

## CAPACITY BUILDING OF STATISTICS TEACHERS' THROUGH MENTORING AND INNOVATIVE WAYS

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*The new K to 12 curriculum has changed a disciplinary mathematics curriculum to a spiral curriculum where learning competencies in statistics are usually placed at the last quarter of the academic year. It also requires each student to take a core course in statistics and probability in senior high school. It has been reported though that many teachers do not finish the minimum learning competencies in statistics. Moreover, there is a lack of teachers who can teach statistics competently. This paper discusses innovative ways of teaching statistics to address such problems like mentoring high school teachers by tertiary level statistics teachers, training teachers in statistics, integrating blended learning and inquiry-based learning, using statistical software, writing books, modules and teaching guide with real life data collection.*

### INTRODUCTION

In the pursuit of the ongoing educational reforms that include the new K to 12 curriculum, innovative ways should be designed to make sure that students acquire statistical literacy and lifelong learning skills. Primary tools that will help attain such goals are to enable the statistics teachers and to provide quality materials in teaching statistics.

The K to 12 curriculum has been implemented in 2016 reforming the basic education curriculum from 10 years to at least 12 years. The old basic education curriculum included 6 years in elementary education and 4 years in secondary education. In this old curriculum, elementary mathematics subjects are taught in spiral approach. Spiral curriculum is where the students are taught by repeating the study of mathematics at different grade levels, each time at a higher difficulty and at a higher depth. However, secondary mathematics subjects are taught in disciplinary approach where first year mathematics focused in arithmetic and algebra, second year mathematics focused in algebra, third year mathematics focused in geometry, and fourth year mathematics focused in advanced algebra and trigonometry. The new K to 12 curriculum starts with a kindergarten level, 6 elementary education levels, 4 junior high school levels and adds two senior high school levels. Mathematics curriculum in elementary and junior high school levels adopted the spiral approach where statistics are taught in the last quarter of the academic year. Junior high school statistics include descriptive statistics (basic concepts, data presentation and numerical measures) in grade 7, counting techniques and introduction to probability in grade 8, probability in grade 10. The additional 2 senior high school levels (grades 11 and 12) include core and specialized subjects. Core subjects will be taken by all senior high school students while specialized subjects depend on the academic track the students choose. The academic tracks include Science, Technology, Engineering and Mathematics (STEM), Accountancy, Business and Management (ABM), and Humanities and Social Sciences (HUMSS). Mathematics core courses in senior high school include General Mathematics and Statistics and Probability. Statistics concepts included in this core course include random variables, probability distributions, normal distribution, sampling distribution, estimation, hypothesis testing, correlation, and regression analysis. Moreover, there are research subjects which require higher statistical concepts like statistical tests involving two or more population means (t-test and analysis of variance), and analysis of categorical data. With these educational reforms, a problem that surfaced is the lack of teachers who can competently teach statistics especially in senior high school. This paper discusses innovative ways to address such problems like mentoring statistics teachers, teacher trainings in statistics, integration of statistical software in teaching statistics, development of instructional materials like statistics books and modules, sharing of resources and teaching experiences, and adopting blended learning and inquiry-based learning pedagogies.

## MENTORING HIGH SCHOOL STATISTICS TEACHERS

Senior high school (grade 11) statistics cover topics which are included in the tertiary level introductory statistics subjects in the old curriculum. Because of the lean number of students in college due to the implementation of additional two years in senior high school, there are cases where tertiary level teachers with experiences in teaching introductory statistics subjects temporarily taught senior high school statistics core course, but this is not sufficient to meet the demand for statistics teachers who are capable of teaching senior high school statistics competently.

Mentoring high school statistics teachers by statistics experts or tertiary level statistics teachers has been adopted as one of the possible solutions. Mentoring of high school teachers includes the following:

- The mentor checks the syllabus or topic outline in senior high school Statistics and Probability subject making sure that all learning competencies required are included.
- The mentor conducts school visits with one-to-one consultation with the teacher being mentored.
- The mentor observes classes of senior high school teachers for both the in-depth discussion of the fundamental concepts of statistics as well as the pedagogies used in teaching statistics with feedback sessions afterwards.
- The mentor allows senior high school teachers to observe his or her classes, and shares with the teachers data-oriented and inquiry-based teaching practices integrated with statistical software.
- The mentor shares his learning materials and resources to the teachers including textbooks, teaching guides, classroom presentations, real-life data, and assessment tools.
- The mentor critiques the assessment (formative, summative, performance tasks and rubrics) prepared by the senior high school statistics teachers and provides suggestions on how to improve them. He must ensure that all necessary standards and learning competencies are included in the assessment.

