Engaging Learners through Data: Senso Eskwela Pilipinas

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Abstract: *The use of real data in teaching and learning statistics has been recommended in the literature. This paper talks about the development and implementation of the Senso Eskwela Pilipinas, the first database in the Philippines that*

builds and provides real data with the intention of making the study of statistics engaging, understandable, relatable, and relevant for Filipino learners.

1. Introduction

The K-to-12 program in the Philippines specifies a very rigorous statistics curriculum, and due to the spiral approach, all teachers from Grade 1 to 11 need to teach statistics. However, statistics remains one of the most difficult topics to teach, and even local tertiary level textbooks are replete with statistical misconceptions [1]. To address this challenge, the authors, under a government-funded project entitled *Technology Innovations on Statistical Reasoning*, created teaching guides that can support Philippine teachers who themselves have limited background in statistics. Further, following CensusAtSchool programs in other countries, a platform named *Senso Eskwela Pilipinas* (SEP) was put together to collect authentic data so that Filipino students would have increased interest and find relevance in learning statistics.

The CensusAtSchool program was first launched in the UK in 2000 with the "dual thrust to enliven data handling activities within the classroom while also educating children about the principles and processes involved in conducting a census" [2, p.1]. With CensusAtSchool, students of different grade levels and from several volunteer schools answer an online survey. The students' responses then become part of a database that students and teachers can access to retrieve sample data for use in different activities for teaching or learning statistics.

The SEP platform follows the general structure of the CensusAtSchool programs while incorporating survey questions that are anchored on unique Filipino experiences and integrating teaching and learning resources that are aligned with the prescribed competencies of the Philippines' Department of Education [3]. Like CensusAtSchool, SEP shares the goal of enriching students' learning experiences in statistics; more specifically, "[t]he sense of belonging that participating pupils feel, purely because they know their own responses will become part of a database of responses from their peers, is fascinating and motivating for them" [4, p. 175].

The importance of situating statistical concepts in contexts that are interesting and relevant to learners has consistently been identified in curriculum documents. The Pre-K-12 Guidelines for Assessment and Instruction in Statistics Education II (GAISE II) indicates that assessments "must require students to use statistical reasoning with context and variability at all stages of the statistical problem-solving process" [5, p. 11]. For example, understanding variability requires students to consider the context in order to recognize whether the variability is due to chance or to controlled conditions [6]. In this way, statistical reasoning is naturally intertwined with context [7]. When students are provided opportunities to work on authentic problems, they learn to develop informal inferential reasoning that works within the given context [8].

The use of authentic data for teaching statistics aligns with constructivist views of learning [9]. Through authentic data, students draw on their prior knowledge to find patterns and make sense of the data through appropriate statistical tools [10]. Authentic data can be gathered from published data sets. Published data can be made more meaningful through data visualization tools such as Gapminder [11]. This tool provides data mostly sourced from the United Nations databank and allows users to generate eye-catching graphs that can highlight multiple variables of interest [12]. Authentic data may also be sourced from students themselves [10]. When students generate their own data, they become more interested and engaged in the analysis [13, 14]. However, it is not easy to collect student data for classroom use. Technology such as Classroom Stats can facilitate the process of data collection [13]. Classroom Stats is a free mobile phone app that enables teachers to send questions to students and see the corresponding descriptive and inferential statistics online and in real time. SEP is designed to add to existing sources of real data that can be used for statistics.

The Analysis, Design, Development, Implementation and Evaluation (ADDIE) [15] approach was adapted in the design, development, and delivery of SEP. This is an instructional system design framework widely used to create effective educational courses and training programs.

This paper reports on the development and implementation of SEP. SEP is freely available and is accessible at https://mathplusresources.com/.

2. Development of Senso Eskwela Pilipinas (SEP)

The first three phases of the ADDIE approach as these relate directly to SEP are elaborated in this section. The discussion of the last two stages is deferred to the succeeding sections of this paper.

