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Science and Quality Education for Sustainability Development in Libya

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Abstract

This paper presents an overview of the current state-of-the-art and emerging education and training approaches designed to meet sustainable development demands at global, regional, national, and local levels. It highlights how crisis-ridden Libya is recognizing the vital role of effective education and training in chemical, biological, environmental science, and engineering disciplines. This is being pursued through best-practice blended learning strategies aligned with global frameworks such as the United Nations Commission for Sustainable Development (UNCSD) Rio+20 Future We Want report (2012), the United Nations Sustainable Development Goals (UN SDGs) 2015–2030, and the Higher Education Sustainability Initiative (HESI). These initiatives aim to harmonize varied content knowledge, expertise, and professional experience. The paper outlines a strategic plan of action to address the challenges of change and development in education and training. It emphasizes the development of essential skills and experience needed for sustainable development professionals to meet increasing job complexity with greater responsibility and accountability. Furthermore, it proposes a framework utilizing outcomes, outputs, baselines, targets, performance indicators, and specific activities to guide the design of formal education and training programs in chemical, biological, and environmental science and engineering. These programs leverage emerging technologies to promote sustainable livelihoods in Libya.

Keywords

New and Emerging Education and Training, Best Practice Blended Learning Approach, Crisis-Ridden Libya, Sustainable Development

Introduction

Education and training in chemical, biological, and environmental sciences and technologies in Libya are undergoing a significant transformation, driven by the urgent need to rebuild a post-conflict nation. Years of civil unrest have led to the destruction of infrastructure, disruption of financial systems, limited access to foreign exchange, and an exodus of expatriate expertise. The goal of this transformation is threefold: (a) to analyze and address complex environmental challenges arising from insecurity and instability; (b) to develop and enforce environmental laws through standardized investigation protocols; and (c) to raise public awareness of environmental protection and sustainability (Bindra et al., 2013).

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This initiative aligns with the *Rio+20 Libyan National Report*, approved by the UN General Assembly in 2012, and reflects Libya's commitment to the *Future We Want* agenda (2012–2022) (Bindra, 2012). It also supports the implementation of the UN Sustainable Development Goals (2015–2030), the 17 goals and 169 targets, and the Higher Education Sustainability Initiative (HESI) by UNESCO. Libya aims to develop localized solutions to biodiversity loss and ensure sustainable livelihoods for future generations through advances in chemical, biological, and environmental science and engineering, in collaboration with EU neighbors, UN agencies, and NGOs.

Acknowledging education as a catalyst for economic and social progress, the Libyan government seeks to equip its workforce with the necessary tools, technologies, and techniques to minimize environmental impact. This is pursued under the leadership of the UN-recognized Presidential Council (PC), the Government of National Accord (GNA), and the Environmental General Authority. The overarching aim is to balance the three pillars of sustainability, social, economic, and environmental, ensuring that infrastructure reconstruction and economic growth proceed in an environmentally sustainable manner. Libya's national policy emphasizes democratic values, inclusive growth, and long-term economic sustainability for future generations. The *Rio+20* national report outlines clear objectives to address the emerging energy challenges and to support a transition toward a low-carbon economy.

Technology-enabled learning, as envisioned by the UNCSD *Rio+20* focal point in Libya, presents a critical challenge: to train a workforce capable of rebuilding the country while promoting sustainable livelihoods. A reflective overview of trends, challenges, and the relevance of higher education, particularly in chemical, biological, and environmental sciences and engineering, suggests that a tension persists between the science of learning and the art of teaching. Concerns raised by commentators such as British neuroscientist Baroness Susan Greenfield, who warns of the detrimental effects of video games and digital media on cognition, reflect ongoing debates. While empirical evidence is limited, some experts warn that although access to information has increased, deep knowledge acquisition may be declining, partly due to overreliance on technology.

Many observers believe that Libya's current educational model, inherited from over four decades of authoritarian rule, is ill-equipped to address today's multifaceted social, economic, and environmental challenges. Reform is needed to cultivate critical and creative thinking among learners. This includes adopting blended learning programs inspired by UNESCO initiatives such as the Management of Social Transformations (MOST), the Man and the Biosphere Programme (MAB), and Promoting Responsible Merit for Entrepreneurship (PRIME), as well as UNIDO. These approaches, previously introduced by one of the authors, aim to empower students with the intellectual tools required to rebuild a sustainable Libya (Bindra et al., 2012).

