Capacity Development in the Water Sector: the case of Massive Open On-line Courses

Colin Mayfield
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Colin Mayfield
Executive Summary

The Sustainable Development Goal 6 targets are all dependent on capacity development as outlined in SDG 6a “Expand international cooperation and capacity-building support to developing countries in water- and sanitation-related activities and programmes “. Massive Open On-line Courses (MOOCs) and distance learning in general have a significant role to play in this expansion. This report examines the role that MOOCs and similar courses could play in capacity development in the water sector.

The appearance of MOOCs in 2010/11 led within 4 years to a huge increase in this type of course and in student enrollment. Some problems with student dropout rates, over-estimating the transformational and disruptive nature of MOOCs and uncertain business models remain, but less “massive” MOOCs with more engaged students are overcoming these problems.

There are many existing distance learning courses and programmes in the water sector designed to train and/or educate professionals, operators, graduate and undergraduate students and, to a lesser extent, members of communities dealing with water issues. There are few existing true MOOCs in the water sector.

MOOCs could supply significant numbers of qualified practitioners for the water sector. A suite of programmes on water-related topics would allow anyone to try the courses and determine whether they were appropriate and useful. If they were, the students could officially enroll in the course or programme to gain a meaningful qualification or simply to upgrade their qualifications.

To make MOOCs more relevant to education and training in the water sector an analysis of the requirements in the sector and the potential demand for such courses is required. Cooperation between institutions preparing MOOCs would be desirable given the substantial time and funding required to produce excellent quality courses.

One attractive model for cooperation would be to produce modules on all aspects of water and sanitation dealing with technical, scientific, social, legal and management topics. These should be produced by recognized experts in each field and should be “stand-alone” or complete in themselves. If all modules were made freely available, users or mentors could assemble different MOOCs by linking relevant modules. Then extracts, simplified or less technical versions of the modules could then be used to produce presentations to encourage public participation and for other training purposes. Adaptive learning, where course materials are more tailored to individual students based on their test results and reactions to the material, can be an integral part of MOOCs.

MOOCs efficiently provide access to quality courses at low or no cost to students around the world, they enable students to try courses at their convenience, they can be tailored to both professional and technical aspects, and they are very suitable to provide adaptive learning courses. Cooperation between institutions would provide many course modules for the water sector that collectively could provide excellent programmes to address the challenges of capacity development for SDG 6 and other issues within the water sector.

Keywords: distance learning; massive open on-line course; MOOC; water jobs; capacity building; water and sanitation; sustainable development goals; SDG 6; IWRM
Introduction

The purpose of this report is to examine the current and future roles of MOOCs (Massive Open Online Courses) in the water and sanitation sector considering the advantages and disadvantages of this mode of education and training. Recommendations on mechanisms to use MOOCs (and related types of courses) to advance capacity development activities in the water sector are given.

The Sustainable Development Goals (SDG) for clean water and sanitation (SDG 6) of the United Nations (https://sustainabledevelopment.un.org/sdg6) set out targets and indicators. The targets to be achieved before 2030 for SDG6 (https://sustainabledevelopment.un.org/sdg6#targets) are clearly laid out and the goals could involve significant capacity development requirements depending upon local conditions.

There are many ongoing capacity building activities pertinent to the water and sanitation and the SDG 6 goals. There are different educational models and courses offered by many different agencies, institutions and businesses. The key MOOC concepts of “Massive” – a large-scale course capable of scaling to bring high-quality education to large numbers of students, “Open” - where the content is open for all to see and use, even if registration is required to participate, “On-line” – where all materials for the courses such as videos, lecture notes, assignments, reference materials and student to student and student to teacher interactions are conducted through on-line interfaces make them applicable to these educational or capacity development efforts.

The idea driving the development of MOOCs was that it would democratize education by making excellent courses available free to anyone in the world, increase quality by using the best teachers and minimize costs to the institutions providing them by omitting examinations and complex marked assignments. The mechanism chosen was on-line courses with self-assessment components coupled with peer-to-peer communication between students and limited contact with faculty members. This is an over-simplification since many different models have been tried, but it encapsulates the key features of many of the more popular MOOCs.

One commonly quoted forerunner for MOOCs was the initiative (now called OpenCourseWare) that started in 1999 when the University of Tübingen in Germany published videos of lectures online for its timms initiative (Tübingen Internet Multimedia Server). The Massachusetts Institute of Technology started MIT OpenCourseWare and Carnegie Mellon University the Open Learning Initiative in 2002. The movement was soon joined by similar projects at Yale, the University of Michigan, Utah State University and the University of California at Berkeley. These courses were not massive, but were open.

MOOCs have evolved and proliferated since 2010 and have led to rampant speculation that they would “democratize education”. “change universities completely”, lead to only 10 universities being left operating in the future, and similar kinds of hyperbole (Dillahunt et al 2014; Vardi, 2012). None of these predictions have proven true, but the growing reach and influence of the concept of MOOCs is undeniable. In the intervening years, there have been changes in the narratives and mythologies surrounding MOOCs and several types of larger online courses have evolved due to obvious early failures, revision of the intent and goals of online educators and developments in pedagogical research on such courses.

In this Report, a treatment of the history of MOOCs is followed by an examination of the problems and some solutions associated with MOOCs and their derivatives. These include the student demographics and completion rates for courses, their ability to reach large numbers of students and the pedagogical research into their production, deployment, and student engagement problems.

The current business models for MOOCs are analyzed and the significant impacts of intellectual property concerns on MOOCs are discussed followed by a treatment of likely future developments of MOOC pedagogy, impact, technology, and newer business models.

Finally, the current MOOC environment in the water sector is examined and potential future applications of MOOCs and their derivatives to education and training in that sector are examined. Recommendations on the more promising avenues for these types of courses in the water sector are presented.

Educational Practice in the Water Sector – An Overview

A broad view of education in the water sector encompasses education at primary and secondary school levels, tertiary education in universities and colleges, post-graduate education and professional and technical training for practitioners. To be comprehensive, it should also address the even broader issue of water literacy in the public (Sammel and McMartin, 2014). The general public’s perception of issues such as water security, scarcity, sustainability, and planning is fragmentary and extremely variable in diverse cultures, countries and populations. Even among professionals in the water sector there are ongoing debates about terminology and the
relative importance of different facets of water management practices (Lautze, 2014).

This diversity in audience leads inevitably to tremendous variability in approaches to education in the water sector. If we acknowledge the importance of water literacy (and more generally - science literacy - Sammel and McMartín, 2014) in the general population and then concentrate on the education of water professionals, practitioners and others involved in solving the problems in the water and sanitation sector such as scientists, policy specialists, economists, politicians, legal experts, community leaders, etc., we can reduce the options to a more reasonable number.

