

PROMOTING STATISTICS IN THE ERA OF DATA SCIENCE AND DATA-DRIVEN INNOVATIONS

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ABSTRACT

This paper aims at highlighting initiatives in developing future statisticians directed at high-school and university levels in Niger. More specifically, it focuses on collaborations, partnerships, outreach initiatives and supporting mechanisms, which may contribute to increase engagement and interest in and attraction to the field of statistics in the era of data science and data-driven innovations. Providing sufficient exposure to modern statistical analysis, computational and graphical tools, written and oral communication skills, and the ever-growing interdisciplinary use of statistics are key activities for building future generations of statisticians. Furthermore, current curricula as well as pedagogical approaches, teaching materials, and assessment methods need to be re-thought in order to meet the requirements of the skills needed in the 21st century ensuring effective interaction with scientists, public institutions, industry, civil society, and policy makers.

Keywords: *Statistics education research; Statistical literacy; Data science; Data-driven innovation*

1. INTRODUCTION

All countries, irrespective of their level of development, need effective and reliable systems for collecting and processing data and information in all areas of activities. These systems are needed at the level of a country as well as locally at smaller scales. In addition, any social, economic or political project depends on predictions and estimates of risks. Collecting data, knowing how to extract information from it, predicting and estimating, these are the characteristics of statistics that are essentially interdisciplinary.

Furthermore, statistics represents a challenge for teachers as well as learners because it involves many conceptual and mathematical concepts. For example, some authors raised the fact that students are more engaged with applied statistics subjects when a variety of activities are used in the different instructional methods (Biggs, 2003; Biggs & Tang, 2011; Kember & McNaught, 2007).

Initiatives in developing statistics in Africa include the STAFVAV (Statistique en Afrique Francophone et Applications au Vivant) program. This 10-year programme was initiated in 2004 and aims at developing applied statistics (M.Sc. and PhD) in Sub-Saharan Francophone Africa, particularly in areas related to living organisms and epidemiology. As highlighted by Bardet (2009), it is crucial to have African academics and researchers well trained in mathematical statistics and able to approach applications. Bardet also raised the fact that in the same period there was not one university in Sub-Saharan Francophone Africa with more than 3 persons with PhD in statistics in its ranks (generally less than 3), all of whom have obtained their PhD outside Africa (France, Canada, the former USSR, etc.).

Moreover, public universities in Niger are facing additional challenges including generating data for basic research, integration of the Information and Communication Technologies (ICT), data-driven policy making, or supporting public decisions in a context of “massification”, lack of infrastructure, improving internet connectivity, traditional separation between academia and the professional world, increasing demand for statisticians and data scientists as well as the inadequate curriculum missing the 21st-century competencies. Although mobile technology and the Internet are offering new learning resources and opportunities worldwide (e.g., Wikipedia, massive open online courses, jobs, scholarships, grants, internships, citizen science and data crowd-sourcing projects, statistical tools and apps, Google search engine for open data, etc.), a minimum of ICT readiness (computer-related activities to measure ICT skills in the context of Target 4.4 of the Sustainable Development Goal 4) is important for harnessing the potential of these online resources and their opportunities. Unfortunately, many students (up to PhD level) miss the minimum requirements for succeeding in the future knowledge-based economy.

Finally, despite the aforementioned characteristics of statistics, it seems that data-science programmes are currently being set up, in many universities worldwide, with no or negligible statistics (discussion at the 9th Australian Conference on Teaching Statistics, OZCOTS 2016); some analysts distinguish between “statistical literacy” and “data literacy” claiming that “data scientists are not statisticians” (ISI President’s Message, October 2017).

This paper highlights initiatives in developing future statisticians directed at high-school and university levels in Niger. Particularly, it is the intent to suggest that Abdou Moumouni University (AMU) is one example of approaches that universities can take. Historically, the Department of Mathematics and Computer Science (DMCS) was associated to the majority of AMU’s initiatives related to statistics (from the creation of curricula to the management of programmes); with recent opportunities and challenges in the field of data science and data-driven innovations, the DMCS becomes the key implementer of AMU’s initiatives related to statistical education, research, and digital innovation.

The elaborations are organised as follows: The first chapter explores capacity building for students, with a focus on teaching statistics through collaboration between departments, linking ICT to statistics and the use of statistical software. The second chapter, which analyses collaboration partners and activities, is followed by concluding remarks.