In a global context where information is abundant and easily accessible, the real challenge lies in fostering wisdom and discernment. Higher education, distinct from vocational training, must focus on transforming students' thinking and equipping them with critical and creative competencies. This paper, grounded in situational analysis, demonstrates how Libya's education and training institutions in chemical, biological, and environmental sciences and engineering are mobilizing their resources to fulfill the country's sustainability commitments and support inclusive national development.

An Assessment of the Existing Situation

Libya has a population of approximately 6.31 million, including 1.7 million students. Of these, over 270,000 are enrolled at the tertiary level, including institutions offering higher technical and vocational education. Higher education in Libya is provided by both general and specialized universities, as well as by technical and vocational institutions. Currently, there are 27 public universities and 56 private universities operating in the country.

Technical and Vocational Education (TVE) plays a vital role in enhancing employability and supplying the labor market with a skilled and qualified workforce. To support this mission, the National Board for Technical and Vocational Education was established to improve the quality of education services by applying international standards, thereby enabling Libya to participate more effectively in national development efforts.

There are 488 TVE institutions in Libya, comprising 16 Technical Colleges, 91 Higher Technical Institutes, and 381 Intermediate Vocational Institutes. Additionally, there are 40 Women Training Centres. The total number of students enrolled in these institutions exceeds 150,000, including 70,442 students in Intermediate Vocational Institutes, 66,457 in Higher Technical Institutes, and 13,192 in Technical Colleges.

A global, national, regional, and local review of the roles of chemical, biological, and environmental science and engineering education highlights a pressing need to develop a foundational understanding of basic ecology. This understanding is critical for addressing environmental issues, fostering values and attitudes supportive of sustainability, and encouraging proactive engagement in environmental problem-solving. Biology, in particular, plays a pivotal role in nurturing positive attitudes toward nature. A multidisciplinary blend of biology, environmental science, and chemical science equips students with vital environmental competencies, including the ability to identify, analyze, and resolve environmental challenges (Sharma & Sharma, 2012).

The current status of chemical, biological, and environmental science and engineering education and training in Libya has been assessed through a comprehensive fact-finding mission. The findings are now informing the development and implementation of new educational strategies. Specifically, three new concentration curricula are being designed. Among these is a pioneering curriculum in *Infrastructure, Biodiversity, and Environmental Protection Management*—the first of its kind in Libya. This initiative is grounded in consultations with stakeholders from industry, academic institutions, and NGOs, representing diverse sectors including aviation, chemistry, biodiversity, and environmental protection. The consensus from these consultations indicates an urgent need to reform curricula, as well as learning and teaching processes, within Libya's higher education system.

This paper critically examines the outcomes of the needs assessment conducted within the Libyan educational context and explores the proposed content, structure, and pedagogical strategies of the newly developed curriculum.

In recent years, there has been growing interest in the field of Environmental Microbiology, which investigates microbial properties and processes that shape the structure and function of both natural and engineered ecosystems. Given that the flow of energy and matter through ecosystems is largely mediated by microbial activity, a thorough understanding of these processes is essential for addressing and preventing environmental problems. Water,

as a central medium for transporting anthropogenic materials, waste, and energy within and across ecosystems, further underscores the importance of microbial ecology.

Microorganisms, being the dominant living components of aquatic ecosystems, play key roles in mediating globally significant biogeochemical processes (Lu et al., 2020). Accordingly, education and training in this area must be rooted in the principles of microbial physiology, ecology, evolution, and environmental science and engineering.

Rationale for Change

The current state of Libyan chemical, biological, environmental science, and engineering education is in disarray. As Libya seeks to position itself as a North African hub, it must actively engage at the highest levels in areas such as biodiversity, civil infrastructure (including aviation), and environmental protection. This shift demands a workforce that is better trained to operate in a fast-changing and complex environment.

The Libyan UNCSD *Rio+20 Future Libya Wants* report (2012–2022) and the Ministry of Planning's *2013–2030 Third Generation Plan* emphasize the urgent need for strategic mapping and human capital development. This strategic objective includes attracting, developing, and retaining skilled professionals through competitive remuneration structures, favorable working conditions, management commitment to training and development, and the creation of programs to enhance staff morale.

These measures are intended to help Libya achieve several key priorities, including sustainable infrastructure, biodiversity and environmental protection, petrochemical development, aviation safety, national security, socio-economic transformation, and growth. The *UN Post-2015–2030 Sustainable Development Goals (SDGs)* offer a unified framework for education reform and sustainable development, supported by the UN Decade of Education for Sustainable Development, UNESCO, the UN University system, the UN Academic Impact, the Global Compact, the Principles for Responsible Management Education, and the UN Environment Programme's Environmental Education and Training initiatives. These frameworks promote knowledge sharing and regular reporting on progress and challenges.