2.1 Analysis

In the analysis phase, existing CensusAtSchool platforms were studied. Different aspects apt for a version for Filipino teachers and students were identified.

First, it was determined that SEP must be a student-centered platform through which numerical and categorical data can be accessed. While there is certainly no shortage of accessible data (e.g., from textbooks and online resources), most of these are foreign or unfamiliar to Filipino learners. Thus, SEP was envisioned to have a single survey that can gather data that are: (i) relevant and relatable to the students; (ii) pedagogically and contextually appropriate, and (iii) suitable to the student's academic level. For (i), the survey questions must involve topics that resonate with elementary/high school students or topics that are related to unique Filipino experiences. For (ii) and (iii), the gathered data should be easy to integrate in lessons and student activities aligned with the Philippine Department of Education's Most Essential Learning Competencies (MELCs) in Grades 1 to 11 statistics [3]. In addition, a needs assessment was performed with a number of teachers from different public schools to identify least mastered competencies in statistics. Then, learning activities would be developed to address these competencies.

In the spirit of the CensusAtSchool programs, it was also deemed important for students to be directly involved in the building of the SEP database so that they would have an appreciation for the data-gathering process and a more natural connection with the data sets. Thus, students should be able to answer the SEP survey after which their responses, stripped of any personal identification, would go into the SEP-wide database that would be readily accessible to them.

In terms of accessibility, SEP should be accessible through a website, to ensure efficient and timely recording of responses into the database. To maximize the number of potential users, it was also decided that SEP must be accessible using different devices such as smartphones, tablets, laptops, or desktop computers.

Through the SEP platform, teachers would have easy access to a large volume of authentic data that could be used in different activities for teaching statistics. However, planning and developing these learning activities might not come very easily. Thus, preparing models or examples of such learning activities were also decided to be an integral component of the development of SEP. More specifically, teaching guides and accompanying student worksheets, aligned with the MELCs especially the least-mastered ones, also had to be developed and made available on the platform. The availability of teaching guides and student worksheets would allow teachers and students to engage in statistics learning activities conveniently, immediately, and effectively. Additionally, teachers might choose to modify the available activities or use these as a basis to create their own learning activities.

2.2 Design and Development

The design phase of SEP was divided into two major activities: i) identifying statistics topics; and ii) creating survey questions along with teaching guides and accompanying student worksheets. For Grades 1 to 6, the topics identified were: constructing and reading pictographs, collecting and organizing data, and probability. For Grades 7 to 10, the topics identified were: creating an infographic or a simple questionnaire, creating a stem and leaf plot, experimental probability, organizing and analyzing data using graphs, ungrouped and grouped data, centrality measures, variability measures, and measures of position. For the Grade 11 Probability and Statistics subject, the topics identified were discrete random variable, central limit theorem, hypothesis testing, confidence intervals for population means or proportion, scatter plot, and best fit line.

Given these topics and the aforementioned requirements on the data to be collected, a total of 31 survey questions were formulated and classified into seven categories: *Myself in Numbers*, *More About Myself*, *Food and Drinks*, *Hobbies and Free Time*, *Traveling and Commuting*, *Study and Sleeping Habits*, *Fun and Games.*

As conceptualized, some of the questions were drafted based on topics that could resonate well with the respondents. For example, Question 9 ("Which pet animals do you have at home?"), Question 13 ("On the average, how much times in a day do you spend playing video games?"), and Question 16 ("In which of the following social networking/media sites do you have an account?") relate to topics familiar with the younger generation. Meanwhile, other questions were aimed to engage the students better by alluding to uniquely Filipino experiences. For instance, Question 14 pertains to students' enjoyment of or familiarity with outdoor games that are commonly played by Filipino children. Question 15, on the other hand, asks about students' familiarity with Filipino superheroes that have been featured in TV shows, movies, or other media. There are also interactive questions aimed to pique students' interest further. For example, students are assigned tasks (e.g., clicking all squares of a particular color in a diagram as quickly as possible) and various metrics on the task completion are recorded [16]. For additional details about the questions, the SEP survey may be fully previewed at https://mathplusresources.com/guest/survey. With this complete 31-question SEP survey, it was aimed that students would develop increased interest and connection to the different SEP datasets. Consequently, it was envisioned that students would ask deeper statistical questions about these datasets and will be more motivated in processing and analyzing them.

