AN OUTCOME-BASED
STATISTICAL CAPACITY DEVELOPMENT PROGRAMME
TO SUPPORT RESEARCH AT A UNIVERSITY

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ABSTRACT

This paper addresses a critical component of the infrastructure necessary for professional development toward more effective teaching and learning of research and statistical methods. In particular, an interdisciplinary in-service model is proposed, which has the potential to better prepare educators to address institution-specific needs amidst dwindling resources. In particular, we present an outcome-based model for developing statistical capacity in research in response to the need for training statisticians in the academia. The aim of the programme was to equip selected faculty with the competencies needed to provide various forms of statistical support services in line with the research, extension, and publication mandate of a large private university in the Philippines. The programme was administered in three phases: (1) training phase, (2) statistical consulting and mentoring phase, and (3) "cascading or extension" phase. Evaluation of the outcome involves participants' demonstration of learning in various statistical methods through serving as resource persons during the cascading activity and the documentation of the statistical consulting experiences made during the programme.

Keywords: Statistical capacity development; Outcome-based model; Training of statisticians in a university

1. CONTEXT AND MOTIVATION

The pursuit to improve teaching, learning, and applications of statistics at all levels of higher education is recognised as an essential component for research to thrive in a university. Rossman (2011), in his interview with Joan Garfield, pointed out the link between statistics, research, and practice; he proposed a way of teaching statistics that moves away from teaching isolated concepts towards teaching statistical thinking that is linked to an approach for answering research questions. In developed countries like the United States, the recognition of statistics education as a research-based discipline is evident in the large number of grant projects towards innovations designed to improve teaching and learning in introductory statistics courses (Hall & Rowell, 2008). In the Philippines, despite recent educational reforms, many college students and faculty members who must have completed an undergraduate or graduate course in statistics are still not able to use their knowledge when confronted with data from research. It is in this context that this paper describes a statistical capacity development

programme for selected faculty members from across various disciplines in a large private university in the Philippines with the aim to develop among these tertiary faculty the competencies needed to teach statistics more effectively and to guide students in using statistical methods in research more appropriately.

1.1 GLOBAL LANDSCAPE IN HIGHER EDUCATION

In this knowledge-based society, universities face the challenges of an increasing pressure on research activity, engagement and competition in research funding as research productivity has become a major determinant in national and global university rankings. Huenneke, Stearns, Martinez, and Laurila (2017) claim that institutional investment in sustainable and long-term term research-capacity building programmes for faculty is essential for faculty in order to support their career development: such programmes should help them to level up their research activity and take on research leadership. Thus, there is a need to connect and balance the investment for teaching and research quality in the academia.

Moreover, as most research in various disciplines involves the collection and analysis of empirical data about the phenomena under study, knowledge of statistical principles and methods has become essential for faculty and researchers in the academia. Schuyten (2001) identifies three types of researchers in the academia: (1) the student, other than a doctoral student as researcher, (2) the doctoral student as researcher, and (3) the professional researcher. For all these types of researchers, the development of research skills comprise a "closely connected triplet of research area, research methodology and statistics" (Schuyten, 2001, p. 228).

The development of statistical capacity is among the four strategic priorities of the International Statistical Institute (ISI) for the period 2017–2021. The 2013 White Paper on statistical capacity building defines the objectives as (ISI Executive Committee 2015-2017, 2017, p. 7):

> "enabling statistical practitioners in the public and private sectors to use state-of-the-art methods for data collection, analysis and interpretation; and contributing to the development of statistical infrastructure and human resources in official, survey, and business statistics as well as in statistical education and research."

Researchers' knowledge and competency in the use of statistics is highly recognised as a determinant of the quality of empirical research in higher education. This is reflected in the theme of the Roundtable Conference of the International Association for Statistical Education (IASE) in Tokyo, Japan in 2000: *Training researchers in the use of statistics.* The proceedings of this conference, published under the same name (Batanero 2001) are a rich source of ideas how to improve the infrastructure, which would assist university staff to deliver more relevant courses in statistics and to improve their research with respect to statistical methodology, which is ever-increasing in importance for empirical research.