2. CAPACITY BUILDING FOR STUDENTS

Convincing students that statistics is important and applicable to their daily life (and is not just comprised of the normal distribution and t-tests) may be seen as one of the biggest challenges that teachers of introductory statistics courses could face. It is important that students see the usefulness of statistics in understanding evidence, and engaging them with data about important social phenomena to support their development as active citizens. Moreover, the changes in the era of data science and data-driven innovations require adaptation of university programmes (at all levels) by taking into account local specificities and cultures. It is essential to compare a given training or capacity-building programme with similar initiatives worldwide. This approach will help identifying what is different in a particular context, what works in this context and what does not work, which may successfully be implemented elsewhere, what are the supporting mechanisms? It is important to mention that in the majority of cases, tackling real problems requires interdisciplinary collaboration and combinations of skills.

In 2017, Abdou Moumouni University registered 20,386 students (see Table 1); depending on faculties, 3 to 5 Bachelor-level and 1 to 3 Master-level courses in statistics are offered per year. The faculties and schools are: Agronomy, Sciences and Technics, Letters and Human Sciences, Health Sciences, Law and Political Sciences, Economics and Management Sciences; and Ecole Normale Supérieure. For Phd level, one common capacity-building course in statistics is offered (in the first year). There are three PhD schools, which are respectively dedicated to “Social Sciences”, “Life and Earth Sciences”, and “Technical Sciences”.

Table 1. Repartition of Abdou Moumouni University (AMU) students in 2017

| Faculties and Schools | Nr of students | % |
|--------------------------------------|----------------|-------|
| Agronomy | 752 | 3.52 |
| Letters and Human Sciences | 7618 | 35.62 |
| Sciences and Technics | 3663 | 17.13 |
| Health Sciences | 3507 | 16.40 |
| Economics and Management Sciences | 1319 | 6.17 |
| Law and Political Sciences | 2344 | 10.96 |
| Ecole Normale Supérieure | 973 | 4.55 |
| PhD School “Social Sciences” | 79 | 0.37 |
| PhD School “Life and Earth Sciences” | 82 | 0.38 |
| PhD School “Technical Sciences” | 49 | 0.23 |

Source: AMU’s student guide – 2017 edition

The evolution of AMU students from 2000 to 2017 is highlighted in Figure 1. In 17 years, the student population has increased by 51% with an average growth rate of 3% every year. This growth rate is contributing to the phenomenon of “massification” (increasing number of students and relative stagnation of the number of human resources and infrastructure).

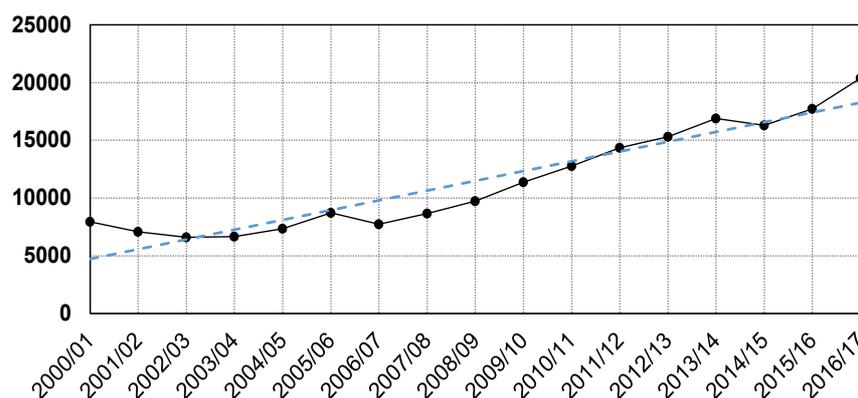


Figure 1. Evolution of AMU’s students from 2000 to 2017

Source: AMU’s student guide 2017

2.1 TEACHING STATISTICS FOR BACHELOR STUDENTS

Collaboration between departments The Department of Mathematics and Computer Science (DMCS), located within the Faculty of Sciences and Technics, regularly collaborates with other university departments for delivering courses in statistics. For example, around 40 to 50 bachelor students in mathematics and computer science take a 40-hour course (descriptive and inferential statistics) during the second year of their 3-year curriculum.