Libya has also introduced the Higher Education Sustainability Initiative (HESI). Initiated in 2012 by a group of UN partners as a voluntary initiative for Higher Education Institutions (HEIs), HESI was developed in preparation for the *Rio+22* conference (see Figure 1).

Figure 1. Sign for HESI

The Sustainability Literacy Test is one of several HESI tools used to assess students' sustainability knowledge upon graduation (Décamps et al., 2017). It evaluates the minimum level of understanding required in economic, social, and environmental responsibility, applicable globally to all tertiary-level students, regardless of program type or institution (Bachelor's, Master's, MBA, or PhD).

Rio+20, like the earlier Rio Earth Summit and Johannesburg Conference, provided a vital opportunity for the global community to evaluate achievements and progress since 1992 (Bindra et al., 2012). It also served as a platform to identify and address the gaps that have hindered the implementation of prior summits' objectives, thus contributing to a post-2012 global agenda. This agenda integrates economic, social, and environmental dimensions in response to the pressing need for inclusive growth and improved living standards amid global crises.

Libya's contribution to the 2012 *United Nations Conference on Sustainable Development* in Rio de Janeiro was part of its broader national reconstruction efforts. It reflects the country's intention to align with international sustainable development goals through a preliminary analysis of its socio-economic and environmental progress since the 1992 Rio Summit, the Johannesburg Summit, and other global events (Emelie, 2020). It also conveys the shared concerns of a liberated Libyan society and its neighboring regional and international partners—including the Mediterranean and Euro-Med region, the Maghreb Union, the African Union, the League of Arab States, the Group of 77, and BRICS.

Libya has launched a revitalized National Environment Strategy (NES) and a National Plan of Action for the Environment and Sustainable Development (NPAE-SD), based on a participatory approach involving all national stakeholders. The strategy aims to achieve sustainable economic growth during and after reconstruction by enacting public policies that improve health and quality of life, conserve and enhance natural resource productivity—particularly oil and gas—reduce economic losses, improve competitiveness, and protect the environment. These goals are further reinforced through the enactment and enforcement of sustainable development laws.

Trends and Research in Education and Learning

The state of the art on research in education and the learning sciences shows that the best ways of learning and teaching are based on the Massive Open Online Courses (MOOCs). This helps integrate emerging technologies for either synchronous or asynchronous modes by applying the following seven principles: (1) Encourage contact between students and faculty. (2) Develop reciprocity and cooperation among students. (3) Use active learning techniques. (4) Give prompt feedback. (5) Emphasize time on task. (6) Communicate high expectations. and (7) Respect diverse talents and ways of learning (Jansen et al., 2020).

An overview of the existing situation shows that integration of emerging technologies is difficult for Libya, like other countries that lack connectivity. Experience from the African unions shows that although the World Bank and other international organizations have aided virtual schools such as the African Virtual University, connectivity is still a problem for delivering Web-based courses. The African Virtual University, right from its inception in 1997, has created a virtual network with 53 institutions in 27 African countries and registered more than 3,000 students (Bateman, 2008). Visionary projects such as the Southern Africa–Western Africa (SAT3/WASC) and the South Africa–Far East submarine cables, along with a recent decline in communication costs, offer hope to African distance education (Farrell, 1999). Lack of support from the government is responsible for delaying the advancement of distance education in Libya It is indeed a frustrating problem for educators who recognize the need to revise the outdated educational system and see asynchronous delivery as part of the answer. Libya's 42 years of old regime politics and culture have lingering effects on the educational system; a system that discredits degrees earned from distance education programs. Libya's potential remains untapped, despite the growing opportunities for asynchronous learning networks. In present-day Libya, it may be necessary to choose emerging technologies that extend face-to-face collaboration for those students participating in mixed-mode delivery.

Thus, online domination in respect of chemical, biology, environmental science & engineering education is leading to an apparent imminent death of the lecture. The trend is similar to the one claimed by economists and innovation gurus like Harvard's Clayton Christensen and technology advocates like Thrun. It is increasingly felt that although a paradigm shift is occurring in education, MOOCs are unable to meet the quality requirements of the learning experience in many situations. Watching videos of lectures and answering multiple-choice questions is gaining ground.