Historically, the approach to education in the water and sanitation sector has been limited to the following:

1. Traditional undergraduate courses at academic institutions (face to face)
2. Post-graduate degree courses with required residence periods at traditional academic institutions (face to face)
3. On-line or distance learning courses with required enrollment, assignments and examinations (on-line or other technologies)
4. On-site short courses presented to small groups (face to face)
5. Professional and technical courses given by academic institutions (both face-to-face and on-line)
6. Professional and technical courses given by non-academic institutions (both face-to-face and online)
7. Hybrid courses – various combinations of on-line and “face-to-face” instruction.
8. MOOCs and MOOC variants (on-line - both open enrollment not-for-credit and for-credit courses).

There can be combinations of these categories such as professional and technical courses given by non-academic institutions that use hybrid or on-line course structures.

The recent prominence of MOOCs in educational practice has led to a proliferation of courses that are labeled as such, but often are neither “open” nor “massive” (depending on the definitions used). For some institutions and agencies, it has become important for several reasons (financial opportunity, reputation, fear of being “left behind”, countering educational companies’ encroachment into their field of expertise, etc.) to produce MOOCs or something that can be labeled as a MOOC.

This does not seem to have happened to any significant extent to education in the water sector. There has not been a large-scale proliferation of MOOCs nor has there been a significant “re-labeling” of existing courses as MOOCs merely to establish a presence in a popular trend.

### History of MOOCs and MOOC variants

The acronym ‘MOOC’ was coined in 2008 by University of Prince Edward Island’s Dave Cormier and applied to an online experiment, “Connectivism and Connective Knowledge” (CCK08), led by Athabasca University’s George Siemens and Stephen Downes of the Canadian National Research Council. This was the first on-line course that was both “massive and online”. It was offered to students registered at the University of Manitoba but was also made available for any who wanted to take it online. About 2200 people took the opportunity and the course was repeated three times. The same software platform was used to present a course in Personal Learning Environments, Networks and Knowledge (PLENK) in 2010 and a course on “Change”.

This CCK08 course is an example of a network-based connectivist course (Siemens, 2004) where students manage their own time, find their own resources and must structure their own learning. This is now known as a c-MOOC. This was different to most on-line courses offered previously where the most common model was directed learning from an authority with quizzes, assignments and examinations. In those, all students followed the same patterns of learning and resources were supplied. A c-MOOC is essentially an extension of courses that employed a discussion forum to enable students to communicate with each other. One of these from the Open University in England (course DT200) used an on-line forum together with printed text, video segments and audio cassettes. It also enrolled over 1200 students making it an early example of a relatively “massive” course.

The CCK08 course was innovative, in that it used the principles of connectivism to teach a course on connectivism and connective knowledge. To quote Stephen Downes “In our first open course—CCK08—we emphasized learners’ control in orienting themselves to complex information” and “Creating and sharing artifacts helped learners to communicate how they had come to understand a topic or concept” (Downes, 2012).

On the other hand, the courses regarded as the first MOOCs in the public eye were much less innovative than the c-MOOCs, consisting of standard video lectures and materials mimicking the standard lecture mode of presentation together with a forum for communication. They are usually referred to as x-MOOCs. They differed from OpenCourseWare in that they added student communication with each other and with the teachers. They were broadcast identically to all enrolled students...
and were similar to many previous on-line courses. Their one point of distinction is that they received massive enrollments due to their being open, freely available and widely publicized. Another difference between the classic x-MOOC and previous on-line courses from universities was that the students enrolled in x-MOOCs did not usually receive any credit unless they were also enrolled as students in the university. In many of the previous smaller on-line courses from universities, students received credit towards a degree or other qualification.

The first x-MOOCs happened in 2011 when Stanford University artificial intelligence professor and Google Vice-President Sebastian Thrun, along with Google’s Director of Research Peter Norvig allowed anyone to sign up for a free online version of their course “Introduction to Artificial Intelligence”. As it was a course for graduate students, they did not expect large enrollments. But after a story in the New York Times, the enrollment reached over 150,000. Later, Stanford’s Andrew Ng’s “Machine Learning” and Jennifer Widom’s “Introduction to Databases” courses were made freely available online. These classes featured short video segments of lectures and exercises (often multiple choice).

In the generally accepted history of MOOCs, the four main players were Coursera, Udacity, The Khan Academy and edX. There are now many other providers, large and small, including other commercial operations such as the Canvas Network, OpenClassrooms, OpenLearning, Iversity, NovoEd, CourseMos, Open2Study, Kadenze (many of which offer free courses) and non-profits such as POHLN, Futurelearn, Academic Earth, Peer to Peer University and Stanford Online. The overall growth rate of MOOCs has been impressive (Figure 1).

The 5 main providers collectively enrolled over 48 million students (Figure 2). The total number of students who signed up for at least one course in 2016 was 58 million. In 2016 there were more than 700 universities involved in MOOCs with 6850 courses available with 2600 starting in 2016.

The distribution of courses between subjects was also analyzed (Figure 3). As in most previous years, courses in Business and Technology (Computer Science, Data Science, Programming) make up 40% of all new courses.

Figure 1. Growth in MOOCs from 2012 to 2017 (Data source: Shah, 2016)
Figure 2. Students enrolled with the five main course providers (Data source: Shah, 2016)

Figure 3. Course Distribution by subject area in 2016 (Data source: Shah, 2016)
When MOOCs and their distribution within academic subjects were analyzed (Shah, 2016), it was found that most of the MOOCs are offered by Coursera. Currently 683 MOOCs, divided into 25 subject fields, are registered on this platform. Because of the number of students enrolled, the relevance and relative dominance of Coursera (with 8.5 million registered users) becomes obvious. The remaining platforms offer a smaller number of MOOCs. However, the number of MOOCs is not the only criterion to describe the course offerings of Coursera and others. Also important is the question of how the MOOCs are integrated into the study programmes or academic courses. Three strategies could be distinguished:

- Most MOOCs are sold individually and often confer certificates upon completion.
- The providers Coursera, Udacity and edX connect individual MOOCs to more complex certificate programs (also called chained MOOCs). These contain up to 10 different MOOCs and are offered as “higher” education programs. For instance, within the program “Specializations on Coursera” the provider offers 10 educational programs based on a set of related MOOCs. Udacity offers “nanodegrees” in information technology and business related subject areas.
- Provision of MOOC-based complete study programs (e.g. Master's programmes. Table 1). The MOOC providers Coursera, edX and Iversity intend to offer more such digital study programs in the future.

Certificates for individual courses (Option 1 above) or chained MOOCs (Option 2) are offered by the MOOC provider or (in some cases) by academic institutions.

There are still some concerns surrounding MOOCs. Interaction between faculty or teachers and students is more difficult in MOOCs because of the large number of enrolled students. Student to student interaction can be fostered by various technologies for communication. There are also problems with identity verification and authentication, especially important if credit is to be granted after successful completion. Plagiarism detection is also an ongoing issue, but detection software is available to help, even though with very large class sizes it is time-consuming to apply. Access to ancillary materials and libraries can be an issue with MOOCs if the materials cannot be provided on-line. Other problem areas are student demographics, low student completion rates and achieving viable business models.