The conference highlighted this need for better understanding of statistical concepts and applications of statistics in research. Batanero (2001) contended that there is an increasing need for the statistician's support in empirical research. In practice, researchers often bring in statisticians into their teams to ensure appropriate management, analysis and interpretation of research data. However, data analysis in applied research is not solely the responsibility of statisticians; some fundamental research-design issues, data analysis, and interpretation within contexts specific to the discipline area under investigation demands a reasonable level of statistical competencies on the side of the researcher and that part cannot be outsourced to statistical consultants or statisticians who join in as members of the research team.

1.2 CONCEPTUAL FRAMEWORK OF THE PROJECT

The statistical-capacity development project described in this paper draws some principles and approaches from cases of training programmes for researchers on the use of statistics, which were presented at this roundtable conference in 2000. These include

- the use of work-based statistical training of researchers using real-world problems confronting them to illustrate statistical methods (Hirotsu, 2001);
- the integration of technology tools in the design to facilitate teaching and learning (Lee, 2001; Stangl, 2001; Galmacci, 2001; Shia, 2001); and
- the application of statistical consulting as a pedagogical and professional development tool (Godino, Batanero & Jaimez, 2001; Jolliffe, 2001);
- the "train the trainers" approach and development of some training materials for a non-degree training programme consisting of class teaching, classroom discussion, and field training (Wei, 2001; Crivisqui, Abruzzini, & Batista, 2001);
- the training of researchers involving a structured view of social research and featuring the use of workshops and short courses through a research resource centre for academic staff and graduate students from a wide range of backgrounds (Glencross & Mji).

Especially, we adopted the "train the trainers" approach to ensure sustainability where local trainers or facilitators could gradually take over the training responsibility towards developing a critical mass of statistically literate and competent graduate student and faculty researchers. Additionally, we draw some ideas from the approach used by Glencross and Mji (2001) to train social science researchers involving a structured view of social research.

Other models of statistical-capacity development in diverse fields also abound in the literature. In Rwanda, for example, Thomson et al (2016) documented a model of multi-month deliverable-driven applied-statistics training (particularly on survey analysis); this project comprised a collaboration of selected research leaders, statisticians, and a PhD candidate who participated in class-based trainings, assigned data-analysis tasks, and in-country mentoring for analysis and manuscript writing.

Furthermore, within the broader context of ongoing capacity building for development across countries, the framework for determining statistical-capacity building indicators developed by Laliberté et al (2002) provided some guidelines for strategic planning of statistical activities. These indicators include integrity, methodological soundness, accuracy and reliability, serviceability, revision policy and practice, and accessibility of data. While these indicators are originally intended for national statistical systems, some of these indicators may be used in localised academic contexts to guide the priority-setting process to meet numerous and diverse statistical needs of researchers as both producers and consumers of statistics. These indicators may provide a framework for planning, monitoring, and evaluation of development activities. Statistical-capacity development is essential as the university pursues the challenge of increasing research activity and, consequently, research productivity, and the different forms of knowledge-based innovations that go along with research.

1.3 PHILIPPINE CONTEXTUAL REALITIES AND CHALLENGES

In the Philippines, the recent reforms in basic and higher education have expanded the curriculum for teaching research and statistics as stand-alone courses starting in Senior High School (students aged 17 to 18), with an additional two years of high school as stipulated in the K to 12 Basic Education Programme, which was launched in 2012 (Department of Education, 2013). In this K to 12 Basic Education Reform, statistics and probability is taught as one of five learning domains of the mathematics curriculum from Grade 1 to 10. Starting with data representations using pictographs in Grade 1, the concepts and skills move with increasing

complexity towards various descriptive statistical tools and measures in Junior High School (Grades 7 to 10). However, students encounter Research Methods and Statistics and Probability as separate stand-alone courses not before the Senior High School.

Furthermore, with the move towards outcome-based education (OBE) in higher education, many undergraduate programmes now articulate research outcomes, such as the production of a thesis as part of their degree requirements. In addition, the training of new researchers within graduate programmes and increased research engagement of university faculty brought about by expanding research grant opportunities have continued to pose a challenge in the development of statistical literacy in research and competency in the management, analysis and interpretation of data arising from research and other sources. With the government's mandate on outcome-based and typology-based quality assurance (Commission on Higher Education, 2012) and provision on multiple pathways to advancing research, innovations, and extensions in higher education, there is the need for higher-education faculty to enhance current skills, competencies, and dispositions to cope with the demands of reformed curricula and research policies against a backdrop of "a dynamic array of economic, social, global and technological forces" (Commission on Higher Education, 2016, p. 1).

