

Towards this end, the British Council commissioned a three-year (2013-16) research and advocacy study, "Universities, Employability and Inclusive Development" to explore the role universities can play in promoting graduate employability in four Sub-Saharan Africa countries: Ghana, Kenya, Nigeria, and South Africa (McCowan, 2014). All the four countries have concerns about graduate employability and work readiness of graduates. Employability can be defined as the possession of relevant knowledge, skills and other attributes that facilitate the gaining and maintaining of worthwhile employment. While employers are generally satisfied with the disciplinary knowledge of students, they perceive significant gaps in their information technology (IT) skills, personal qualities (e.g. reliability) and transferable skills (e.g. team working and problem solving). Research carried out in Nigeria has shown a significant 'skills mismatch' between employer requirements and graduates display of skills in the workplace, particularly in relation to communication, IT, decision-making and critical thinking (Pitan and Adedeji, 2012). The extent to which graduate unemployment is due to a skills gap, or to a simple lack of jobs is as yet unresolved (McCowan, 2014).

Nevertheless, the British Council study identified three compelling reasons for enhancing the quality of university education in order to improve graduate student employability. First, there is need to improve the quality of taught courses. Analytical, problem solving and written communication skills, for example, depend on high quality teaching and learning provision. Second, universities can enable a broader learning experience for students. Experiential learning in the community—whether through work attachments, voluntary placements or other experiences—as well as on-campus, through student societies and other extra-curricular activities should be facilitated. Employers increasingly value global perspectives and understanding of diversity and these qualities can be developed through these forms of engagement on campus and beyond. Thirdly it is the provision of targeted employability input by universities. Careers advisory services are an obvious focal point in this regard, as well as job fairs and other interactions with employers. Closer links with employers are urged, to update curricula and involve industry representatives in course delivery and quality work placements. More importantly, transferable skills and critical thinking that will allow graduates to adapt to make a positive impact on a rapidly changing economy and society are essential (McCowan, 2014).

Continued Professional Development via eLearning and innovative approaches

The dependence of researchers on a limited range of formal experimental designs has become a straightjacket when it comes to understanding responses in farmer fields. Several relevant lessons have emerged from a combination of field experiences and scholarly study over the last several decades that provide a rich trove of experiences and approaches to draw on (Vanlauwe *et al.,* 2016). These lessons and experiences range from the pioneering efforts highlighted in the "Green Book" (Patel *et al.,* 2004) that intended to equip young African scholars with an understanding of the complexity of smallholder farming systems to the hundreds of academic programs now addressing complex agricultural systems (Vanlauwe *et al.,* 2016). However, despite the Green Book being around for a decade, the next generation of young agricultural research scientists are still trained in a classical mode to strive to reduce complexity and focus on single factors in heterogeneous farming systems (Vanlauwe *et al.,* 2016).

To build capacity beyond traditional training regimes, new approaches are needed that incorporate additional skills and perspectives to facilitate knowledge creation that is not only academically rigorous, but also usable in practice. Usable knowledge for sustainable development has long been produced by researchers in the absence of formal training, suggesting that informal and experiential approaches should not be underrated (Clark *et al.,* 2016). Many training

models and modes are possible. Clark et al. (2016) suggest that effective training should usually involve some mix of specially developed curriculum materials, innovative ways of integrating those materials into the existing training regimes of researchers, and internships in established programs that are effectively crafting usable knowledge for sustainable development.

As aquaculture is a global activity, substantial scope also exists for more rapid dissemination of innovations through e-learning (Seixas *et al.,* 2012). E-learning has considerable potential to improve learning opportunities for participants in the aquaculture sector. For example, there is little need to travel when pursuing an e- learning course, thus making considerable savings in terms of time, effort and money (Seixas *et al.,* 2015; Seixas *et al.,* 2012). When workers can participate while remaining in the workplace, work flow will suffer less interruption. In addition, learners from different regions can participate and interact within a single virtual classroom, which can help in the exchange of experiences and ideas (Seixas *et al.,* 2012). Moreover, in order to facilitate uptake and utilisation of technologies, African countries have in recent years laid the foundation for long-term strategy for professional, technical and vocational education aimed at enhancing the skills and expertise of its professional and technical human resources (FARA, 2014). For example, the e-learning Africa Report 2015 recognize the importance of Technical Vocational Education and Training (TVET) as the key to a country's competitiveness, prosperity and social inclusion (Manji *et al.,* 2015). On a positive note, ninety-five per cent of people surveyed by eLearning Africa reported that ICTs are the key to improving education. Majority of respondents have taken online courses or self-taught themselves skills using online resources (Manji *et al.,* 2015).

Promotion of Lifelong learning in Aquaculture studies

Lifelong learning is not a novel idea in Africa. Indeed, many scholars have posited that it was deeply embedded within African culture and epistemology long before the start of colonialism (Omolewa, 2009). Long before then, Africans knew and adopted the idea that learning generally involves a deliberate effort that must be made in order to acquire (and increase) skills, knowledge or understanding, and strengthen values, interests and attitudes. It was expected that effective learning would lead to change, development and a desire to learn more. Within the lifelong learning concept, Africans knew that the critical areas to increase participation in learning processes involved: (i) discovering and sharing new knowledge on how to stimulate the demand for learning; (ii) creating new opportunities for, and awareness of, formal, non-formal and informal learning; (iii) providing access to resources that empower learners; and (iv) extending the campaign's influence and presence as a powerful advocate for learning.

Lifelong learning is now the guiding principle for policy strategies concerned with objectives ranging from a nation's economic well-being and competitiveness to its people's sense of personal fulfilment and social cohesion. One of the guiding principles to guide the implementation of the Continental Education Strategy for Africa (CESA 2016-2025) is a "Holistic, inclusive and equitable education with good conditions for lifelong learning is sine qua non for sustainable development". It has taken decades for the Informal and non-formal Education and training to be recognized as an important sector contributing to educational development in Africa. Alternative modes of education that fall under the informal and non-formal education and training label have provided learning and training opportunities to millions of African children, youth and adults. Therefore, lifelong learning needs to be implemented in such a way that all users can fill their gaps in lack of knowledge and skills.

Conclusion

There is substantial social benefit in promoting an innovative and sustainable aquaculture industry that contributes positively to food security and human health. Absolutely

crucial for this is a higher education level of science communication, including the targeted utilization of the new media. This provides a wide range of opportunity for interactive, participative sharing of the social dialogue for societal transformation. The current status quo of the scientific knowledge should be presented in an understandable, yet also blended way, and should be actively and participatively shared with society. To facilitate this, education offers should attempt to establish a relation to the key factors of social transformation. At the same time, opportunities for life-long on-the-job learning should be extended through publicly funded further education courses and post-graduate qualifications, for example, in the form of a relevant 'sabbatical' for employees. Besides, new curricula and degree courses and modules, completely new professions might be needed. In this regard, continued professional development involving e-learning and other innovative approaches can make an important contribution to the sector. Finally, there is need to better recognise and value non-formal and informal learning and skill development and develop approaches that are more learner-centred and take account of the increasing availability and diversity of potential learning channels and materials.

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