For the second major activity under the design phase, a functional specification document for SEP was drafted. This document contained the intended capabilities of the platform, the process flows that would govern it, and its initial appearance. Figure 2.1 summarizes the key information from the document. A more detailed discussion of the features pertaining to user types and process flows are found in the next section.

The initial appearance and underlying interface of SEP were designed using the software Balsamiq Wireframe [17]. The art assets, on the other hand, were created using the open-source vector graphics software Inkscape [18]. Prototypes were then used to test the process flows and were explained to the web developers for the intended functional capabilities of the platform. The use of both software was substantive so that more time and resources were spent on the pedagogical aspects of instructional design rather than on the technical side of web-based applications development. User tests were carried out with some teachers and students shortly after. Revisions on the design and functionalities of the platform were carried out from following the user tests.

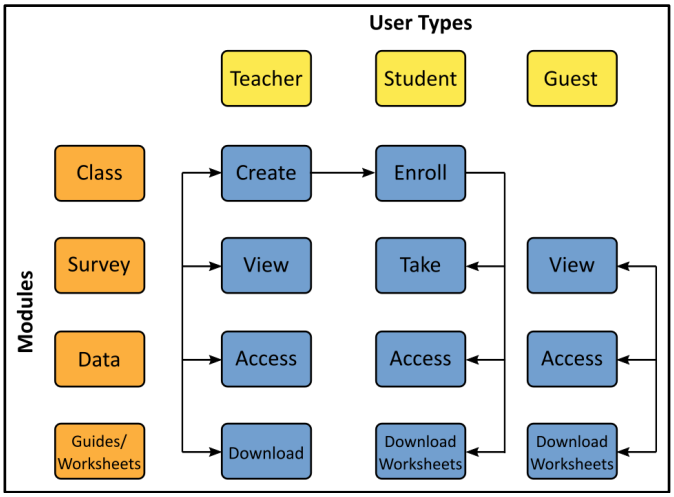
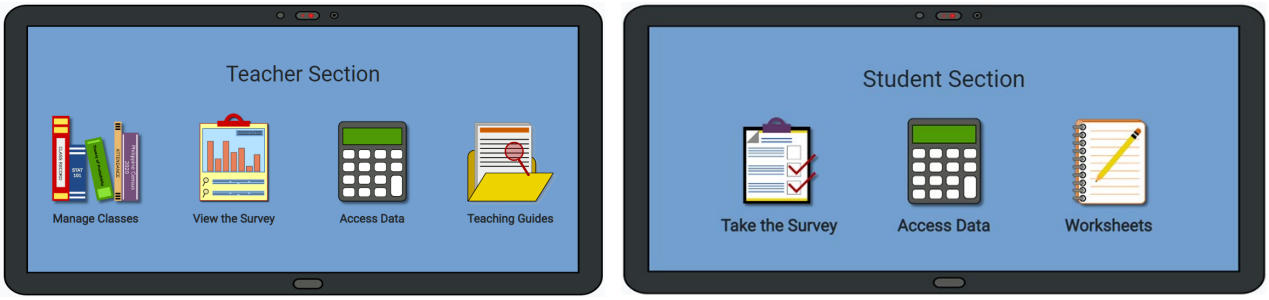


Figure 2.1 User types, modules, and process flows in SEP

3. Features of SEP

As evident from Figure 2.1, the SEP platform has three types of SEP accounts: *teacher*, *student*, and *guest*. Each account has well-defined allowable actions and degrees of accessibility to each of the four main modules (i.e., class, survey, data, and guides/worksheets) of the platform. The modules/features accessible to the teacher and student account types are visually summarized in Figure 3.1. Guest accounts have access to View the Survey, Access Data (limited), and Worksheets.