As colleges and universities actively engage in research activities to respond to the challenges of reform, increasing research productivity and community engagement, there is a need for more professionals who can manage, analyse and make sense of data. However, in the Philippines, there is a shortfall of graduates from statistics degrees and the need for statisticians in the academia is more keenly felt; Bersales (2006) surveyed academic institutions that offered programmes in Statistics and Applied Mathematics/Statistics from 1998/99 to 2004/2005 and found out that although enrolment trend is increasing, there is still a lack of graduates from these programmes to meet the statistical manpower needs of government, business and industry, and the academia. The Commission on Higher Education's (CHED) database (2010) shows that only 32 of the more than 1700 higher education institutions (HEIs) offer BS or BA in statistics, applied statistics, or mathematical science with statistics as major field. Only five universities offer MS (statistics or applied statistics) and two offer PhD (statistics). Undergraduate enrolment remained low and flat with an average of around 400 graduates annually and nationally (Commission on Higher Education, 2010).

With the dearth of graduates in statistics-degree programmes in the Philippine context, several collaborative reform efforts were done in the past in training mathematics teachers to teach statistics in a more data-oriented approach to address gaps in conceptual learning and focus in real-world applications of statistics in research contexts (Reston & Bersales, 2011). However, with the recent educational reforms in both basic and higher education, the increase in research-course requirements from Senior High School to undergraduate and graduate programmes has led to an increased demand of student and faculty researchers on professionals whom they can consult on statistical methods for processing research data. Thus, there has been a need also to train research and statistics faculty in universities on statistical practice in the analysis of data in research, and to capacitate student researchers to manage and analyse their own research data with the aid of technology.

David (2009) contended that to promote the use of statistics as an information-gathering tool at the core of modern scientific method, it is important to actively integrate statistics in the education system. Moreover, the integration of statistics and probability in the school-mathematics curriculum in the Philippines has led many students to associate the experience of learning statistics with the more mechanistic calculation and problem-solving drills they experience in most mathematics classrooms. These unpleasant experiences must have contributed to students' and even to teachers' lack of confidence in learning statistics, and needs to be addressed. David (2009) further asserted that statistics is not mathematics and though both disciplines deal with numbers, statistics actually deals with data, which are numbers with context – the what, why, when, where and how behind the numbers.

With the lack of statistical manpower in the academia, investing in institutional statistical-capacity-building activities including training and statistical assistance provided to researchers

may help to improve the research outcomes and the productivity of a university. Further, there are internationally agreed standards, methods, and guidelines for statistical reporting that student and faculty researchers may need to be updated. Thus, in this age of rapid changes in information and communication technology, statistics, as the science of learning from data, may be approached in a more practical way with the aid of technology tools. Statistical concepts and processes are clearly not all that is needed for research and development but they play a critical role in measuring, processing, and managing data from research and other administrative routine operations of an institution.

Cognisant of the important role that statistics-capacity development plays in building research capacity, in this paper, we describe the case of an on-going outcome-based, continuing professional development programme for a multi-disciplinary team of university faculty with the goal of developing statistical capacity through a combination of training, statistical consulting, and other services to support the university mandate on research, development, and extension.

2. THE CAPACITY-DEVELOPMENT PROGRAMME IN STATISTICS

Capacity development, particularly among the faculty, is one of the critical challenges that many higher-education institutions face, particularly in developing countries. It requires identification of potential participants and stakeholders and assessment of existing practices to be informed by research towards more evidence-based and effective interventional programmes for increased sustainability. North, Gal & Zewotir (2014) argued that the notion of capacity-building in the area of statistics education is a complex undertaking when viewed in the context of a developing country. Using South Africa as a case study, they described an intervention programme for building statistical capacity among mathematics teachers teaching statistics to illustrate the complex and multi-faceted nature of statistical capacity building. In the Philippines, there have been several reform efforts towards building teachers' capacity to teach statistics more effectively (Reston & Bersales, 2013). In this paper, we describe a programme towards building the capacity of tertiary faculty towards more effective applications of statistical methods in research and in providing support for student researchers in managing their data in research.