Case Study on Libyan

Like elsewhere in Libya, too, increasingly chemical biology & environmental professionals do need scientific, engineering, economics, law, and policy skills to translate collective resolve and resources into effective environmental actions through activities that are both experimental and analytical in nature. In Libya too most environmental professionals as part-time students at Libya Academy, full-time students at Al Jaitouna University, Al Garabouli High Institute, and Civil Aviation Technical College are being trained to focus on the critical environmental problems that transcend national and regional borders, yet also have local relevance by recognizing the interconnections between land, air, water, and biodiversity, as well as the interdependence of human and ecological health.

The Libyan team has undertaken several case studies related to leaking solvent tanks of the Brega Marketing company, which entered the habitat soil of an endangered species of amphibian. In order to resolve or understand the extent of soil contamination and subsurface transport of solvent, a computer model is developed using knowledge of chemical & chemistry

sciences to characterize the molecular bonding of the solvent to the specific soil type. Libyan biologists help in studying the impacts upon soil arthropods, plants, and ultimately pond-dwelling organisms that are the food of the endangered amphibian. Another interesting study pertains to soil erosion. Using calculations of surface runoff by soil scientists and sediment transport estimates in overland flow by Fluvial geomorphologists, physicists contribute by assessing changes in light transmission in the receiving waters. Libyan Biologists also help analyze subsequent impacts to aquatic flora and fauna from increases in water turbidity. This is achieved through industry academy interaction in collaboration with numerous academic, industry, and research departments in Science and the Schools of Engineering, Management, Public Health, Public Policy, and Law. Due to limited face-to-face interaction among part-time faculty and students, education and training are increasingly being delivered through distance learning, which enables learners and instructors to be physically apart while maintaining communication in various ways. Thus, it is evolving as independent study, computer-based instruction, computer-assisted instruction, video courses, videoconferencing, web-based instruction, and online learning.

The rapid growth of online distance education, like elsewhere in the world, in Libya has prompted the need to revise delivery structures and rethink pedagogical practices that were once appropriate. As new technologies are emerging, they offer unique opportunities to foster interaction and collaboration among learners, thus creating a true learning community.

Pilot experience in Libya shows that coping with part-time faculty and part-time scholars requires distance education that relies on the creation of learning communities. Through technology, interaction and collaboration are now being achieved and become attainable in either asynchronous or synchronous learning networks. The emergence of social software, software that enables a group of individuals to collaborate via the Internet, is adding a new dimension to online learning. The versatility of social software and other collaboration tools supports constructivist environments that seek to motivate, cultivate, and meet the needs of both present and future learners.

Impact of Emerging Technologies

Libyan centers of learning are looking for chemical, environmental engineering jobs and internship opportunities for their members; promote interest in biological, environmental science & engineering within the community; seek to foster interaction among Environmental Engineering undergraduates, graduate students, and faculty, and sponsor speakers. Classroom Presenter, like a Tablet PC-based interaction system, helps support the sharing of digital ink on slides between instructors and students. Initial deployments show that using the technology can achieve a wide range of educational goals and foster a more participatory classroom environment. However, distance education tutors and researchers are concerned with issues like how much interactivity a distance course could provide for students, since interaction is considered a necessary ingredient for a successful learning experience. Authors find that new technology tools are helping to modify how learners gather data and collaborate. Emerging technologies provide opportunities for instructor-student as well as student-student real-time and/or time-delayed collaboration. User-friendly applications are an asset to business and educational settings alike. The first-generation Web tools include email, chat rooms, and discussion boards, among others.

Second-generation Web tools to take interactivity to the next level include Blogs (Weblogs), wikis, and podcasts (also called vlogs if they use video, or audio blogs if only audio

is used) can be implemented alone or in conjunction with applications such as Imeem™, Writeboard™, and InstaColl™ to create engaging learning environments (Augar, 2004).

Like elsewhere in Libya, instructors as well as students currently use blogs to boost the learning experience; some blogs are student-controlled while others are instructor-managed. The broadcasting of audio or video files over a podcast has a news aggregator installed; the news aggregator processes the RSS feeds and accesses the broadcasts. Audio blogging, or podcasting, is getting popular with the advent of the iPod™, using MP3 audio files. Podcasts using video are easy to create with a digital video camera. It is impacting the way distance educators deliver instruction as well as the manner in which students are engaged in learning. New models of teaching are now using RSS technology to deliver up-to-the-minute expert commentaries, for example, or to have students broadcast their analysis of topics studied. Distance educators are now integrating these resources into the virtual or face-to-face classroom. Libyans using the Education Network of Australia (Beldarrain, 2016) find that it helps keep an up-to-date listing of educational RSS feeds to help educators get connected. Some teachers do allow their students to suggest topics and then work in teams to research the topic, select information, write the script, and record their show.