Professional training (statistical process control, multivariate statistical process control and quality-control tools, geo-statistics) is also delivered for students of the departments of Biology, Chemistry, and Geology who are enrolled respectively in the professional training of staff in the agro alimentary, mining, and petroleum industries. It is also important to mention that teachers from the DMCS regularly teach introductory statistics courses for health sciences and for economics and management sciences. Calculus and probability theory are only required for introductory statistics courses for bachelor students specialising in mathematics and computer science.

The programme outcomes include 3 to 5 admissions (per year) to the prestigious and highly competitive regional specialised high schools of statistics, applied economics and demography, namely ENSEA of Abidjan (Ivory Coast), DSD-ENEAA of Dakar (Senegal), and ISSEA of Yaoundé (Cameroon). Moreover, around 500 students from AMU registered for the International Statistical Literacy Poster Competition 2018-19. This competition was a real capacity-building experience for these students who worked in teams (2 to 5 students) and investigated questions using real data, conducted smartphone and paper-based data collection, used their mathematical and graphical skills, interpreted statistical results, and developed their communication skills. They also discovered JMP from SAS student edition software. For example, the ISLP statistical literacy poster competition fostered collaboration between four students (males) from the DMCS and one student (female) from the Department of Geography.

Linking ICT to statistics A common ICT course is provided since 2014 to all bachelor students of the Faculty of Sciences and Technics (with backgrounds in Mathematics, Computer Science, Geology, Biology, Chemistry, Biochemistry, Physics, Electronics, Electrical Engineering, and Automatism). It aims at improving students ICT skills for meeting the job market requirements. More specifically, this course aims at introducing students to terminologies, concepts and tools related to the latest advances in the field of ICT. As such, the educational and professional aspects are addressed for a better competitiveness of the learners.

The teaching mode is hybrid: face-to-face and e-learning. Around 330 to 500 bachelor students take this course per year and it integrates some statistical concepts, real-time data collection and analysis, data-analytics tools, and auto-graded quick multiple choice quizzes (Figure 2). These quizzes (from Google Forms) represent collaborative data-innovation tools, which provide global and individual instant feedback on students' performance. Using Google's machine-learning algorithms, Forms can predict the correct answer as a teacher types the question, as well as provide options for wrong answers; facts that contribute to saving time. Quizzes help achieve the course objectives by assessing a variety of learning outcomes relating to all of the competencies in Bloom's taxonomy and by offering to students and teachers the latest features of Google Suite for Education and related cloud-based services, tools, and apps.

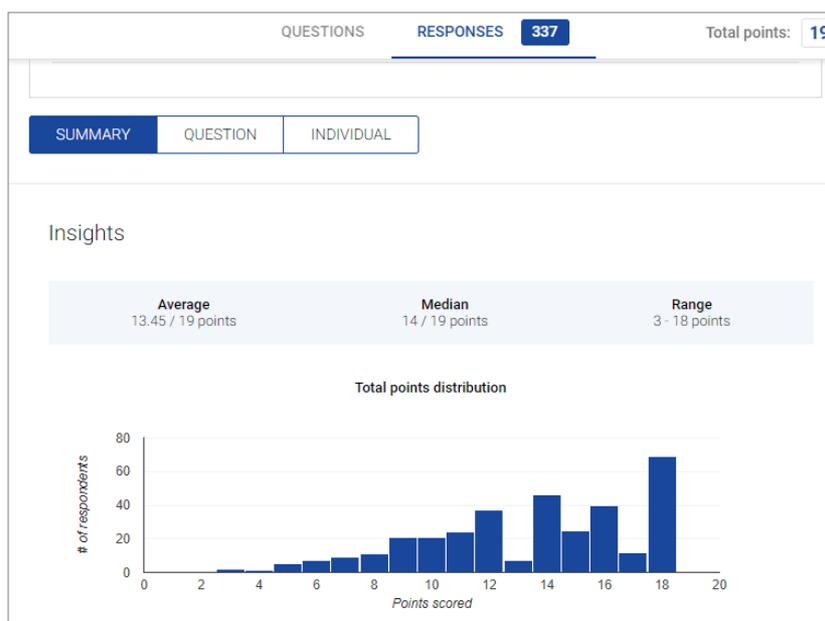


Figure 2. Google-Forms based auto-graded quiz with corresponding statistics and insights administrated for 337 bachelor students in 2017