### Student Demographics and Completion Rates

The demographics of enrolled students has changed little over the years since 2011. In a study on 32 sessions of 24 courses on Coursera up to July 2013 given by the University of Pennsylvania’s Open Learning Initiative (Christensen et al., 2013), the “student population tends to be young, well educated, and employed, with a majority from developed countries. There are significantly more males than females taking MOOCs, especially in developing countries”. More than 80% of respondents to an e-mail survey had post-secondary degrees and over 40% had education beyond a Bachelor’s level degree. Over 40% were under 30 years of age, and less than 10% were over 60. About 62% were employed and 13% reported being unemployed or retired. These tendencies towards, young, male and employed were even more marked in the developing countries and the BRICS (Brazil, Russia, India, China and South Africa) countries. The two main reasons for taking a MOOC were “curiosity, just for fun” (50%) and “to gain skills to do my job better” (44%). This varied by subject area – in the humanities courses about 75% were taken for curiosity and only 12% for improving job skills, whereas in the science, health and math courses 39% took the course to improve job skills. There were distinct differences in enrollment patterns between countries; in the United States, about 45% enrolled in the science and healthcare-related classes while in the rest of the world the most popular courses were Social Science, Economics and Business.” These proportions vary in different studies, and may not even be comparable given different survey methods and questions, but the general trends remain; students take MOOCs for curiosity or to improve job skills, male students predominate, and most successful students have had previous exposure to higher education.

The originators of MOOCs (especially x-MOOCs) saw them as a way to bring quality education to low income earners in the lesser developed countries. Studies have shown that most MOOC participants were from North America and Europe with only a few from South East Asia, Asia and Africa (Clow, 2013; Liyanagunawardena et al., 2013; Coffrin et al., 2014; Stine et al., 2013).

A recent study (Garrido and Koepke, 2016) revisited these earlier conclusions and found that almost 50% of students in Colombia, the Philippines and South Africa (the countries studied) received completion certificates for at least one course and over 70% completed the course if they were already employed. Most of the MOOCs were given by established and highly-regarded institutions in their own countries. The users were also from diverse income and educational backgrounds but
primarily from low- and medium-income categories (+80%). Female participants achieved completion rates higher than males. Other observations were that MOOC users in the three countries tended to be younger and from more diverse educational backgrounds than users in developed countries and that gaining specific skills to perform better in their job, obtaining professional certification, preparing for additional education, and finding a new job were the top motivations of young people to engage with MOOCs. The most popular subjects were computer sciences, language, business and management. Also, the higher the use of desktop or laptop computer as the main device for accessing the internet, the higher the rate of completion and certification (Yoder, 2016).

In general, however, the overall completion rate for MOOCs has been disturbingly low. Onah et al. (2014), Ho et al. (2014) and Rivard (2013) place the dropout rate at 85%, 95% and surpassing 90%, respectively. Even more significantly, the participation and collaboration efforts of students drop dramatically after the first week of the courses and in some cases become zero.

This has been interpreted variously as the major problem with MOOCs and as the sign that students get what they want (audit, overview, browsing materials, etc.) from a MOOC and that it is to be expected and is even desirable. It depends on the perspective of the viewer. It may be that MOOCs may be valuable even to those who do not engage in the course beyond browsing the content. A substantial proportion of the enrolled students in most MOOCs are teachers, Seaton et al (2015) in an analysis of 11 MITx courses on edX in the spring of 2014 found that 1 in 4 (28.0%) respondents identify as past or present teachers, while nearly one in ten (8.7%) identify as current teachers. An interesting possibility is that teachers are using MOOCs to “flip” their classroom by providing the MOOCs to their students. This is bolstered by anecdotal evidence. A small percentage of the teachers responding to this survey teach the topic of the course in their school or college. This raises very interesting possibilities for targeting MOOCs towards teachers or having an adaptive MOOC where teachers can review, extract and use specific parts in their teaching activities.

Jordan (2015) in a review of 221 MOOCs discovered from MOOC-aggregating sites such as Class Central and by web searches found that the completion rates (defined as the percentage of enrolled students who completed the course) varied from 0.7% to 52.1%, with a median value of 12.6%. Longer courses had lower completion rates, more recent courses had higher percentage completion rates and courses using auto grading also had higher completion rates.

Since the motives for students enrolling in MOOCs are so variable and the completion rates are low, it might be possible to tailor courses to accommodate the various categories of student engagement or requirements in an adaptive curriculum tailored to the capacity and progress of each student. Tomlinson (2003) confirmed the merits of this adaptive curriculum or differentiated instruction.

Vu and Fadde (2014) classified student engagement in a course on computer-assisted language learning for 512 learners from 27 countries. Approximately 45% paid tuition and they received a certificate of completion if they achieved an overall 80% grade. Stanford University’s Learning Analytics group (McKay, 2013) arrived at very similar conclusions. They found that people take classes or stop for assorted reasons, and therefore referring globally to “dropouts” makes no sense in the online context. They identified four groups of participants:

- Those who completed most assignments,
- Those who audited,
- Those who gradually disengaged and
- Those who sporadically sampled.

Also, most students who sign up never actually show up, making their inclusion in the data problematic. Data collection is not simply to record who is doing what but to “provide educators, instructional designers and platform developers with insights for designing effective and potentially adaptive learning environments that best meet the needs of MOOC participants,”

The situation with c-MOOCs is more complex. They require even more effort on the part of the student since the materials are, to a considerable extent, self- or group-generated, and shared with others for comment and improvement. The involvement is therefore greater, and one would expect a rapid dropout as the students realize the degree of involvement required. Overall, though, the rates seem similar or better than those in x-MOOCs, maybe because c-MOOCs are “less massive”, are open about what is required to complete the course and may thus select more motivated students, or are simply more engaging than most x-MOOCs (Frick and Dagli, 2016).

Despite parity in total enrollment in tertiary education in many countries, women have not yet achieved parity in the STEM subjects (Science, Technology, Engineering and Math). As an example, in the United States, women represented a larger percentage of Master’s and Doctoral students in engineering in 2015 than the year before. They also earned a larger share of graduate than Bachelor’s degrees in engineering. Females were awarded 19.9 percent of all Bachelor’s degrees awarded by an engineering program in 2015 and made up 21.4 percent of undergraduates enrolled in engineering. They received 25.2 percent of Master’s degrees and 23.1
percent of doctoral degrees in 2015. Women represented 24.1 percent of students studying for a Master's degree in 2015 and 26.2 percent of those pursuing a doctorate. (Yoder, 2016)

When some MOOC pioneers declared that they would democratize education and educate the world very quickly and for free, they were speculating without evidence. As that evidence accumulates, it is clear that a great deal of dedication, time and effort is required to complete a meaningful course. Without a reason to do so, few will complete the homework assignments, quizzes and examinations; but that still does not mean that they derived no benefit from the course.