2.1 GOAL AND DESIGN OF THE PROGRAMME

In designing this statistical capacity-development programme, we built on
- the concept of technical training but expanded this view of professional development to a full range of learning activities with personalised experiences and opportunities for professional growth and collaboration,
- the use of technological platforms, and
- the integration of the research within the professional development model.

In this context, the programme design is anchored on outcome-based principles, which start with a clear articulation of intended learning outcomes of the programme and designing backwards to ensure that the outcomes are attained by the participants. The programme design consisted of a mix of data-based training workshops focused on acquiring specific statistical knowledge and skills required for particular research tasks as well as opportunities for active engagement with data, statistical consulting, mentoring, and integrative experiences through cascading activities that connect learning to practice.

With the goal of building statistical capacity at the university to establish a sustainable pool of human resources who can process, analyse, and interpret data in research, the main culminating outcome of significance for this programme is that the participants were able to

demonstrate knowledge and competencies in statistical principles and methods as applied to research data through serving as consultants in research projects within their respective fields, and as resource persons in short-term courses on specific data-based applications of statistical methods for research.

The programme extended over 10 months and was administered in three phases:
   (1) the training phase,
   (2) the statistical consulting and mentoring phase, and
   (3) the diffusion phase.

Evaluation of the outcome involves participants' demonstration of learning in various statistical methods through serving as resource persons during the cascading activity and the documentation of the statistical consulting experiences made during the programme

2.2 ADMINISTRATION OF THE PROGRAMME AT OUR UNIVERSITY

The recent curricular and research reforms in the Philippines have resulted in increasing number of research-methods courses that articulate research outcome and additionally – especially brought about by expanding research grant opportunities – in increased research engagement of university faculty. To cope with these challenges in the teaching and the practice of research, which are multiplied because of the scarcity of statistics graduates, a statistical-capacity-development programme of an initial pool of faculty from different disciplines was conceptualised in order to establish a Statistics Centre through government funding from CHED's Institutional Development and Innovation Grant (IDIG).

The first cohort of participants comprised a purposeful selection of 15 faculty members of the university who represented their schools upon the recommendation of their department chairs. The criteria for identification and selection of participants included the following:

   (1) Full-time permanent status as faculty member of the university,
   (2) with at least three years teaching experience in research, statistics or related courses,
   (3) with research experience in mentoring/advising undergraduate and graduate students' research, or in being a member of undergraduate/graduate thesis committee,
   (4) willing to undergo the training and mentoring program and deliver the expected outputs within the specified period, and
   (5) must be willing to serve the Centre for at least three years, after completion of the statistical capacity building programme.

The multi-disciplinary nature of the team of participants is reflected in the composition of the disciplines they represent as shown in Table 1.

Initially, when this capacity development programme was implemented in the Academic Year 2016/17, only tertiary faculty were considered to participate in the programme but it was recommended by the university administration to include Senior High-School teachers since these teachers need to be capacitated to teach the stand-alone research and statistics courses in their curriculum. When the K to 12 Basic Education reform was launched in 2012, the first cohort of Senior High-School students entered Grade 11 in 2015/16, and thus, it was on its second year of implementation when this statistical capacity development programme was conceptualised. Besides, it is recognised that the foundational knowledge and skills of research and statistics needed in tertiary level are built in the Senior High-School programme.

Table 1. Distribution of 15 Participants in the Statistical Capacity Development Project

School/Academic Unit	No.	Major Field of Specialisation
Business and Economics	1	Business Management
Architecture, Fine Arts and Design	1	Interior Design
Arts and Sciences	4	Biology, Computer and Information Science, Psychology, Mathematics
Education	1	Science Education
Engineering	3	Chemical Engineering, Computer Engineering, Industrial Engineering
Law and Governance	1	Political Science
Health Care Professions	1	Nursing
Senior High School	3	Mathematics, Science Education

2.3 TRAINING PHASE

This phase spanned over a period of nine months through workshop-based short-course sessions, which were delivered jointly by selected resource persons from within the university and invited professors and statistics practitioners from the University of the Philippines – Diliman School of Statistics and the De La Salle University who flew in from Manila to Cebu City for the training workshops. Prior to the actual training, an initialisation meeting and pre-assessment was done to provide baseline data on the participants' level of knowledge and competency for teaching and doing statistics-related activities.