The quiz in Figure 2 was administered as homework after the ICT course (semester 3) for 337 bachelor students of the Faculty of Sciences and Technics. The quiz tested the students' awareness about the United Nations Sustainable Development Goals (SDGs) as well as the World Health Organization guidelines for ambient (outdoor) air quality. This experience has shown that a carefully designed formative assessment with instant feedback may enhance students' self-efficacy and interest in the course. The data collected from this quiz as well as parameters from the distribution of scores attained will be used during the introductory statistics course in semester 4 as example of real data, descriptive statistics, and foundation for the whole process of inference. More details can be found in Sidi Zakari (2018a) and on the course website (TIC, n.d.). The ICT course is certainly contributing to teaching the next generation of statistics students to "think with data" through sufficient exposure to modern statistical analysis, computational and graphical tools, and communication skills as highlighted by Horton & Hardin (2015).

Furthermore, capacity-building activities are regularly organised by the AMU students associations and clubs during their scientific and cultural weeks. For example, in November 2018, a workshop on Citizen Science, Open Data and SDGs was organised by the student association for 60 undergraduate students (51 males and 9 females) who discovered the current legislation in terms of access and use of public information (at national and regional levels). Additional details on capacity-building activities, such as using mobile phones for tracking air pollution, can be found in Sidi Zakari (2018b).

2.2 CAPACITY BUILDING FOR MASTER STUDENTS

Collaboration between departments The Department of Mathematics and Computer Science delivers courses in mathematical statistics, design of questionnaires, data collection and analysis, and data mining for master students who are specialising in statistics (an average of 3 to 5 students enrol to these courses each year). Students from other departments (particularly chemistry and biology) also benefit from professional courses in biostatistics, chemometrics, and statistical monitoring of industrial processes (15 to 20 students enrol to these professional courses yearly). These professional courses are based on specialised documents and training materials published by international organisations like the Food and Agriculture Organization of the United Nations, private companies, and engineering schools.

Using statistical software Although the main statistical software used during previous master's courses has been R; in 2018, other software packages like R-Instat (free and open-source), JMP from SAS student edition, Tableau, and Open Data Kit (ODK) have been integrated into the curriculum.

It is important to mention that it may be too costly to buy large software packages (SPSS, SAS, etc.) for students; therefore, JMP student edition or R is used. As R is very complex and less user-friendly, the African Data Initiative project, which aims to support improved statistics and data literacy across Africa, has developed R-Instat to simplify the application of R. R in its original form would not be suitable for students that use statistics but study other disciplines than mathematics. R-Instat, however, also supports greatly the use of software for mathematics students who want to specialise in statistics.

As free and open-source software, ODK is suitable for collecting, managing, and using data in resource-constrained environments; since it allows the collection of data (via mobile devices running on Android or cross-platform operating systems) offline and submission of data, when internet connectivity is available.

Pedagogical digital resources including videos and discussion forums are provided, so that the students have the ability to choose software to use in their courses and projects. For example, some students experienced Excel's statistical functions on interactive whiteboard. An illustrative Youtube video (in French) entitled "*Ressources numériques pédagogiques et apprentissage de la statistique*" won the first prize of Agence Universitaire de la Francophonie

(Bureau Régional Afrique de l’Ouest) competition in 2018 on innovation in pedagogy entitled “Mon innovation en 120 secondes”.

Using statistical software (web-based or not) is a key element for transforming graduate as well as undergraduate education based on a traditional statistics curriculum with mathematical and probabilistic foundations. It is that students are – more than in the Western World – interested in *practical* applications rather than in a theoretically sound education (though this is an emerging trend also in Western countries).

2.3 CAPACITY BUILDING FOR PHD STUDENTS

Capacity building in statistics was conducted in 2015 for PhD students during a two-day workshop entitled “Data collection and statistical analysis methods” with around 50 participants with diverse backgrounds in humanities, life and earth sciences, and technical sciences. This course coordinated by the directors of the PhD schools was implemented jointly by the DMCS and the Department of Geography. It is supposed to be held each year and it targets new PhD students and the ideal situation is to teach this course quarterly. The small number of specialised teachers in statistics prevents it from teaching it more often. More details about this training can be found on the dedicated website (TIC, n.d.).