**Business Models for MOOCs**

MOOCs need sustainable business models. There is a continuum ranging from free, through subsidized, cost-recovery and profit-oriented models. In addition to the owners or producers of the courses, there are also companies and free software companies that derive revenue from the sale, maintenance or operation of the technologies used to deliver the MOOCs. Sometimes these are the same (edX, Coursera, the Khan Academy and Udacity) but sometimes software suppliers (Moodle, Blackboard, Desire2Learn) only provide the platforms and are not necessarily involved in managing and delivering courses or programmes.

Many industries such as music, movies, news, travel and real estate have already borne the changes coming from digital disruption, and some, such as newspapers, travel agents, and, to a lesser extent, the real estate industry, have seen very large decreases in revenue and profits. The on-line versions of those industries or the survivors from earlier times have used two main methods to monetize the free information easily available to consumers. The first method is to provide free information or services and charge for complementary features including analysis and value-added activities. LinkedIn has a free service for its users plus a premium service with added capabilities. The second method is to find a way to charge someone else other than the consumer for information and services; LinkedIn can charge employers and recruiters for specific and targeted access to their large roster of users seeking employment.

Although the first proponents of MOOCs predicted they would severely impact university and college finances, post-secondary education, so far, has seen only a minor impact of MOOCs on their finances. Most MOOCs from universities are on-line versions (often modified) of courses normally presented on-campus or paid on-line courses that have an academic credit attached for successful completion (Bellefiaemme et al., 2014). The academic institutions rely upon accreditation (a form of quality control), reputation and control of academic credits and degrees or other qualifications to sustain the university income. With some notable exceptions, MOOCs have not penetrated this income stream; most do not offer credit towards degrees, and they struggle with such issues as positive student identification, cheating, the perceived lower quality of MOOCs and similar issues. Another problem is that certain types of subjects such as computer science and mathematics can be presented as for-credit x-MOOCs using technology to administer them, mark assignments and final exams with lower levels of input from the teachers. Many other subjects cannot be operated in that manner and require greater teacher involvement. This imposes a limit on enrollment in that type of course for logistical reasons.

It may be possible for universities and colleges to adopt one or more of the income models where the student pays tuition for course content, peer assistance, certification of some kind, tutoring or collaborative group learning. Employers may pay for analytics and certification or for customized courses and continuing education for their employees (Teplechuk, 2013). Sponsors may pay for course production and delivery in areas that align with their interests or requirements. Other types of sponsors such as foundations may fund course production and dissemination as a “public good” for altruistic reasons (combating or adapting to climate change, public health issues of general concern, etc.). If the courses are still made available free of charge to students who do not want or need credit, credentials or feedback, the essence of the “Open Online Course” ideal could be maintained.

Many of these opportunities also apply to the commercial MOOC sector where well-funded companies can produce high quality courses. For some of the income streams, accreditation and significant credit towards a respected qualification are almost mandatory. The initial surge in venture capital funding for MOOC companies seems to have withered and most are now trying to find income models that will be profitable. Udacity has pivoted towards offering professionals or companies vocational courses of relevance to their interests and away from the traditional x-MOOC. Most of its courses are no longer free. Many of the commercial MOOC providers now see the +22-year-old, professional who wishes to enhance their career prospects as their primary market together with corporately funded training and upgrading courses for employees.

There has been a recent trend for MOOC providers to offer post-graduate degrees in cooperation with universities (Table 1). The costs of these degrees range from US$6600 to US$30,780 (at current exchange rates). This trend will accelerate in the future; Coursera intends to offer 20 such degree’s programs in the future.
Table 1. Post-graduate degrees offered by MOOC providers (2017)

<table>
<thead>
<tr>
<th>Degrees</th>
<th>Provider</th>
<th>University</th>
<th>Cost (US$)</th>
</tr>
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<tbody>
<tr>
<td>MS Computer Science</td>
<td>Udacity</td>
<td>Georgia Tech</td>
<td>6,600</td>
</tr>
<tr>
<td>MS Analytics</td>
<td>edX</td>
<td>Georgia Tech</td>
<td>10,000</td>
</tr>
<tr>
<td>MBA</td>
<td>Coursera</td>
<td>University of Illinois</td>
<td>22,000</td>
</tr>
<tr>
<td>MBA</td>
<td>Coursera</td>
<td>University of Illinois</td>
<td>22,000</td>
</tr>
<tr>
<td>MS CS Data Science</td>
<td>Coursera</td>
<td>University of Illinois</td>
<td>19,200</td>
</tr>
<tr>
<td>MS Accounting</td>
<td>Coursera</td>
<td>University of Illinois</td>
<td>27,200</td>
</tr>
<tr>
<td>Masters in Innovation and Entrepreneurship</td>
<td>Coursera</td>
<td>HEC Paris</td>
<td>23,500</td>
</tr>
<tr>
<td>Cyber Security</td>
<td>FutureLearn</td>
<td>Deakin University</td>
<td>30,780</td>
</tr>
<tr>
<td>Masters in Development and Humanitarian Action</td>
<td>FutureLearn</td>
<td>Deakin University</td>
<td>30,780</td>
</tr>
<tr>
<td>Masters in Professional Practice: Information Technology</td>
<td>FutureLearn</td>
<td>Deakin University</td>
<td>30,780</td>
</tr>
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More recently, Clarissa Shen (company VP of Udacity) declared MOOCs as “dead” “at least for the goals we had set for ourselves” and “MOOCs have been too content-only focused and not a model that engages our students deeply. They are an improvement on pure content libraries when done well, but as a product not what we felt achieved success for our students and industry partners.” Udacity is moving more strongly toward a more curated experience and away from “millions of videos” working with companies like Google, IBM and Amazon to develop this new experience (Young, 2017).

Coursera and Google are launching a “Grow with Google” programme where Google will provide up to $1 billion to provide digital skills to the US workforce to take beginning students to an entry level IT job in 8 to 12 months. Steve Woz of Apple has founded Woz U to teach computer science courses, initially on-line but then in 30 locations around the US. (Young, 2017)

A trend in 2017 was the continuing rise in micro-credentials (e.g. Coursera’s Specializations, Udacity’s Nanodegree, IBM’s Badges and edX’s MicroMasters). These mostly target the graduate marketplace and allow students to gain skills more quickly and cheaply. MIT Professional Education’s new Digital Plus Programs are also concentrating on cooperation with companies and organizations and they deliver smaller courses (less than 50 students) and are not open enrollment. After taking courses, students can obtain a professional certificate from MIT. The courses could potentially be customized for individual companies or organizations (Johnson, 2017)

There have been concerns raised about the intellectual property (IP) and copyright aspects of MOOCs. The two major concerns are use of copyrighted materials and ownership of the IP in MOOCs. Copyright laws are complex, vary between countries and are open to reinterpretation during any legal proceedings. There are many potential intellectual property concerns with MOOCs simply because of their potential for distribution to very large numbers of students. This contrasts with the much smaller number of known and registered undergraduate or graduate students in courses at university and even in most previous online courses. The problem is in the concept of “massive” leading to distribution of materials to a very large audience without any control.