In terms of teaching and research, 12 of the 15 participants had prior experience in teaching statistics and or research within their respective fields but most of them had limited experience in training and professional development activities related to statistics. When asked to self-assess their knowledge and skills on a range of statistical topics and methods, the majority of them expressed moderate to high levels of knowledge of descriptive statistics and sampling but low to moderate levels in doing inferential methods, multivariate data analysis, data mining, and statistical modelling.

As to familiarity with statistical software, most of the 15 participants had used *Microsoft Excel* to generate tables and graphs and descriptive summary measures using the *Data Analysis ToolPak*. Moreover, less than 50% of the participants had prior experience in using software such as the *Statistical Package for the Social Science* (SPSS), *Minitab*, or the statistical programme *R*. The pre-assessment data informed and guided the design and implementation of the following workshop-based courses:

- Data management and descriptive statistics using Excel and SPSS.
- Inferential statistics: Parameter estimation and tests for comparing means and proportions using Excel and SPSS.
- Sampling designs and data collection methods.
- Correlation and regression analyses with Excel and SPSS.
- Nonparametric statistics using R Studio.
- Statistics of surveys and polls.
- Quantitative-research problem conceptualisation and research designs.

- Research-instrument development and validation.
- Design of experiments and analysis of variance techniques with SPSS.
- Sample size estimation, effect size, and statistical power analysis.
- Multivariate data analysis: Factor analysis and cluster analysis.
- Multivariate data analysis: Multiple regression and multiple discriminant analysis.

Most of these courses were delivered in 2-3 days with real data from research and technology integration. The diverse background and experience in the teaching and practice of statistics among the 15 participants posed great challenges to the design of the training but these were addressed by providing options in the participation of single training courses. Five of them who had more advanced knowledge and experience in teaching undergraduate statistics and research were exempted from attending the first five basic courses and were provided alternative opportunities to attend more advanced workshops such as on classification and regression trees (CART) organised by the Philippine Statistical Association and another two participants attended Cognitive Diagnostic Modelling (CDM) at the UP-Diliman School of Statistics.

2.4 STATISTICAL CONSULTING AND MENTORING PHASE

As an outcome-based capacity development programme, attendance and active participation in the workshop sessions during the training phase were not sufficient. Alongside with the ongoing training, participants were required to submit evidence of learning through statistical consulting experience as a service learning requirement and competency in data management and analysis through submission of a data-based project report using real data within the university or within their academic unit. For the service learning requirement, participants demonstrated competency in applying their knowledge of statistical principles and methods by providing free advice and assistance in the statistical aspects of actual research projects of student or faculty researchers. It is, in essence, a service-learning activity since the participants provided the services for free as a way of experiencing and learning the process of statistical consulting while being mentored by a more experienced colleague. A sample of some participants' service-learning engagements with students and faculty researchers illustrates the diversity of the demands:

- Providing free statistical advice and assistance to a faculty member of the Department of Architecture on his master's thesis in urban design where the faculty participant assisted in crafting an assessment tool for measuring "urban blight" in Cebu or Mandaue City by identifying the variables and indicators, including the design of a template using worksheets for encoding data that may be analysed through SPSS.
- Guiding a group of chemical engineering students in designing the experiment and analysing the data for their undergraduate thesis on the investigation of the effect of *Malunggay* seed cake coagulant on the level of chemical oxygen demand (COD) of wastewater produced from a carrageenan factory.
- Assisting a group of accountancy students on descriptive and correlation analysis for investigating the *relationship between innovation and profitability performance.*

In most of these situations, the participants assisted students within their respective disciplines, except for the case of the mathematics faculty member who teaches statistics to various groups of students and who was able to assist students in business, accountancy, library science, and other fields. For the experience in the statistical consulting process, reflections of some participants on the experience revealed that despite some perceived limitations in prior knowledge of statistics, the capacity building programme and mentorship experience has enhanced their appreciation of the relevance of statistical applications for research in their

respective disciplines. This is evident in some of the following quotes from their reflections on the activity:

"Throughout the course of the Statistical Capacity Building Programme, I honestly had trouble catching up because I have a very weak foundation. Although during the mentorship programme, my mentor was kind enough to entertain my consultations. […] I felt that my insight was sufficient in the early stages of the consulting experience. These include crafting the design problem and relating it to the research questionnaire, preparing the codebook and the data collection. But I would still say I have a long way to go. The experience has enriched me with the basic concepts of statistics to analyse data with software and bridge it with topics that were discussed throughout the programme to be able to successfully guide and mentor others in my school/college."