The main benefit of using RSS feeds is that they allow the information to be "pushed" to the receiver, instead of the receiver having to seek the information. Pushing" information to the learner is found to be beneficial when the instructor wants to provide course updates, communicate group feedback, or introduce the discussion topic for the week. Wikis, like blogs, are either instructor-managed or student-managed. Wikis do promote collaboration among instructors, staff, and students. "Collaborative icebreaker" Deakin University's wiki not only helps to promote student interaction but also gives a chance to socialize and get acquainted. Teaching models that integrate technologies such as blogs or wikis do help in more learner control and thus are more effective at delivering instructional strategies that support knowledge construction. Open-source technologies such as Imeem™, InstaColl™, and Writeboard™ do help increase real-time collaboration between learners, especially in courses that are fully asynchronous (Teixeira and Lin, 2014).

In a nutshell, educators like those elsewhere in Libya are now beginning to realize the power of wikis, blogs, and podcasts, as well as emerging social software applications. It is found that it is the responsibility of instructional designers, administrators, and technology experts to investigate which tool offers the best solution for the task of providing interaction in synchronous and asynchronous online distance learning environments. Emerging technologies that have an impact on new models of teaching and new ways of learning require using flexible models that allow designers to begin at any given point in the process, anchoring the use of technology on collaborative instructional strategies that lead the student toward achieving the desired learning outcomes. Technology tools are found to have changed the roles of learners as well as instructors. It helps tap into a student's expertise and promotes collaboration through peer-to-peer mentoring, teamwork, and other strategies (Dziuban et al., 2015).

UNCSD RIO+20 Focal Point for Sustainable Development

UNCSD, Rio+20, like the past Rio Earth Summit and Johannesburg Conferences, did provide an opportunity for the international community, including Libya, to assess achievements and progress since 1992 together. It also gave a forum to highlight the unmet objectives and gaps that have hindered implementation of the decisions and recommendations of the two previous summits, with a view to making the improvements needed for the post-2012 global agenda in

respect of Libya & its special needs for rebuilding after an 8 month conflict followed by 3 year-long turmoil. This agenda acknowledges the legitimate expectations by incorporating economic, social, and environmental concerns, in order to better respond to the necessity for growth and progress that can ensure a decent standard of living for citizens in a context of multidimensional international crisis. Libya's input to the United Nations Conference on Sustainable Development, held in Rio de Janeiro from June 20-22, 2012 (Eck, 2011), is part of both Libya's national rebuilding efforts and the international community's global effort to promote support and enhance development that is respectful of the environment. It is the outcome of a non-exhaustive analysis of New Libya's socio-economic and environmental achievements as a result of the commitments made at the 1992 Rio Summit, Johannesburg Summit, and numerous subsequent events & conferences. It also reflects the concerns that free Libyan society emerging out of the recent crisis and faced with the formidable task of rebuilding the nation shares with its neighbor regional and international partners in the Mediterranean & Euro-Med region, Megreb Union, African Union, the League of Arab States and the Group of 77 and BRICS, which it shared once again in 2012.

Libya has initiated a revitalized national environment strategy (NES) and a national plan of action for the environment and sustainable development in the context of a participatory approach involving all stakeholders as national actors. The national environmental strategy aims to achieve sustainable & inclusive economic growth both during and after rebuilding by putting in place public policies to improve health and quality of life, conserve and increase the productivity of natural resources especially its Oil and Gas reserves, reduce economic losses and increase competitiveness and, lastly, protect the environment. It is committed to putting into practice through the rebuilding of Libyan laws on sustainable development.

A number of initiatives have also been created, including the First Libyan Environmental Engineering & Sciences Center (EESC), Libyan Business Council for Sustainable Development (LBCSD), Libyan 350 org, Libyan National Platform for Risk Reduction, Care Libya Brand Foundation (CLBF), Green Sky Initiative, Desert Prosperity Initiative, Sustainable Solid Waste Management Initiative. The national, regional rebuilding schemes and initiatives provide a policy framework for a wide range of environmental protection and regional rebuilding development after the Arab Spring, aimed at sustainable development.