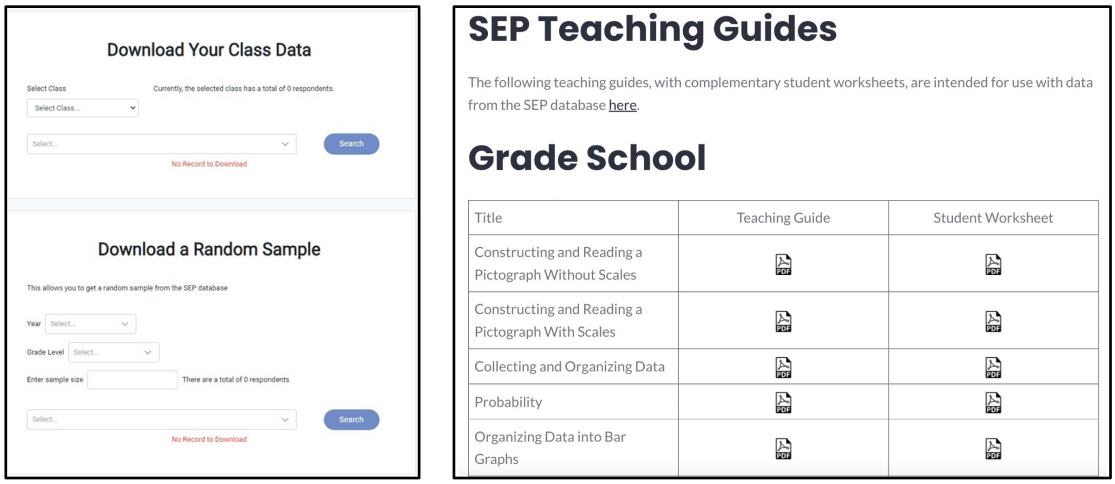
(a) (b)

Figure 3.1 Main SEP menus showing the features available to (a) teachers and (b) students

A teacher account may initiate the main process flow of SEP after creating a new class in the *class* module. This module will generate a set of student class codes. A student with a class code can then enroll in the said class by entering the code in the platform. Each code is unique to a student and is used by SEP to identify the student. Upholding privacy laws, SEP does not ask or store any personal information during students' enrollment and login. Once logged in, the student can answer the SEP survey in the *survey* module. The system allows the student to submit one complete set of responses to the survey. Once submitted, SEP stores the student's responses into the database permanently, unless the class in which the student belongs is deleted by the teacher. Any data stored in SEP can now be accessed in the *data* module by any type of user account. Note, however, that a *guest* account can only access a random set of data, unlike a *teacher* or *student* account which is given access to their respective class's data. Moreover, a *teacher* or *guest* account is only allowed to view the survey. While such a user may enter responses to the survey questions, these will not be stored in the SEP

database. Lastly, all user types are allowed to download the student worksheets. However, only a *teacher* account can access and download the teaching guides. Figure 3.2 shows the data retrieval interfaces of SEP and learning activities for the grade school level.

Teachers, as previously mentioned, may download data (Figure 3.2(a)) on particular questions from their own class/es or as random samples from the entire SEP database. For random samples, year and grade levels as well as desired sample size may be specified. The data set will be downloadable as a single spreadsheet.



(a) (b)