In addition, the mentor notes his observations regarding the senior high school statistics syllabus, methods of teaching, and assessment given to the students. He provides suggestions and recommendations both to the teachers and/or concerned school administrators.

Mentorship programs were encouraged by the Senior High School Support-K to 12 Transition Program of Commission on Higher Education (CHED). Examples of which are the solo and unit grants under Content Knowledge Development Grants for Higher Education Institute (HEI) Units.

With the first batch of senior high school students graduating this year, an evaluation of such mentoring programs is being planned. Some feedback from mentored high school teachers are noted below:

1. *Did the mentoring program help you in teaching statistics?*

*“Yes, in a lot of ways. But the most important thing for me was the confidence that the mentor was able to give. I was more confident in preparing and delivering my lessons since I know that it was fulfilling the standards set”*

*“Mentoring thru Ms. Shirlee helped me a lot. In a scale of 1-10, I would give it a 10.”*

2. *In what aspect is the mentoring program helpful (syllabus, teaching strategies, content, assessment)?*

*“For me, being able to align with the standard syllabus was the most helpful aspect. Moreover, having an expert to talk proved to be very valuable to me.”*

*“The highlight of the mentoring program is the strategic approach. Ms Shirlee had shared her expertise in reaching out to my learners thru curriculum design, references and materials especially the PowerPoint presentations, and the preparation of the course syllabus.”*

3. *How did this mentoring program help you in teaching statistics?*

*“Since it has been a long time when I took my own Statistics courses in college, I needed to review a lot of the content again. Having a mentor helped in verifying technical statistics concepts before I taught it to my classes.”*

*“As a long time teacher of Math and Statistics, I gained fresh insights to learning and teaching. I guess the most important thing she did for me is when she continuously affirm my confidence. To me, that is very, very important.”*

4. *What part of the mentoring program do you like most and why?*

*“It was very helpful to have a mentor who one email or text was just away whenever I had a question or concern.”*

5. *Do you have suggestions on how to improve the mentoring program?*

*“If the schedule permits it, perhaps the mentee can observe the mentor's classes. That would be a valuable learning experience for the mentee.”*

*“I guess the teacher must be given the hour to go out and consult the mentor. It has to be a two-way approach where the teacher and the mentor share the responsibilities of seeing each other. The present system is disadvantageous for the mentor because she has to go to the school all the time.”*

## TRAINING STATISTICS TEACHERS

The Curriculum Standards of the National Council of Teachers of Mathematics (2000) and the College Board's description of the Advanced Placement course in Statistics (2002) emphasize the need for teachers who understand the fundamental statistical concepts and can teach the subject with data-oriented activities. A report from the Conference Board of the Mathematical Sciences (2001) recognizes the importance of better training in statistics for prospective teachers.

As early as 2015, trainings for prospective teachers in senior high school statistics have started. Some of these teachers will become trainers of senior high school statistics in their respective places and groups of schools. They were given pre-assessment and post-assessment, but records were kept confidential. All topics in senior high school statistics were discussed and real-life problems with data were solved with the use of calculators and statistical software. Teachers were shared with instructional materials like modules, notes, real-life data, classroom power point presentations, performance tasks, and sample examinations.

Government institutions like Commission on Higher Education (CHED) and Department of Education (DepEd) also conducted various teaching training programs the following years which included training of Statistics teachers. CHED conducted trainings to tertiary teachers who would be teaching senior high school core courses such as General Mathematics and Statistics and Probability. DepEd conducted trainings to secondary teachers who would be teaching senior high school mathematics including statistics. CHED also offered to higher education institutions funding for making and conducting training programs for prospective senior high school teachers. Unit grants for designing and implementing workshops, seminars, or lectured focused on improving the content knowledge of SHS teachers were encouraged and supported by the CHED K to 12 Transition Program. Sample training programs in statistics are but not limited to the following: 3 to 5-day intensive training, series of 4 or 5 Saturday training sessions, or weeklong morning or afternoon workshop sessions. Such trainings focus on enhancing statistics content knowledge as well as strengthening teaching strategies. There is also a nationwide training conducted by CHED K to 12 transition team where inquiry-based learning (IBL) pedagogy was applied in making lesson exemplars and demonstrating them as well. It started with a national training of trainers for Science, Technology, Engineering and Mathematics (STEM) Education, and was then rolled out to regional trainings all over the country. CHED Memorandum Order No. 09, series of 2016 provides the details on the “Guidelines for the Institutional Development and Innovation Grants under the K to 12 Transition Program”.