The country is committed to implementing numerous initiatives to foster education and training on sustainable development. Authors as a focal point in Libya have set up a network of technical institutions committed to education and training on Eco-Efficiency and sustainable development in the country (Maatugh and Bindra, 2016). Technical Educational colleges are involved in this unique effort. The country is committed to launching an updated, fully-fledged technical educational program, including online resources for use in colleges. Over the years, colleges have become capacity-building experts, and the key audience is the young generation. Future Leaders Teams are being designed to train young executives on sustainability topics using innovative ways to improve the quality of the educational system. Training workshops are regularly held to educate companies on key business and sustainable development issues and to understand how these could impact their competitiveness. The Technical Colleges Directorate is collecting best practice examples, ranging from Eco-Efficiency to Corporate Social Responsibility (CSR) and inclusive business, illustrating how companies have drawn value from putting sustainability into practice. The CSR initiative of technical colleges is running a forum to demonstrate how Libyan companies need to pursue resource efficiency initiatives. CSR is included in the curriculum of students majoring in economic development.

New Initiatives and Strategy in Libya

The numerous new initiatives by a team of leading former and serving professors, professionals, NGOs, and experts in Libya, as outlined elsewhere by one of the authors, are based on principles that govern both ecological systems and control and diversify economic systems. It is based on Rio +20 Future. We want a framework that advocates and requires the need to use citizen power backed by intelligent management of the ecosystems and nature-based infrastructure. Libyan initiative is based on the logic that the low-carbon or no-carbon economy is not a burden on growth but rather a new engine for growth, employment, and the reduction of persistent frustration due to lack of stability, security, and weak governance. Through an educated citizen power system using emerging technologies for a better learning and teaching system, as illustrated in biology, civil & environmental engineering, it helps provide vital links between the economy, society, and environment (Anderson, 2016). The initiative takes into account the transformation of production processes, production and consumption patterns while contributing to a reduction per unit in reduced waste, pollution, and the use of resources, materials, and energy, waste, and pollution emission that will help revitalize and diversify economies, create decent employment opportunities, promote sustainable trade, reduce poverty, and improve equity and income distribution.

The Libyan strategy includes a project to use Proactive implementation of emerging technologies in the teaching and learning process by use of information and communications technologies to reform the science & technical education and research system, which has the potential to become a model for the proper integration of emerging technologies in education and science.

Libyan UNCSD Rio+20 Focal point, as described elsewhere, is leading the country in developing system-level improvement, institutional level improvement, and individual level improvement based on key principles for GEF-UNDP supported National Capacity Self-Assessment. The current initiative and strategy on enhanced use of emerging technologies in teaching and learning process by use of information and communications technologies in biology, environment, and chemistry sciences education aims at ensuring, at relatively short notice, access to and progressive ownership by the Libyans of the required technical, functional, and instrumental capacities. At the international level, Libya intends to acquire assistance not only in transferring, adapting, adopting, absorbing, and embracing advanced technology and governance practices but also access to the most up-to-date and unbiased scientific data and information to confront challenges of the future. The objective is to help the country to play an effective and leading role in promoting international cooperation with organizations of the UN System, among others UNESCO, UNIDO, United Nations Support Mission in Libya (UNSMIL), United Nations Development (UNDP), International Civil Aviation Organization (ICAO), United Nations Environment Programme (UNEP), United Nations Educational, Food and Agriculture Organization (FAO), as well as, regional counterparts (EU Erasmus Plus, Mediterranean, Euro-Med, Megreb Union, Arab, Sahel and other African) and also other multi- and bilateral funding or assistance providing sources.

Based on the case study of Libya in Africa, we find that the challenges faced by Libya present numerous opportunities, especially in the fields of chemical, biological, environmental science & engineering education research, and innovation. To take advantage of these opportunities and contribute to solving these challenges, Libya, like other African countries, must initiate systemic reforms to improve the quality of education at all levels and professionalize their education systems in order to educate and train youth, in particular, in the

fields of science, technology, and engineering. For Libya, like elsewhere in Africa, to achieve the goal of economic transformation, it will be imperative for countries to invest strategically in the education and training of youth. To make this happen, African synergy should be activated to promote enhanced regional integration on the one hand, and to advance science and technology in Africa on the other. To help realize its full potential, Libya, like elsewhere in the African continent, must develop partnerships, networking of researchers and students, and the establishment of collaboration with other, more established, schools on other continents, such as cooperation with the prestigious Conference des grandes écoles44 (CGE). It also noted that while seven establishments are African, only one is based in sub-Saharan Africa: The International Institute of Water and Environmental Engineering (2iE) in Ouagadougou, Burkina Faso (Mazoyer, 2021). What is required is a formula for change as shown below (Doppelt and McDonough, 2017). This requires Libya to join #OneWorldOneAcademicLibrary Vs. #OneAfricaOneAcademicLibrary for Global Success.