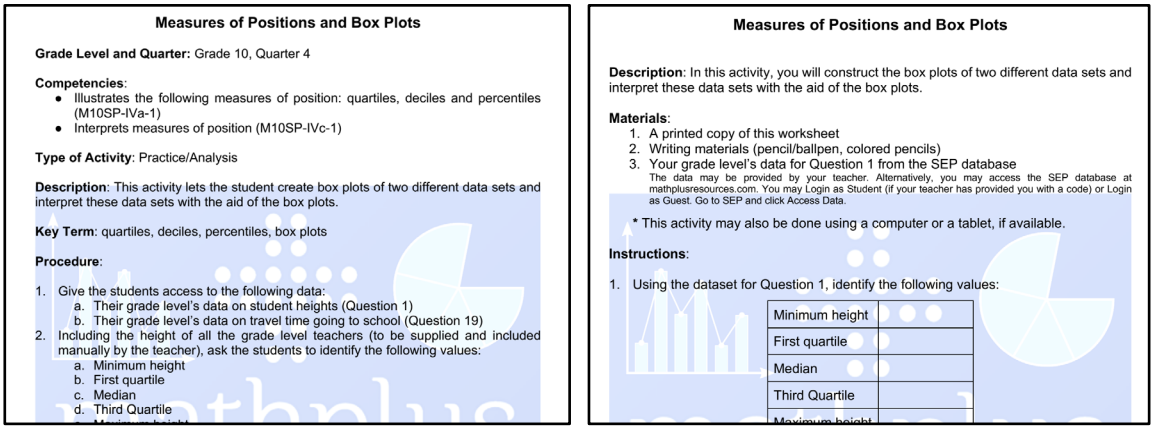
Figure 3.2 (a) Data retrieval interfaces of SEP; (b) SEP learning activities for grade school

As shown in Figure 3.2(b), each SEP learning activity is drafted as a teaching guide and a student worksheet. Each teaching guide indicates the grade level, the competencies covered (based on MELCS prescribed by the Department of Education), type of activity (instruction, practice, assessment, exploration), brief description of the activity, key terms, and the procedure. The procedure consists of a step-by-step guide on how to implement the activity. This usually starts with identifying the SEP data to be used. A student worksheet gives students precise instructions for implementing learning activities using SEP data. Each worksheet contains a description of the activity, materials needed, and step-by-step instructions that are parallel to the procedure given in the corresponding teaching guide. For students who are doing independent work (i.e., without explicit instructions from the teacher), a worksheet also briefly describes the process of data retrieval from the SEP database. In most cases, a student worksheet will also contain fields/boxes for student responses. Figure 3.3 shows an example of a teaching guide and a student worksheet for the topic "Measures of Positions and Box Plots," written to address one of the least learned competencies (measures of position) based on feedback from some teachers. Appendices 1 and 2 present two example activities that make use of SEP data. Some of the SEP learning activities also correspond to performance tasks, which are meant to be a more comprehensive and integrative form of assessment; these are discussed in more detail in [19].

4. Implementation and Deployment of SEP

SEP was formally launched and made accessible to the public last September 24-25, 2020 in a webinar entitled *Senso Eskwela at Iba Pa* [20]. The first day was devoted to an introduction to SEP, providing information on access, use of SEP's features, and integration of SEP into the classroom at

different grade levels. The second day showcased three guest teachers, who shared their insights about using SEP in classes at the grade school, junior high school, and senior high school levels. Since the launch, SEP has been used in some classes in public schools under particular DepEd School Divisions.



Measures of Positions and Box Plots

Grade Level and Quarter: Grade 10, Quarter 4

Competencies:
- Illustrates the following measures of position: quartiles, deciles and percentiles (M10SP-IVa-1)
- Interprets measures of position (M10SP-IVc-1)

Type of Activity: Practice/Analysis

Description: This activity lets the student create box plots of two different data sets and interpret these data sets with the aid of the box plots.

Key Term: quartiles, deciles, percentiles, box plots

Procedure:

1. Give the students access to the following data:
   a. Their grade level's data on student heights (Question 1)
   b. Their grade level's data on travel time going to school (Question 19)
2. Including the height of all the grade level teachers (to be supplied and included manually by the teacher), ask the students to identify the following values:
   a. Minimum height
   b. First quartile
   c. Median
   d. Third Quartile

Measures of Positions and Box Plots

Description: In this activity, you will construct the box plots of two different data sets and interpret these data sets with the aid of the box plots.

Materials:
1. A printed copy of this worksheet
2. Writing materials (pencil/ballpen, colored pencils)
3. Your grade level's data for Question 1 from the SEP database
   The data may be provided by your teacher. Alternatively, you may access the SEP database at mathplusresources.com. You may Login as Student (if your teacher has provided you with a code) or Login as Guest. Go to SEP and click Access Data.