The other important aspect of IP issues is that of the ownership of materials developed for use in MOOCs. The ownership of IP is often dictated by policies that can vary between institutions. The most common situations are 1.) when either the university owns everything developed with campus resources and licenses it to faculty member or 2). the faculty member (author) owns their ideas and licenses them to the university. In pre-MOOC days, this was of little concern to most faculty members or authors because there was very little direct market for those materials outside of the standard course structures. MOOCs have changed that and; with the possibility of substantial financial gains from large MOOCs, both universities and authors are much more concerned with IP and ownership issues. Complicating the picture is the reality that universities are signing deals with course providers...
providers like Coursera that can change the rights and privileges of MOOC ownership and give rights to the private sector company to change and modify materials or re-use them in other courses.

This is an evolving area and many institutions are still working out the IP and financial implications for the institution and the MOOC authors. These policies will have a direct impact on the future of MOOCs (Domonell, 2013).

**The Future of MOOCs**

The initial crop of x-MOOCs attempted to replicate the Ivy League experience by videotaping lectures and having little real assessment. The c-MOOCs had a different model that involved students interacting and was a new kind of course that held promise to improve the educational experience of on-line students. The x-MOOCs did not achieve their stated goal and the dropout rates were very high. It is also arguable that the high dropout rate was inevitable given the difference in expectations of the enrolled students and the universities presenting the courses (Vu & Fadde, 2014).

Some of the requirements for success in MOOCs are a clear statement of the goals of the course that matches the aspirations of the students, a clear and well-reasoned pedagogy for the courses, a mechanism to engage students and make communication easy and effective, assessment of progress and accomplishment, a recognition that credit is desirable for many students, and a careful analysis of the successes and failures of the courses.

There are numerous pedagogical models (Dabbagh, 2005) but one significant one is that of Merrill (2002, 2009, 2015) who proposed that there were a set of interrelated prescriptive instructional principles that he called First Principles of Instruction. He specified a four-phase cycle of instruction that is centered around a series of increasingly complex authentic problems or tasks:

1. Activation
2. Demonstration
3. Application and
4. Integration.

These were proposed to apply no matter the medium of instruction over the range from face-to-face small classes to the larger MOOC classes.

Another dimension of instruction that is suited to MOOCs is differentiated or adaptive learning. Learning is adapted to the individual students using information gleaned from their performance in the course. The technology behind most MOOCs is extremely well suited to gather data, sometimes in detail, about what, when and how a student progresses (or not) through the course materials. Their understanding and comprehension can be tested at intervals and their pathway through course materials, remedial sessions, extra information sources, quizzes, assignments and examinations can be modified based on that understanding. In theory, progress through each of Merrill’s “first principles” can be examined for each student and the course materials and assignments changed to optimize that student’s progress.

Based on the analyses above, a way forward might be to produce adaptive courses that tailor themselves to the individual student’s entrance knowledge and abilities and modify the presentation based on those metrics and on the students’ progress through the course. This is much more difficult than simply replicating standard courses in an online version.

Another issue is that massive courses may not be the best way forward. The only virtue of the massive course is efficiency in reaching large enrollments. If this efficiency is not matched with efficacy, then the size becomes a problem rather than a virtue. Ironically, smaller MOOCs may be better. This seems to be the trend in more recent (M)OOCs. If these smaller (M)OOCs are not “open” in the sense of either being open to everyone to enroll and/or free (no cost to enroll) then we are left with “online” education – hardly a revolutionary idea!

However, there still may be a good case to be made for having “tiers” of student types in MOOCs (whether they are massive or not). This idea comes from observations of the behavior of students in MOOCs. Vu & Fadde (2014) called it “rings of engagement” from the common observation that different students have distinct levels of engagement and persistence with course materials, assignments and overall completion. Upon questioning, some were simply trying out the material to see if they could do it, some were “browsing” to get specific skills or subject areas, some were auditing but had no desire to do assignments or complete the course and some were working their way through the whole course. This last group was the one that led to the 7% to 10% completion rates often observed. The assumption was that this was the best metric for the success of the course, but the argument could be made that the other groups gained exactly what they wanted from the course (even if that was to realize they needed more preparation or simply could not do it). From that viewpoint, MOOCs have value beyond simple measurements of completion rates. The comparison has been made between MOOCs and a university course where anyone from the public could enroll and try to complete the course; the completion rate in that case might be equally low – but it could still be a valuable experience for the individual students.
MOOCs can generate a lot of data about how students use the materials, how they engage with videos, assignments, printed materials and on-line resources. This is easily captured with the technologies used to run the MOOC and can be a source of interesting pedagogical data if it can be linked to outcomes and progress of the students. This could lead to an improvement in the teaching and learning models used in MOOCs (or any on-line course).

Provision of courses in different languages would be a valuable addition for MOOCs. Especially in technical subjects, this is not easily accomplished through machine translation (for example, Google Translate) because of the specialized vocabularies involved. One approach has been “community translation” (Beaven et al, 2013) or by a crowd-sourcing approach such as the Open Course Ware platform SlideWiki. When an acceptable translation system has evolved, it will add to the reach and value of MOOCs since they can much more easily be made available to larger numbers of students around the world.

MOOCs seem to be very suitable for delivering professional development and in-career training. All the big MOOC providers have moved to a model where the courses are no longer free, and they are attempting to get institutional or employer recognition for their course offerings. Coursera has changed its approach and now concentrates on professional development courses for individuals and has been making partnerships with companies to provide them with education and training for their employees. Udacity has always been targeted towards that type of marketplace. In many ways, MOOCs, especially the x-MOOCs, are well suited to such applications because the users are well motivated to complete courses and derive immediate benefit through their employment rather than needing official credits. Some companies such as Microsoft, Google and AT&T are trying internal MOOCs for corporate learning for similar reasons.

A good illustration of professional development with MOOCs is with iMBAs delivered via MOOCs.

Class Central (2017) assessed the enrollments in 2016 in these programs and found that the number of enrolled students varied considerably between the various types of cost structure. There were 1.2 million enrolled in free programs, 49,000 gained certificates (for an average of $50 each), 150 received college credit (for an average of $1000) and 800 received a degree at an average cost of $22,000.