## DEVELOPING INSTRUCTIONAL MATERIALS

The importance of instructional materials tailored to the content has been stated by many research studies in promoting quality education. Aside from guiding the teachers, instructional materials such as books and modules help improve students' knowledge, abilities and skills. There is a need for a variety of materials to support statistics education instruction promoting statistical thinking, active learning, conceptual understanding, real-life data, use of technology, collaborative learning, and communication skills. These instructional materials include books with more emphasis on statistical thinking, conceptual understanding, and genuine data, activity books and laboratory manuals providing investigations to foster students' active learning, genuine datasets, and

assessment tools, such as projects, focusing more on students' conceptual understanding and ability to think statistically (Moore, 2000). These recommended features are integrated together in writing books, teaching guides, lesson exemplars, and other instructional materials to guide the senior high school statistics teachers. Some books that were intended for tertiary introductory statistics courses were modified to fit the senior high school statistics content standards and learning competencies. These books are supplemented with teaching guides and/or visual presentations. The book entitled *Probability, Statistics and Applications for Senior High School* (Ocampo and Tresvalles, 2017) includes real-life introductory situations, concept map for interconnections of statistical concepts, learning goals, statistical investigations to foster students' active and collaborative learning, conceptual understanding of statistical concepts and procedures with examples and solutions, stat tips to note important statistical ideas, performance tasks, integrations of statistical software, statistical connections, famous statisticians, formative exercises, pre- and post- assessment tools. An example of a book intended for tertiary introductory statistics book which is revised as a senior high school statistics instruction book is *Statistical Literacy for Lifelong Learning* (Arcilla et al., 2017). This book covers numerous topics more than the content standards and minimum learning competencies prescribed for senior high school statistics core course ranging from descriptive statistics, counting techniques and probability, random variables and probability distributions, sampling distribution, estimation and hypothesis testing involving one and two populations, and correlation and regression analyses. Each chapter includes big ideas, essential questions, concept map, in-depth discussion of statistical concepts with examples and solutions, performance tasks, statistical links, pop-up statistical notes, practice exercises and summative assessment. Both books are supplemented with teaching guides which include learning outcomes (scope and sequence, content and performance standards, objectives), assessment at the levels of understanding and performance (performance tasks), detailed learning plan, resources and materials, and solutions and answer keys.

Lesson exemplars using inquiry-based learning were also exhibited in the trainings conducted for senior high school statistics teachers. The parts of the inquiry-based lesson exemplars include lesson outline, materials, learning resources, procedures (introduction, motivation, statistical investigation, delivery, statistical concepts with examples and solutions, notes to teachers), practice, enrichment with integration of statistical software), evaluation and answers to evaluation. IBL lesson exemplars for SHS mathematics subjects are compiled together and shared in google drive for free to SHS teachers. The first part of a 16-page IBL lesson exemplar is shown below.

### ***INQUIRY-BASED LESSON PLAN ON CORRELATION ANALYSIS***

#### ***Correlation: Analyzing Bivariate Numerical Data***

##### ***I. Lesson Outline:***

*At the end of the lesson, the student should be able to:*

1. *Illustrate the nature of bivariate data*
2. *Construct a scatter plot*
3. *Describe the shape (form), the trend (direction), and the variation (strength) based on a scatter plot*
4. *Estimate the strength of association between the variables based on a scatter plot*
5. *Calculate the Pearson correlation coefficient and interpret*
6. *Solve problems involving correlation analysis*

##### ***II. Materials***

*Leonardo da Vinci's human body perspectives (power point presentation or illustration)  
graphing papers, colored pencils/pens, ruler  
scientific calculators/computers*

##### ***III. Learning Resources***

*Arcilla, R., Co, F., Ocampo, S. & Tresvalles, R. (2017) Statistical Literacy for Lifelong Learning. (2<sup>nd</sup> ed.). Philippines: ABIVA Publishing House, Inc.*

*Ocampo, S. & Tresvalles, R. (2016) Probability and Statistics for Senior High School. Philippines: ABIVA Publishing House, Inc.*

*Walpole, R. Myers, R., Ye, K. & Myers, S. (2012) Probability and Statistics for Scientists and Engineers (9<sup>th</sup> ed.). Pearson Education, Inc.*

#### IV. Procedures

##### A. Introduction

Show to the students a picture of *Vitruvian Man*, a drawing of Leonardo da Vinci around 1490 which shows the proportions of the human body. Ask them what proportions of human body are shown in the drawing. Ask them if height is related to any of the following: (a) arm span, (b) kneeling height, (c) hand length.

**Note to Teachers:** Leonardo da Vinci (1452-1519) drew a sketch of a man indicating that a person's height is roughly equal to the person's arm span. Being a scientist and an artist, Leonardo da Vinci combined these skills to make instructions for other artists on how to proportion the human body in painting and sculpture. These instructions include: (1) height is equal to arm span; (2) kneeling height is three-fourths of the height; and (3) hand length is one-ninth of the height.