Other specific training courses are also delivered to these students. For example, PhD students working on air-pollution data receive a training based on the Open Air Project (Environmental Research Group, n.d.) with its statistical modelling tools like quantile regression as well as new digital data sources. These experiences inspired the conception of the video entitled “*Harnessing the data revolution for reducing the impact of air pollution in Niger*”. This video is available on Youtube and was submitted to the Africa’s Champions of Science-Africa Storytelling Challenge (organised in 2018 by Johnson and Johnson Innovation).

PhD and MSc students are also encouraged to participate in regional or international schools of statistics and data science like the first Data-Science School entitled “From data to value and knowledge” organised by the Institute of Mathematics and Physics (in Benin; in December 2018). The School topics were: Big-Data science (intro and internet of things applications), Data engineering with NoSQL, Data processing with Spark, Data analytics and Machine learning, Data visualisation, Deep learning with Tensorflow, Case studies and New trends.

3. COLLABORATION PARTNERS AND ACTIVITIES

Data represent a new commodity and are a key economic ingredient like oil was about a century ago. In this era of data revolution, this commodity should be “refined” to be useful and valuable. Advances in data science and business analytics, as the two main areas of statistical tools for (big) data analysis, are important for increased value added by data. Particularly, in the context of “data philanthropy”, there is a growing movement whereby private companies across a variety of industries share their data to advance the public good.

Data science is considered as the practice of using automated methods to analyse massive amounts of data and to extract knowledge from them while business analytics is the practice of transforming data into (business) insights to allow for better decision-making. Big data poses big challenges for the universities worldwide as they require a set of specific competencies that were partly lacking from traditional degrees in statistics and related areas. Scientific research is also challenged as big data has a set of features related to their size, structure, and scope that make traditional statistical and econometric methods unsuited; another challenge arises from innovative methods directly imported from computer science, which are originally meant for structured independent and identically distributed data.

The national statistical offices and institutes are also facing challenges related to big data (as an alternative source of data for production of official statistics): How to collect, process, and disseminate data after the (on-going) data revolution? How to compete (or cooperate) with

private “data refineries”? How to educate data users in a context of new digital-data sources and new demands for more detailed, more accurate and timelier official statistics? How to increase data accessibility and yet maintaining privacy and confidentiality?

Furthermore, the DMCS submitted a proposal for the 2018 Collaborative Data Innovations for the Sustainable Development’s call organised by The World Bank in collaboration with the Global Partnership for Sustainable Development Data. This call aims to encourage collaboration, experimentation, and learning in the field of sustainable development data by supporting projects that result in data or methods, which allow data to be produced faster; in a more cost-effective manner; at a higher resolution or granularity; or address data gaps. The submitted proposal was entitled “*Leveraging crowd-sourcing and citizen science for bridging data gaps on information and communication technologies’ skills in public universities of Niger*” and focused on two areas, namely “Scaling local data for impact” and “Fostering synergies between communities of non-official data and official statistics”.

This proposal made use of the following types of data: Administrative data, geospatial data, metadata, official statistics, Open data, photo or video data, private sector data, qualitative data, survey data, unstructured data, Web or social-media data, and paradata (e.g., geographic location of the respondents, the used devices, browsers and platforms; level of vocabulary in a text). The collaborating organisations and project end users are: Ministry of Higher Education, Research and Innovation, Consortium of the 8 public universities of Niger, National Institute of Statistics, National Agency for the Promotion of Employment, Niger Emploi website (private), National Agency for the Information Society, Nigeriens Students Union (represented by the delegation of AMU) and National Coordination of The International Statistical Literacy Project. More information about some of these collaborators is given in the next section.

3.1 COLLABORATION WITH PUBLIC INSTITUTIONS

Ministry of Higher Education, Research, and Innovation This ministry regularly collaborates with public universities in Niger in order to improve official statistics. Specific projects create regular interactions between the Division of Statistics and Computer Science of this ministry, and the Department of Mathematics and Computer Science of Abdou Moumouni University. Internship opportunities into national civic service are currently proposed to students in statistics.