MOOCs may come to play a role in higher education different to that initially envisaged. The more nuanced theory of higher education that is proposed by Christensen is that online learning may be a “sustaining innovation” that will work alongside traditional campuses and face-to-face teaching to strengthen universities and colleges. Those institutions that can adapt to, and embrace, the innovative technologies will be best placed to continue with what is excellent and special about what they do already, while taking best advantage of what is new.

The Role of MOOCs in the Water Sector

If we consider the current and potential roles of MOOCs (and their variants) in education and training for the water sector, they have advantages and features that could positively impact such activities. If we couple that with the analysis of job functions in the water sector (UN Water, 2016) their role in capacity development comes into a clearer focus. The jobs in water sectors fall into three functional categories:

- Water resources management, including integrated water resources management (IWRM) and ecosystem restoration and remediation;
- Building, operating and maintaining water infrastructure; and
- Provision of water related services including water supply, sanitation and wastewater management.

To quote UN Water (2016), “These jobs serve as the building blocks for a wide array of water-dependent job opportunities in sectors such as agriculture (including fisheries and aquaculture), energy and industry. Specifically, investments in safe drinking water and sanitation have been shown to foster economic growth, with high rates of return. Access to a safe and reliable water supply and sanitation services at home and the workplace, coupled with appropriate hygiene, is critical to maintaining a healthy, educated and productive workforce. Many ancillary jobs also enable employment in water-dependent sectors. These include jobs in regulatory institutions within public administrations, infrastructure financing, real estate, wholesale and retail trade, and construction. Together, water jobs and ancillary jobs provide the enabling environment and necessary support to the activities or operation of numerous organizations, institutions, industries and systems, and to the jobs they generate. By estimating the potential employment supported by investments in the conservation, treatment and delivery of water, governments can determine the investment and employment policies that will increase and improve jobs across the economy.”

“In addition to jobs in agriculture and industry, sectors with heavily water-dependent jobs include forestry,
inland fisheries and aquaculture, mining and resource extraction, water supply and sanitation and most types of power generation. This category also includes some jobs in the health care, tourism and ecosystem management sectors. The analyses made in this Report have allowed to estimate that more than 1.4 billion jobs, or 42% of the world’s total active workforce, are heavily water-dependent. It is further estimated that 1.2 billion jobs, or 36% of the world’s total active workforce, are moderately water-dependent. These are sectors that do not require access to significant quantities of water resources to realize most of their activities, but for which water is nonetheless a necessary component in part(s) of their value chains. Examples of sectors with moderately water-dependent jobs include construction, recreation and transportation. In essence, 78% of jobs constituting the global workforce are dependent on water.”

In terms of capacity development, UN Water emphasizes the importance of innovative and adequate tools: “The skills, qualities and capacities of employed human resources are vital for the successful performance of the water sectors and for the sustained use, adaptation and development of scientific and technological innovations. This is particularly salient in view of the broadening fields of expertise that are needed for these sectors, which include water resources management, building and managing water infrastructure, and the provision of water-related services. The lack of capacity and the challenges facing the water sectors require the design of adequate training tools and innovative learning approaches to enhance the competencies of staff as well as to strengthen institutional capacity. This applies to government and its agencies, river basin organizations as well as other groups including private sector organizations. Solutions to filling these gaps include: creating an enabling policy environment for collaborative frameworks between the education sector, sector employers (public, private, NGOs), trade unions and employees; developing incentives to attract and retain staff; strengthening technical and vocational training; and giving attention to human resources capacity development in rural areas. New and transversal skills also need to be instilled to respond to new needs.” (emphasis added) (UN Water, 2016).

The educational requirements of the water sector necessarily involve the tertiary education system (colleges, universities and similar institutions). These are the source of many of the people employed in the water and sanitation sector and their educational attainments and their expertise must be of interest to the eventual employers whether that be academia, the private sector or the public sector. A one-dimensional emphasis on technical training is not enough. There needs to be a cadre of people, each expert in different disciplines, so that the complex problems inherent in providing safe secure, sustainable and clean water and adequate sanitation can be addressed. These problems, by definition, require expertise in engineering, science, ecology, planning, sociology, law, psychology and other disciplines. Since solutions are often specific to regions or even watersheds the capacity development process needs to be flexible enough to provide these skills together with the capacity to adapt them to specific cases. One important lesson that flows from this is that there is an on-going need for capacity development in leadership capacity, collaboration skills, managing innovation and change management. This may require a change in the way education (and training) is done in the future for the water sector.

Compared to other areas of study such as computer science, there are few MOOCs in the water sector. Even if we define MOOCs very loosely, where they do not have to be massive (more than tens of thousands of students), but must be open for anyone to enroll in and complete, they are still not numerous.

In a survey of known institutions providing courses in the water sector, plus the major universities involved in MOOCs and the most active companies delivering MOOCs, there were only a few courses of relevance. For example, Coursera, the major company providing MOOCs, had courses on “Water Supply and Sanitation Policy in Developing Countries Part 1: Understanding Complex Problems” and “Water Supply and Sanitation Policy in Developing Countries Part 2: Developing Effective Interventions” from the University of Manchester, “Planning & Design of Sanitation Systems”, “Municipal Solid Waste Management in Developing Countries” and “Introduction to Faecal Sludge Management” from École Polytechnique Fédérale de Lausanne, and “Water Resources Management and Policy” from the University of Geneva. Others of peripheral interest to students in the water sector included “Global Environmental Management” from the Technical University of Denmark, “Ecosystem Services: a Method for Sustainable Development” from the University of Geneva, “Introduction to Sustainability” from the University of Illinois at Urbana-Champaign, “Our Earth: Its Climate, History, and Processes” from the University of Manchester and “Introduction to Environmental Law and Policy” from the University of North Carolina at Chapel Hill. This is 11 courses out of the 2104 courses advertised by Coursera.

Similarly, edX had 29 courses listed as related to water, but only 9 were directly applicable; the others were only of peripheral interest. Three of the water courses (Urban Sewage Treatment, Drinking Water Treatment and Introduction to Water and Climate) comprise the syllabus for an X-Series program from the Delft University of Technology. X-Series courses are
designed “to develop a deep understanding of exciting and in-demand fields”.

The only course listed as applicable to water on FutureLearn was “Elements of Renewable Energy”. OpenLearning has courses listed as “The New Hydrology”, “Water Engineering”, “Water Resources: Treatment and Distribution”, “Water Treatment”, “The Water Cycle”, and “Water Engineering in Agriculture”. The Open CourseWare Consortium list only one applicable course “Water Quality Control” from MIT. Udacity, XuetangX and Stanford Online had no courses on water.

The successful completion rate statistics for most of these courses are not available.

It must be emphasized that this cannot be a complete list since some universities and companies only promote courses that are currently offered or soon to be offered. They may have other courses available or in preparation that would be relevant to the water sector. However, there are few real MOOCs available and very few organized and comprehensive programmes dealing with the water sector.