"As an advisor of undergraduate students' theses, the statistical consulting experience has built my confidence to engage my research students to apply statistics and ensure that data gathered from the experiment must be correctly analysed and presented in order to produce a paper of high integrity."

As to demonstration of statistical competency in dealing with data, the participants served as data analyst for ongoing projects and institutional data, such as in the following examples:

- Conduct of a baseline survey on how the higher-education institutions and the faculty in the tertiary sector are prepared to implement the new General Education Curriculum.
- Descriptive analysis of student failures in interior-design-studio classes at the university.
- Statistical analysis of the rating data of primary and secondary reviewers of chemical engineering undergraduate theses (2014-2016).
- Analysis of institutional data from faculty performance evaluation as basis for recommendations for action at department and school level.
- Statistical assistance provided to graduate students and several faculty colleagues in the analysis of data in their master's theses and doctoral dissertations

2.5 THE DIFFUSION PHASE

In this phase of the capacity-development programme, the information and the knowledge acquired by the participants in the training and mentoring phase were shared to other faculty members through a cascading activity, which was organised in the form of a seminar-workshop. The purpose of the cascading activity was two-fold: First, it aimed to provide the programme participants the opportunity to demonstrate their capacity to facilitate statistics-related workshops by serving as resource persons to invited teachers and researchers from within the university and from other universities in the city and other provinces. Second, the cascading activity was a form of extension and thus, diffusion of the statistical knowledge and competencies gained in the programme. The workshops included data-based computer hands-on activities covering the topics in the training phase. However, the cascading activity was implemented in two levels, with a total of 20 participants comprising faculty researchers mostly from within the university. The basic level involved a two-day seminar workshop on basic descriptive and inferential statistics including sampling and research-instrument validation while another two days were scheduled for the advanced-level topics on design and analysis of experiments, multivariate data analysis, classification and regression trees (CART), and cognitive diagnostic modelling. These workshops in the cascading activity provided an opportunity for the participants in the statistical-capacity development programme to enhance their knowledge and skills in workshop facilitation and demonstration of statistical concepts and methods in the hands-on activities with real data in facilitating others to deal with them.

At the end of the cascading activity, the participants accomplished a retrospective evaluation of the activity. On a scale from 1 (least satisfied) to 10 (most satisfied), their modal response on the following aspects of evaluation were as follows: Goal attainment in improving their

statistical literacy (8); goal attainment in improving their statistical competency in dealing with data from research and other contexts (7); relevance of sessions and activities to their teaching and/or research [10]; and competency of resource persons/workshop facilitators (9). In both basic and advanced level, many participants found that the sessions were fast-paced and they needed more time to process their learning and more practice in hands-on data-based activities with software.

Some of their comments were as follows:
- Too many topics for too short a time.
- Time always ran out of every session. More time is needed.
- All sessions are really relevant.
- This type of activity needs to be conducted at least twice per semester to cover all areas of statistics.
- Statistics seems difficult but if given time and practice, then this is doable and very useful for me.

As for future training in statistical applications in research, the following measurements were recommended:
- Use of SPSS in doing correlation and regression analyses.
- Training for SEM (structural equation modelling) using R studio.
- Knowledge on the appropriateness of questionnaire items and statistical tools to meet the objectives of the study.
- Relating topics on statistics to architectural/design research and related fields.

Furthermore, only 8 of the 15 participants completed all the required outcomes culminating in serving as resource persons during the cascading activity. While most participants expressed interest in developing their statistical capacity for research, several had competing priorities aside from teaching and research. For instance, four participants had administrative appointments as department chairs and academic coordinators, which pose a challenge on their participation due to restricted time and conflicting schedules.