##### B. Motivation

Group the students (at least 10 per group) and ask them to do data gathering. Ask them to measure their heights, arm spans, kneeling heights, and hand lengths. Perform the statistical investigation below.

##### Statistical Investigation

1. Record your height. Work with a partner to measure your kneeling height, arm span, and hand length. Combine your data with data from the rest of your class.
2. Graph by plotting in separate rectangular coordinate planes the following pairs of variables. What trend can you observe?
  - 2.1 height (x) and arm span (y)
  - 2.2 height (x) and kneeling height (y)
  - 2.3 height (x) and hand length (y)
3. In each graph, draw a line which is closest to all points. Can you measure the degree of linear relationship between height and arm span? Height and kneeling height? Height and hand length? How?
4. Ask the students to discuss the trends they have observed in the scatter plots they made.
  - “What trend do you see?”
  - “Is there a constant upward trend that follows a straight line pattern?”
  - “Is there a constant downward trend that follows a straight line pattern?”
  - “How strong is the trend?”
  - “Is the trend strongly visible?”
  - “Is the trend weakly visible?”
  - “Do almost all the points lie in a straight line?”

**Note to Teachers:** In the scatter plot, observe that the trend is increasing, that is, the points seem to form an upward straight line from left to right. This implies that as height increases, arm span also increases. The increasing trend in the scatter plot in Figure 2 is strongly visible.

3. Let the students discuss how to determine/measure the strength of linear relationship between the two quantitative variables. Explain that if the two variables are both quantitative, the degree of linear relationship between these variables can be measured using **Pearson's sample product moment correlation coefficient** or **Pearson's r**.

**Notes to Teachers:** The correlation coefficient is a measure of the strength of the linear association between two variables. The Pearson's sample product moment correlation coefficient or Pearson's  $r$  is the appropriate statistic to measure the degree of linear relationship between two quantitative/numerical/metric variables. The population correlation coefficient is denoted by  $\rho$ . Its value ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation). The closer the correlation coefficient is to either -1 or +1, the stronger the linear relationship is. The closer the correlation coefficient to 0, the weaker the linear relationship is. Similarly, Pearson's  $r$  ranges from -1 (perfect negative correlation) to +1 (perfect positive correlation), and is interpreted in the same manner.

4. Relate the trend that you could see on a scatter plot with the sign (positive or negative) of a correlation coefficient

**Note to Teachers:** If points follow closely a straight line of positive slope, then you have a high positive correlation between the two variables. A positive correlation means direct linear relationship between the two variables implying that as the value of one variable increases, the value

of the other variable also increases. If points follow closely a straight line of negative slope, then you have a high negative correlation between the two variables. Negative correlation implies that as the value of one variable increases, the value of the other variable decreases.

- C. Delivery
- D. Practice
- E. Enrichment
- F. Evaluation

CHED also initiated a project for the development of teaching guides for SHS with the help of experts and specialists in statistics, mathematics and sciences from public and private schools, colleges and universities. A teaching guide for SHS Statistics and Probability core subject was developed by Albert, et al (2016) which include the following: K to 12 SHS Statistics and Probability Curriculum contents, content and performance standards, and learning competencies, chapters on exploring data, random variables and probability distributions, sampling, estimation of parameters, tests of hypotheses, and correlation and regression analysis. Each chapter contains several lessons with the following parts: overview of lesson, learning competencies, learning outline, references, development of lesson (motivation, activities, main lesson, and examples), key points, and assessment. (Albert, et al, 2016). This teaching guide for SHS Statistics and Probability is available on line for free and can be downloaded from the CHED website <http://teachtogether.chedk12.com/>. The teaching guides were also modified in the format prescript by DepEd which can be used for public or private DepEd supervised schools.

#### INCORPORATING BLENDED LEARNING AND STATISTICAL SOFTWARE

Blended learning is a practice of using both online and face-to-face learning experiences when teaching students. It is referred to as hybrid learning or mixed-mode learning of e-learning and classroom instruction. Some teachers resorted to blended learning to be able to finish the coverage of the prescribed topics. Some teachers use blended learning since it increases engagement of the students who are continuously connected on-line using electronic gadgets like smart phones, electronic tablets and computer laptops. On-line activities include practice exercises and uploading of tutorial videos and classroom presentations on various statistics topics. Some learning outputs which include survey results were presented in the form of video presentations or screen casting along with written reports in paper publication format.

Use of statistical software was also integrated in statistics classes. Free statistical software like PhStat2 add in Microsoft Excel is used to analyze real-life data. The use of statistical software made the analysis of long real-life data workable and interpretable which made the students appreciative of the statistical procedures applied.

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