Formula For Leading Change Effectively

Vision + Skills + Incentives + Resources + Action Plan = **CHANGE**
-------- + Skills + Incentives + Resources + Action Plan = **CONFUSION**
Vision + ------- + Incentives + Resources + Action Plan = **ANXIETY**
Vision + Skills + ---------- + Resources + Action Plan = **RESISTANCE**
Vision + Skills + Incentives + ---------- + Action Plan = **FRUSTRATION**
Vision + Skills + Incentives + Resources + ---------- = **CHAOS**

Libya is calling on everyone to connect, #OneAfricaOneAcademicLibrary Vs #AfricanLibrariesCongress for #OneAfricaOneEducation for the same quality learning resources access that no one is left behind.

Discussion of Stakeholders Survey Results

Based on pilot-scale surveys, stakeholder workshops, interviews, and consultative meetings, it was found that biology, environmental, and chemistry science education in Libya requires not only the incorporation of emerging technologies in teaching and learning but also a fundamental reform of the curriculum. This reform is necessary to respond to the broader challenge of rebuilding post-conflict Libya. Preliminary findings revealed that students' attitudes, interests, and preferences toward these science subjects significantly influence their academic progress and learning outcomes. Libyan students are particularly shaped by the quality and style of curriculum delivery, the relevance of course content, and the availability of suitable educational resources. Additionally, student achievement is influenced by expectations and support from significant individuals in their lives, access to educational opportunities both inside and outside formal institutions, and their perceived sense of personal success and self-efficacy. Younger students expressed a generally positive attitude towards science, with over 60% indicating an interest in continuing science studies into adulthood. Nearly a quarter believed they could become scientists in the future. When asked to self-evaluate their scientific ability, 35% of first-year university students rated themselves in the top category, compared to only 16% of final-year students.

Employers participating in the study uniformly reported challenges in recruiting adequately qualified personnel for entry-level positions. Significant resources are being allocated to provide new hires with basic knowledge, highlighting a gap in the preparedness of

graduates. These organizations emphasized the need for an integrated, technology-driven curriculum in biology, environmental management, and chemistry at the tertiary level. In particular, the introduction of a diploma program in environmental science and engineering was seen as a promising strategy to improve the overall quality of future applicants.

Another major insight from stakeholder feedback was the importance of fostering student–student interaction as a cornerstone of effective learning. Respondents noted that emerging technologies could facilitate such interaction by enabling synchronous and asynchronous collaboration. For instance, social software platforms like *Imeem*™ offer not only instant messaging functions but also additional features that promote real-time and delayed interaction, depending on the learner's schedule and convenience. These platforms allow learners greater control over their learning experiences without the limitations of time and place. Stakeholders expressed strong support for the implementation of advanced information technology systems, alongside the development of the digital competencies needed to operate effectively in an information-rich, technologically mediated environment.

Experts from UNESCO, UNDP, UNIDO, and UNEP collectively emphasized the need to develop a new framework approach for education and training in Libya. This framework should include clearly defined outcomes, outputs, baselines, targets, performance indicators, and specific activities. Such a model would support the design and implementation of formal training programs using emerging educational technologies, particularly in the areas of quality, health, safety, and environment (QHSE). The overarching aim is to upgrade biology, environmental, and chemistry science education and training so that graduates acquire the competencies required to perform increasingly complex roles with greater accountability and responsibility. This approach aligns with Libya's national strategy for sustainable development and labor market competitiveness.

To further explore health, safety, and environment (HSE) education priorities, the study employed a multi-method research approach involving empirical investigation, semi-structured interviews, questionnaires, and case studies. The analysis identified 92 HSE indicators relevant to the fields of biology, chemistry, and environmental science. Of these, 32 indicators fell within the 0–49% response range based on modal distribution, while the remaining 60 indicators fell within the 50–100% response range. The latter group, having received higher response rates, was selected for further evaluation due to its perceived importance and applicability in HSE management practices.

Each of the 60 selected indicators was assessed using a three-point ordinal scale based on perceived importance: 1 (Critical), 2 (Important), and 3 (Minor Importance). Critical indicators were defined as essential for effective HSE performance, such that their absence could potentially lead to system failure. Important indicators, though not indispensable, were viewed as significantly enhancing operational efficiency and HSE performance. Minor importance indicators were considered supplementary and had minimal direct impact on HSE outcomes.