3. CONCLUSIONS AND FUTURE DIRECTIONS

We presented the case of a university's on-going programme of developing statistical capacity of a multi-disciplinary team of selected faculty, which comprise a mix of training, statistical consulting, and mentoring experiences, and a cascading activity where the participants extend their knowledge and competencies by serving as resource persons. The whole project illustrates how funding from government and collaboration with other universities and a professional association, the Philippine Statistical Association, may bring about the much needed statistical capacity for university staff both for teaching and for research. The gain in statistical competencies developed by the participants during the programme was assessed through their demonstration of outcomes in their ability to analyse research and institutional data, engage in statistical consulting with actual students and faculty researchers, and to serve as resource person and facilitator in short-term data-based and computer-aided workshops on basic and more advanced statistical methods. Statistical capacity was developed through a mix of training and experiential service-learning activities.

In the midst of increasing research-course requirements for students and expectations on faculty research productivity, this capacity-development programme is geared towards establishing an institutional centre comprising a multi-disciplinary team of trained faculty on research and statistics to provide support in statistical applications for research and data-based solutions among student and faculty researchers at the university and its linked communities. The support services include the following:

(1) Review of the statistical aspects of quantitative-research proposals;
(2) Consulting on data collection, sampling and sample size estimation, and statistical power analysis;
(3) Development and validation of tests and research instruments;
(4) Continuing statistical-capacity development for teachers and researchers on data management, organisation, and analysis using appropriate tools and software (e.g., Excel, SPSS, Minitab, R Studio, *Geogebra*, and other open-access web-based resources); and
(5) Collaboration with established researchers with external grants on the statistical aspects of their research projects.

The on-going statistical-capacity development of the selected faculty is moving towards this direction as the role of the university faculty has continued to evolve to meet the pressing demands of teaching, research, extension, and production. Moreover, as argued by North, Gal & Zewotir (2014), the notion of capacity-building in the area of statistics education is a complex undertaking when viewed in the context of a developing country as it takes into consideration distinctive goals and contextual constraints. In the case of this statistical capacity development programme at a large private sectarian university in the Philippines, the complexity takes into account the scarce resources in terms of statistical expertise for research and technology infrastructure for more effective and efficient delivery of statistical services. Furthermore, training a multi-disciplinary team with diverse backgrounds compounded by conflicting schedules and other priority and task assignments have posed some limitations on the attainment of the goal and desired outcome of programme.

To address these challenges, we recommended that participants who completed the programme are classified into four clusters based on their demonstration of desired outcomes. Corresponding to the university administration's classification of institutional research and development (R & D) projects, Cluster 1 comprises those faculty participants who can provide support to undergraduate and graduate students and early-career faculty researchers in developmental tasks while Cluster 2 comprises those who are able to provide mentoring and statistical support to institutional R & D projects. On the other hand, Cluster 3 comprises those faculty researchers who can collaborate or be part of the research team with established researchers to take charge of the statistical aspects of their externally funded projects and finally, Cluster 4 are those who can apply statistical methods and processes as part of the production of knowledge and technology innovations through R & D projects. Moreover, an evaluation of the participants' demonstration of outcomes indicates that most of them are on Cluster 1 and 2, and thus, there is need for continuous professional development, evaluation, and administrative support for this first generation of participants to move to more advanced levels of statistical capacity in Clusters 3 and 4.

Summing up, statistical capacity development is not simply a linear process that produces desired outcomes given some inputs; rather, it is a complex, dynamic, and evolving process that takes into consideration the interaction of programme goals with individuals of diverse backgrounds, contextual factors, implementation constraints, and the specificities of the multidisciplinary character of statistical applications in research.

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REFERENCES

Batanero, C. (Ed.) (2001). *Training researchers in the use of statistics*. Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Bersales (2006). Academic programmes in statistics in the Philippines. *The Philippine Statistician*, 55(3-4), 29–41.