National Institute of Statistics The Abdou Moumouni University regularly collaborates with the National Institute of Statistics (INS-Niger, n.d.) on many activities including empirical studies (INS-Niger, 2014, 2015, 2016), workshops, “Cafés Statistiques”, African Day of Statistics, International Open Data Day, students competitions, internships, etc. The INS-Niger is the primary custodian and driver of national Open Data agendas and policy implementations.

Currently one of the flagship collaborative projects is the creation of the National High School of Statistics (NHSS), which will enrol 15 students each 2 years (pilot phase for the 2018-21 period). The number of students from this school will certainly increase due to a strong demand for statisticians at all levels; but it is important to mention a potential gender inequality, as the current cohort of students includes only 2 female students. This flagship project is part of the second National Strategy for the Development of Statistics (NSDS 2017-21). The NHSS will offer 2-year degree in Engineering of Statistical Practices based on the curriculum of ENSEA of Abidjan (Ivory Coast) which will also prepare and accompany the membership of the NHSS to the Network of African Schools of Statistics.

In fact, the statistical structures of the National Statistical System (NSS), existing central and regional, and those planned at the departmental and communal level for the management of statistics related to decentralisation, must produce reliable and up-to-date statistics, useful for the implementation, monitoring and evaluation of national and international development strategies, policies and programmes. However, they lack qualified and sufficient human resources. Despite the efforts made by the INS-Niger in terms of training actions, from 2005 to

the present day, the satisfaction rate has not reached 20% and this situation of inadequate human resources remains more and more persistent given the solicitation of the NSS. The NSS human resource management diagnostic, developed as part of the NSDS 2017-2021, has recently confirmed this.

Furthermore, collaboration between national statistics offices and universities has been identified among means for acquiring skilled statisticians and supporting data-science-driven work (Conference of European Statisticians, 2017). The Department of Mathematics and Computer Science in partnership with the Department of Economics and Management (Abdou Moumouni University) and INS-Niger is planning to set up local 2-years full-time professional Master degrees in Data Science and Business Analytics, which will integrate mathematics and statistics, programming and data base, domain knowledge and soft skills, and communication and visualisation; all of which are identified as competencies and skills for future statisticians (Conference of European Statisticians, 2017).

National Agency for the Information Society Abdou Moumouni University also collaborates with the National Agency for the Information Society (ANSI, n.d.) on ICT for development activities, the development of the university website, and also on national legislation related to personal-data privacy and security. Universities play a central role in the Niger 2.0 national strategy or the smart-cities and smart-villages initiatives. As advocated by Manyika et al. (2011), it is important to address policies related to privacy, security, intellectual property, and liability in a big-data world.

3.2 PARTNERSHIPS

Partnerships with the private sector The promotion of statistics is also conducted through partnerships with the private sector; this includes joint work with enterprises such as Tech-innov (n.d.), an international awards-winning enterprise working in the field of big data for smart irrigation and climate-smart agriculture in Niger. We are planning future activities for integrating sensor-based data collection and analysis via mobile meteorological stations or unmanned aerial vehicles. As advocated by Kyng, Bilgin, and Puang-Ngern (2016), big data, data science and computer science are important for statistics education.

Collaboration with civil society Collaboration with civil society is managed through participation in regional or national conferences and events for promoting Open Data. For example the *Conférence Afrique Francophone sur les Données Ouvertes* (MDENP, 2017) is a key conference for discussing open-data issues in the framework of the *Global Open Data Index* and the *Open Data Barometer*. Civil Society's participation in this effort is very important for ensuring the accountability of governments as well as setting up innovative approaches to develop love for statistics in students and society at large (citizens). International events, such as the Open Data Day and Open Science week represent great opportunities of collaboration with civil society.

The Africa Data Revolution Report 2018 found that “In some governments there is a slow iterative cycle between innovation, adoption, resistance, and re-alignment before finally resulting in Open Government Data (OGD) institutionalisation and eventual maturity. There is huge diversity between African governments and each country presents a complex and unique picture”.

Other outreach activities The Department of Mathematics and Computer Science regularly conducts outreach activities within the university as well as in high schools. These activities include participation in several competitions, such as the International Statistical Literacy Poster Competition (ISLP, n.d.), the ReSAKSS Data Challenge (ReSAKKS, n.d.), the Inspire Challenge of CGIAR (n.d.), or the Data for Climate Action Challenge run by the United Nations (UN, n.d.) and which aims to “demonstrate the transformative power of data-driven innovation,

mobilising business leaders and the data science community to generate new approaches to climate action and sustainable development”.