To quantify the degree of consensus among respondents, the Variation Ratio (VR) was calculated. This measure, defined as the proportion of responses that do not fall into the modal category, provides insight into the distribution and agreement of opinions. VR is calculated using the formula $VR = 1 – (f_{mode} / N)$, where f_{mode} represents the frequency of the modal category and N is the total number of responses. A VR of 0 indicates complete agreement,

while values of 0.5 or less suggest majority consensus. Values exceeding 0.5 imply a lack of consensus.

In addition to the VR, the Index of Diversity (ID) was used to evaluate response dispersion. This index measures how widely opinions are distributed across categories and is calculated using the formula $ID = 1 - \Sigma(P\_k^2)$, where P_k is the proportion of responses in category k. For example, if 84% of respondents rated a particular indicator as critical, 9% as important, and 7% as minor, the ID would be calculated as $1 - [(0.84)^2 + (0.09)^2 + (0.07)^2] = 0.28$. This index places greater emphasis on larger proportions by squaring them, providing a useful measure of response concentration. A low index indicates strong agreement among respondents, while a high index suggests a broader distribution of opinions. An index close to 0 suggests near unanimity; an index near 0.05 indicates clustering around two categories; and an index approaching 0.06 implies a nearly uniform distribution across all three categories, reflecting substantial disagreement.

In summary, the measurement of HSE performance indicators using both the Variation Ratio and the Index of Diversity offers a robust and context-sensitive method for identifying critical educational and operational needs within Libyan organizations. These metrics support evidence-based decision-making for curriculum reform, workforce training, and sustainable development in the fields of environmental science, chemistry, and biology.

Conclusion

Education and training in chemical, biological, environmental sciences, and engineering in Libya are undergoing a period of radical transformation, guided by the UNCSD Rio+20 Future We Want framework and the UN Post-2015 Sustainable Development Goals (SDGs). This transformation is essential for rebuilding a clean and green Libya and requires the development of a highly skilled workforce capable of addressing complex issues related to reconstruction, including certification, regulation, security, master planning, protocol development, and corporate responsibility. Appraisals of the current situation, along with needs assessment surveys conducted among industry stakeholders and government officials, clearly highlight the urgent need for an improved curriculum and the integration of emerging technologies in both teaching and learning, particularly in the fields of biology, environmental science, and green chemistry.

This educational reform must focus on building specialized competencies through blended learning models that align with the guidelines of the Libyan UNCSD Rio+20 national report, and adopt best practices from UNESCO, UNIDO, and UNEP. The proposed framework approach incorporates outcomes, outputs, baselines, targets, performance indicators, and actionable activities to design comprehensive education and training programs. These programs are to be implemented across various disciplines—chemical, biological, environmental protection science, and engineering—with a focus on leveraging emerging technologies to promote sustainable livelihoods. The overarching objective is the development of a Rebuilding Management Qualification at the higher education level.

The findings presented in this paper demonstrate that rebuilding and rehabilitation management should be conceptualized as an integrated process wherein the manager effectively plans, prepares, and delivers a quality product safely and efficiently. This process should encompass the regulation, evaluation, definition, acquisition, allocation, direction, and

control of critical resources—such as time, finances, personnel, services, and materials—to achieve defined objectives. Survey results support the introduction of a rebuilding and rehabilitation management qualification that encompasses a broad spectrum of knowledge in chemical, biological, and environmental sciences, engineering, and green chemistry. Such a qualification would equip professionals to lead and manage reconstruction efforts across various phases, including research, planning, design, implementation, and evaluation, in both local and international contexts.

To be effective, professionals in this field must possess a historical understanding of the rebuilding and rehabilitation industry, regulatory literacy, interdisciplinary knowledge, and a high level of professional competency grounded in practical experience. Given the scale, scope, and complexity of the transformation underway in Libyan education and workforce development, it is anticipated that the introduction of new blended learning programs will provide the necessary support to address critical workforce shortages and prepare graduates for the multidimensional demands of this evolving profession.

Finally, in order to unlock the full potential of this transformation, Libya—like many other nations across the African continent—must foster strategic partnerships, strengthen researcher and student networks, and collaborate with well-established institutions abroad. This includes cooperation with elite academic bodies such as the Conférence des Grandes Écoles (CGE), which can provide valuable models of excellence and opportunities for cross-continental collaboration.

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