Crivisqui, E., Abruzzini, S. & Batista, C. M. (2001). How to overcome the gap between the available statistical methods and their effective use by researchers in social sciences: A few thoughts about the experience in the PRESTA programme. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 277–293). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Commission on Higher Education (2012). CHED Memorandum Order No. 46: Policy standard to enhance quality assurance (QA) in Philippine Higher Education through an outcome-based and typology-based QA. Quezon City, Philippines: Commission on Higher Education. [Online: ched.gov.ph/memorandum-orders/]

Commission on Higher Education (2016). CHED Memorandum Order No. 52. Pathways to equity, relevance and advancement in research, innovation, and extension in Philippine higher education. Quezon City, Philippines: Commission on Higher Education. [Online: ched.gov.ph/memorandum-orders/]

da Ponte J. P., Noll J. (2018). Building Capacity in statistics teacher education. In: D. Ben-Zvi, K. Makar, & J. Garfield (Eds.), *International handbook of research in statistics education*. Springer, Cham.

David, I. P. (2009). How is statistics different from mathematics? And why is the distinction important? *The Philippine Statistician*, 58.

Department of Education (2013). *The K to 12 Basic Education Programme*.
[Online: www.deped.gov.ph/k-to-12/about/k-to-12-basic-education-curriculum/]

Galmacci, G. (2001). The impact of the internet on researchers' training. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 159–169). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Godino, J., Batanero, C. & Jaimez, R. G. (2001). The statistical consultancy workshop as a pedagogical tool. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 339–353). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Glencross, M. & Mji, A. (20019: The role of a research resource centre in the training of social science researchers. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 245–257). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Hirotsu, C. (2001). Statistical training of the researchers in total quality management: The Japanese experience. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 53–63). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Huenneke, L. F., Stearns, D. M., Martinez, J. D., & Laurila, K. (2017). Key strategies for building research capacity of university faculty members. *Innovations in Higher Education*, 42(5–6), 421–435.

ISI Executive Committee 2015-2017 (2017). *ISI Strategy 2017-2021*. The Hague, The Netherlands: International Statistical Institute.
[Online: isi-web.org/index.php/about-isi/what-is-isi/strategic-plans]

Laliberté, L., Harrison, M., Khawaja, S., Tongeren, J. van, Allen, D., Andrade, C., & Carlson, B. (2002). *The framework for determining statistical capacity building indicators*. Washington, D.C.: International Monetary Fund.

Hall, M. R. & Rowell, G. H. (2008). Introductory statistics education and the National Science Foundation, *Journal of Statistics Education, 16* (2), 1–10.
[Online: https://doi.org/10.1080/10691898.2008.11889562]

North, D., Gal, I., & Zewotir, T. (2014). Building capacity for developing statistical literacy in a developing country: Lessons learned from an intervention. *Statistics Education Research Journal*, 13(2), 15–27.
[Online: http://iase-web.org/documents/SERJ/SERJ13(2)_North.pdf?1417993657]

Reston, E., & Bersales, L. G. (2011). Reform efforts in training mathematics teachers to teach statistics: Challenges and prospects. In C. Batanero, G. Burrill, & C. Reading (Eds.), *Teaching statistics in school mathematics – Challenges for teaching and teacher education: A Joint Study ICMI/IASE Study* (pp. 41–45). New York: Springer.

Rossman, A. (2011). Interview with Joan Garfield. *Journal of Statistics Education*, *19*(3), 1–24.
[Online: www.amstat.org/publications/jse/v19n3/rossmanint.pdf]

Rossman, A. (2017). Interview with Dennis Pearl. *Journal of Statistics Education, 25*(1), 1–9.
[Online: http://jse.amstat.org/v19n3/rossmanint.pdf]

Schuyten, G. (2001). Research skills: A closely connected triplet of research area, research methodology and statistics. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 227–230). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Shia, B. (2001). How to think about statistical consultation. Learning from data. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 371–377). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Stangl, D. (2001). Design of an internet course for training medical researchers in Bayesian statistical methods. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 147–157). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

Thomson, D. R., Semakula, M., Hirschhorn, L. R., Murray, M., Ndahindwa, V., Manzi, A., Mukabutera, A., Karema, C., Condo, J., & Hedt-Gauthier, B. (2016). Applied statistical training to strengthen analysis and health research capacity in Rwanda. *Health Research and Policy Systems, 14:* 73. [Online: dx.doi.org/10.1186/s12961-016-0144-x]

Wei, Y. (2001). The training of researchers in the use of statistics in China. In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 311–317). Voorburg, The Netherlands: International Association for Statistical Education and International Statistical Institute.
[Online: iase-web.org/Conference_Proceedings.php?p=Training_Researchers_2000]

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