There are some specialized institutions that are dedicated to water education. Perhaps the foremost is the IHE-Delft Institute for Water Education (https://www.un-ihe.org/). It is the largest international graduate water education facility in the world and is based in Delft, the Netherlands. It offers a wide variety of educational courses in the field of water. In addition to four MSc programmes and the PhD Programme, the Institute also offers a range of short and online courses tailored to specific needs. IHE offers a total of 26 online courses including “Ecological Sanitation”, “Grey Water Management, Treatment and Use”, “Industrial Resource Management and Cleaner Production”, “Modelling Sanitation Systems”, “Constructed Wetlands for Wastewater Treatment”, “Environmental Flows”, “Goverance of Decentralized Sanitation”, “Industrial Effluent Treatment”, “Partnerships for Water Supply and Sanitation”, “Solid Waste Management”, “Water Transport and Distribution”, “Decision Support Systems in River Basin Management”, “Biological Wastewater Treatment: Principles, Modelling and Design”, “Fecal Sludge Management”, “Urban Drainage and Sewerage”, “Flood Modelling for Management”, and many others. There are enrollment limits and the courses typically run for a few months for 8 hours study time per week. There is also a recommendation that students have, at least a Bachelor’s degree and some years of working experience. Although these are not MOOCs in the traditional sense, they certainly have the potential to support the development of such courses.

The International Water Association (http://iwa-network.org/iwa-learn) has courses available ranging from “Water Reform and Governance”, “Water Quality and Sanitation Training Program – Short and long term” to “Online Course on Biological Wastewater Treatment: Principles, Modelling and Design” and 49 others. They range in cost from $0 to $4670.00 and cover wide variety of courses specific to water and WASH issues to courses of interest on sustainability, smart cities, leadership, climate change and management. Most courses listed are from other institutions such as IHE Delft Institute for Water Education, the International Water Centre (www.watercentre.org), the Open University (www.open.ac.uk/) and Delft University of Technology (https://www.tudelft.nl/en/).

As another example, the University of Loughborough’s Water, Engineering and Development Centre (WEDC) in England offers distance learning M.Sc., Postgraduate Diploma, Postgraduate Certificate, and Professional Development programs requiring completion of different modules to gain the qualifications in Water and Waste Engineering, Water and Environmental Management or Infrastructure in Emergencies. Enrollment is often restricted, and the courses are targeted towards graduates from a Bachelor level program. Again, these courses could support the development of MOOCs.

In addition to these courses and programs, there are the standard Master’s and Ph.D. programs of study in water-related areas at many universities. As examples, McGill University in Montreal offers a 1-year, non-thesis, MSc program in Integrated Water Resource Management (IWRM) and an 8-week online certification program in Integrated and Adaptive Water Resources Planning, Management & Governance, TH Köln (University of Applied Science) and the University of Jordan offer a joint 2-year M.Sc. on IWRM with Focus on the MENA Region.

There are many organizations and institutions offering professional training in the water sector. Cap-Net UNDP (www.capnet.org) is prominent in this field, holding short courses and workshops on many water-related topics and producing training manuals. Over 20 specialized programmes have been developed on various aspects of sustainable water management and published in English, French, Portuguese and Spanish. Cap-Net UNDP trains more than 2,000 participants every year and over 10,000 professionals are accessing Cap-Net UNDP materials remotely. Although not MOOCs in the classic sense, the availability of the online materials and manuals has some of the features of a MOOC. The International Office for Water (IOWater) has supported the development of training for 25 years around the world and has usually presented courses face-to-face in countries.
There is an obvious lack of MOOC-style courses and programmes for the water sector. This could be because the classic MOOC model is not applicable nor appropriate since the sector is already well-served by current offerings, or because of low numbers of potential students compared with other areas, or a lack of data about potential students or their geographic distribution, or the costs of producing high-quality MOOCs and communications and interaction with students are high, or there is not yet an appropriate and sustainable business model, or there is a lack of suitable pedagogical models or there is a reluctance of providers to enter the marketplace.

The UN-Water data on jobs in the water sector and the obvious need for capacity development to achieve the SDG6 goals shows that there is a marketplace for two principal areas: professional development and capacity development for practitioners and technical training for operatives in many positions associated with water and sanitation operations. MOOCs (in one or more of their various incarnations) would seem an appropriate way to provide some of this capacity development and training.

Many current MOOC providers have transitioned to a model where technical training and professional development are keystones of their business model. This is largely because these functions can be monetized, and some form of credit can be provided to participants that is valuable in their career. Provision of credit towards academic credentials has proved more problematic but that is not the prime motive for many of the students in these professional development and technical training courses; one recognized important outcome is that their employer values and rewards participation and completion of the courses and programmes.

It would seem appropriate, therefore, to encourage the production of MOOC-style courses and especially well-designed and comprehensive programmes of study for these functions (and others as appropriate). Most available courses are stand-alone, without a progression through a programme that leads to progressive improvement in knowledge and understanding of the complexities of a topic area. This should be addressed by designing and providing such course programmes.

One of the problems that MOOCs have experienced is that, in most of the first batch of courses, pre-existing course lectures were simply transferred to video and quizzes, a communication channel and some assignments were added, and access was freely available for everyone. This model was partly responsible both for the very high enrollments and for the very high dropout rates. Other factors were the unreasonable expectations from the academic institutions about the learners and the goals of those learners not necessarily matching those of the institution. As MOOCs transitioned to become less massive and less open, and, at least for the commercial MOOC providers, more targeted towards professional development, these dropout rates declined.

MOOC-style courses also could be designed from the beginning to provide data on individual student progress and success or failure so that individualized curricula could be based on that data. These adaptive courses are much easier to provide when such data is generated from the student’s activities; even so, it is a time-consuming (i.e., expensive) process to develop such courses. Cooperative efforts by providers, academia, professional development institutions and others may be the best, most cost-effective, way to proceed.

MOOC-style courses could also be tailored to encourage learning of leadership and collaboration skills in the water sector. The elevated level of interactivity that can be achieved in a well-designed MOOC can be used to foster these skills with specific assignments and projects. This, again, would require a significant investment in curriculum design and carefully designed pedagogy to accomplish, but would certainly provide some very significant benefits. The c-MOOC or (connectivist-MOOC) where the participants generate individually and collectively much of the materials for the course seems particularly appropriate for the task of learning leadership and collaborative skills. The courses could be specifically designed to encourage these activities.

The value of MOOCs in providing academic credit towards a diploma or degree in the water sector is less certain. Most academic institutions, and certainly many faculty members in those institutions, do not look favourably on granting such credit under most circumstances.

At the post-graduate level there is a well-established set of post-graduate degree programmes and other academic credentials. For students in the less-developed countries, however, MOOCs could provide less expensive post-graduate diplomas or degrees even if the MOOCs were only a partial fulfillment of the overall degree requirements.