Mobile-devices-based data crowd-sourcing and citizen-science activities are also regularly conducted for raising awareness of the *UN Sustainable Development Goals Agenda 2030*. More details on these activities can be found in Sidi Zakari (2018b). Other initiatives include the participation in the *African Data Initiative* (through capacity building on R-Instat software), in the *International Statistical Literacy Project*, in the *Next Einstein Forum*, and in outreach activities of the *Global Young Academy*. Finally, it is also important to motivate students to participate in international events and conferences such as the OpenCon2018 of the OpenCon Community (n.d.), which aims to “Empowering the Next Generation to Advance Open Access, Open Education and Open Data”.

4. CONCLUDING REMARKS

This paper highlighted some challenges and opportunities related to initiatives in developing future generations of statisticians in the era of data science and data-driven innovations.

In the particular context of public universities in Niger (as a Francophone Sub-Saharan country) the lack of qualified academics and researchers in applied statistics and data science combined with technological challenges impact negatively the number of Bachelor, Master or PhD holders in statistics or related areas as well as the quality of the training. Moreover, although students seem to be more interested in practical applications rather than in a theoretically sound education, the traditional separation between academia and the professional world reduce their chance to enter a highly competitive job market. An illustration is the case of National Statistical Offices (NSOs), which are among the largest employers of statisticians and economists; but in general, universities do not prepare students well to work at NSOs.

The majority of initiatives highlighted in this paper cover a recent period from 2014 to 2019 and there is currently not any accompanying research in the cost-effectiveness of the various initiatives. Nevertheless, the increasing yearly admissions of Bachelor students from the Department of Mathematics and Computer Science (3 to 5 students per cohort of 40 to 50 students) in regional high schools of statistics, yearly regional awards related to innovation in pedagogy, a recent \$ 4000 small grant from *Conférence Afrique Francophone sur les Données Ouvertes* or participation of 500 students from lower and upper secondary schools and universities in the International Statistical Literacy Poster Competition 2018-2019 as well as all fostered synergies between communities of non-official data and official statistics represent some success stories as compared to other programmes that do not integrate all these activities.

The supporting mechanisms behind these success stories include the use of up-to-date curricula (in French and English languages), collaboration between departments, team work, student-teacher dialogue, integration of Information and Communication Technologies, the use of statistical software and mobile data collection tools, public and private partnerships, and regional and international collaboration; but continuous monitoring and updating is needed.

More specifically, the impact of the many competitions that students are encouraged to participate (particularly female students) includes the fact that students see the usefulness of statistics in understanding evidence, and engaging them with data about important social phenomena will support their development as active and empowered citizens. Moreover, it is building a corporate identity for the students, boosts their skills, increases their job prospects, and increases the number of students enrolling in mathematics and computer science or specialising in statistics.

Another important point is the urgent need of the creation of a local interdisciplinary working group on Data Science which will include academics, researchers, graduate students (PhD and M.Sc.), data analysts, and practitioners. This working group is necessary for overcoming challenges as well as harnessing the potential of big data for universities and NSOs, since data science combines several disciplines, including data engineering, advanced statistics

and probability, and software programming to derive knowledge and insight from structured and unstructured data. Comments from leading industry data scientists at the UN World Data Forum 2018 included:

“Data Science is not a person – it’s a team. Diversity of specialists essential. Need curiosity in problems; problem-solving; bring together data, data problem-solving, technical; but all members need statistical foundations.”

It is also important to have statistical consulting units in universities, which will work on improving statistical methodologies of PhD and M.Sc. thesis or scientific publications as well as generating additional financial resources through external activities. Finally, it is important on the one hand to “open the debate about and explore pathways for the potential use of private and corporately-held data for the social good” and on the other hand to remind that

“A shift in mind-set will not happen as long as decisions about which government data sets to release are made only by statisticians and economists accounting directly to politicians. The broader data ecosystem, including data analysts, business intelligence professionals, social scientists, and domain experts as well as users need to inform this debate at the very highest levels” (The Africa Data Revolution Report, 2018).

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