At the undergraduate level, the situation is complex; there are already recognized degree programs given solely by distance learning (although not by MOOCs) in various disciplines. These were not found so far in the disciplines closely associated with the water sector, but it may be inevitable that such programmes will appear. An interim stage may be where a hybrid or blended structure, part MOOC (or at least, on-line) and part traditional face-to-face courses, is used. A “flipped” course is different; the background materials are provided ahead of the student-teacher interaction and the lecture is replaced by a discussion of those materials mediated, but not directed, by the teacher. It
is conceivable that a MOOC in that role could be useful for participants in less-developed countries if the video (or audio) communications technologies would handle the traffic involved and mechanisms to facilitate and encourage participation were employed.

The use of MOOCs or MOOC-style courses for the water sector is not inevitable. As MOOCs proliferate in universities, colleges and the private sector, there will be complete programmes of courses in water management and other professional activities in the sector. There will also be post-graduate programmes for diplomas or Master’s degrees. The level to which they can satisfy the academic requirements of the institutions will determine their development and thus availability and numbers. The proliferation of “course Master’s” degrees with no research component would indicate that this will happen in the water sector. It is less likely that Ph.D. degrees will follow that course except to provide excellent graduate-level courses from other institutions to the Ph.D. candidates.

It appears reasonable to use the principles of the MOOC for technical training and professional development courses where large numbers of people can attempt the course, decide on whether it is appropriate for their level of expertise, available time and career aspirations and decide whether to continue to completion or to simply browse or audit the course to fulfill their own goals. If the courses remain free, these can be valuable functions. If a small fee is charged for some functions or for a certificate of completion, certain students will find this worthwhile and justifiable and will be willing to pay. Others, in less-developed areas of the world, might have this fee waived or paid from the income to the course or programme from students in the developed world or from bursaries provided by charitable organizations, governments or other agencies.

The increasing popularity of micro-credentials, in both the private sector education companies and in universities, could have value in the water sector if the employers recognize, value and reward these new skills.

Conclusions

- The quality of courses promoted as MOOCs has been very variable; most early ones simply took videos of lectures and posted them with some additional materials. This did not work well in an on-line, interactive environment and later courses specifically prepared or modified for on-line delivery were much more effective.

- MOOCs have traditionally suffered from very high dropout rates averaging around 85% - 90% for the larger courses, but as the concept has matured and the courses have become smaller, students have become more committed and the dropout rates have fallen. Dropout rates are not a valid metric to determine failure. There is some good evidence that MOOCs can be very effective in some less developed countries with very high completion rates and a wide representation of income and educational attainment in the participants.

- The emphasis for MOOCs has been in tertiary education and professional development where disruption of the current models seemed desirable to the proponents. It may be the case that MOOCs will be equally or more valuable and effective as community teaching systems or as additions to curricula in all levels in education systems.

- In the water sector, there are many existing face-to-face and distance learning courses and programmes designed to train and/or educate professionals, graduate and undergraduate students and, to a lesser extent, members of communities dealing with water issues. There are few extant MOOCs, but some organizations are proposing or preparing them.

- The advantages of MOOCs for the water sector could be significant. If excellent courses on the many aspects of the sector could be produced, they would allow anyone in the world to, at least, attempt the course and see if the MOOC approach and the content provided was suitable for them. If a series of courses were developed for complete programmes in, for example, transboundary issues, water security, water quality measurement, climate change adaptation and so on, they could be even more valuable and effective.

- One feature of MOOCs that deserves attention for the water and sanitation sector is the possibility that the different variants of the same basic courses that are being given or planned be replaced by a series of high-quality modules, available as MOOCs, that can be repurposed and used in future courses. This repository of materials and resources would be freely available to use and modify (perhaps under a Creative Commons type of license - https://creativecommons.org/).

- If designed correctly, MOOCs can also produce interesting information about how each student progresses through the courses, how they learn most effectively, which concepts prove more difficult, how long each section takes to complete, and many other facets of the learning experience. This information can then be incorporated into later course designs. This is especially relevant if the
MOOC is being delivered to a group of students from diverse backgrounds and cultures.

• The production of adaptive or differentiated learning courses also presents an opportunity in the water and sanitation sector. Although expensive and more difficult to produce than standard MOOCs, they would provide many advantages for the varied educational and cultural backgrounds of participants around the world. If course materials were shared and freely available, it would allow these adaptive courses to be more easily produced.

• Capacity development in the water sector has some interesting challenges that could be addressed by MOOCs while recognizing that other challenges could not. For instance, capacity development in IWRM is a complex process involving many different sets of expertise, including the engineering, biology, chemistry, ecology, hydrology, hydrogeology, information technology, communications, governance, management, legal, economic and socioeconomic aspects plus reliance on community involvement in the process. There are also technical aspects such as water and wastewater plant operations that impinge on the IWRM process. For effective IWRM, the expert participants need excellent communication skills and a “common expertise base” or “common knowledge base” to facilitate that communication process. A set of adaptive MOOCs that adapts to each participant’s set of skills and knowledge and then provides them with the other shared “common knowledge base” would assist in this process.

• Capacity development by MOOCs would help to achieve the main recommendations of UN Water (2016);
  i. Creating an enabling policy environment for collaborative frameworks between the education sector, sector employers (public, private, NGOs), trade unions and employees. Collaborative frameworks can be a feature of MOOCs where the curriculum materials are developed, produced, and delivered by partners and where each partner contributes their expertise to the course structure.

  ii. Developing incentives to attract and retain staff. Attracting and retaining staff is not directly addressed by MOOCs, but opportunities for training and education in the workplace, especially if it free or paid for by the employer, is an inducement that should not be underestimated.

  iii. Strengthening technical and vocational training. Technical and vocational training is eminently suited to MOOCs.

  iv. Giving attention to human resources capacity development in rural areas. If internet access is available, then MOOCs can serve rural areas very effectively.

  v. New and transversal skills also need to be instilled to respond to new needs. The tranversal skills (or core skills, basic skills or soft skills) essential as a base for the competencies required for employment can be imparted through MOOCs, but often require more contact and interaction between learner and teacher than is common in MOOCs.

• Although attention has been focused on the role of MOOCs in replacing or enhancing traditional educational processes and on their transformative role in delivering education on a massive scale, one aspect that has been often overlooked is the potential of MOOCs to deliver true lifelong learning to very large numbers of people (UNESCO, 2016). Not all capacity development has to be through formal educational systems. The very large enrollments in free MOOCs has shown a huge demand for access to courses on many diverse topics. Very few of these enrolled students went on to complete the course requirements to achieve a certificate or diploma, but their experience may have been just as useful in their situation.

• Finally, although gender parity in tertiary education has been achieved in much of the world, in the STEM subjects (Science, Technology, Engineering and Math), especially at the graduate level, it has not. This represents an opportunity to expand and improve the pool of qualified professionals and technical personnel for the water sector by applying open, online education processes to help decrease this disparity.

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