* This activity may also be done using a computer or a tablet, if available.

Instructions:

1. Using the dataset for Question 1, identify the following values:

Minimum height	
First quartile	
Median	
Third Quartile	

(a) (b)

Figure 3.3 A sample (a) teaching guide and (b) student worksheet

In addressing lack of internet connectivity among students, it was suggested to teachers to provide pre-downloaded datasets for learning activities in classes. These data sets can be shared to students through offline modes such as Bluetooth or portable storage devices. While this workaround will require careful planning by the teacher, it will allow the students to use authentic SEP datasets for their activities without needing to go online. The authors have taken advantage of the use of pre-downloaded SEP data sets in deploying learning materials via offline content distribution channels, such as in a community LTE Network. The deployment of probability and statistics learning packages that use pre-downloaded SEP data sets are further reported in [21].

A similar approach was utilized in partnership with Project REIINN (Resilient Education Information Infrastructure for the New Normal) of the Philippines' Department of Science and Technology - Advanced Science and Technology Institute (DOST-ASTI). The primary objective of Project REIINN (https://rcast.asti.dost.gov.ph/) is to study and to pioneer the use of a digital datacasting framework to distribute teaching resources. In March 2022, the authors have set up probability and statistics learning activities in REIINN's EdukasTV digital datacasting platform (Figure 4.1) that was deployed to two public elementary schools.

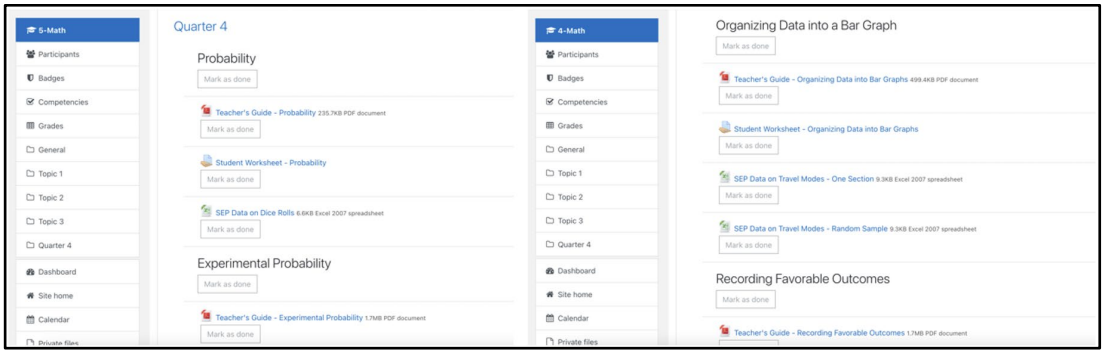


Figure 4.1 Screenshots of Probability and Statistics learning activities, with pre-downloaded SEP data sets, in Project REIINN's EdukasTV platform

5. Initial Integration and Evaluation

To gather initial feedback on the potential effects of SEP on learning statistics, SEP was integrated into two Grade 11 classes of Probability & Statistics during the 3rd quarter of SY2020-2021. One class consisted of students under the Science, Technology, Engineering and Mathematics (STEM) track and the other section consisted of students from Accounting, Business and Management (ABM) track. There were 39 students from the STEM track (18 (Male), 21 (Female)); and 28 students from the ABM track (11 (Male), 17 (Female)). Due to the COVID-19 pandemic, the two classes were in distance learning mode. The teachers of these two classes mainly used Messenger Classroom to communicate with the students about the lessons and the use of SEP. Google Meet was used occasionally to further discuss and explain concepts. Moreover, Google Forms were utilized for formative assessment and for gathering feedback about the SEP.

Aside from the use of SEP, activities that made use of SEP data (from the two classes) were also integrated into the lessons (i.e., introduction to probability distributions and discrete random variables). Some of the students' actual output from the SEP activities are shown in Figure 5.1.

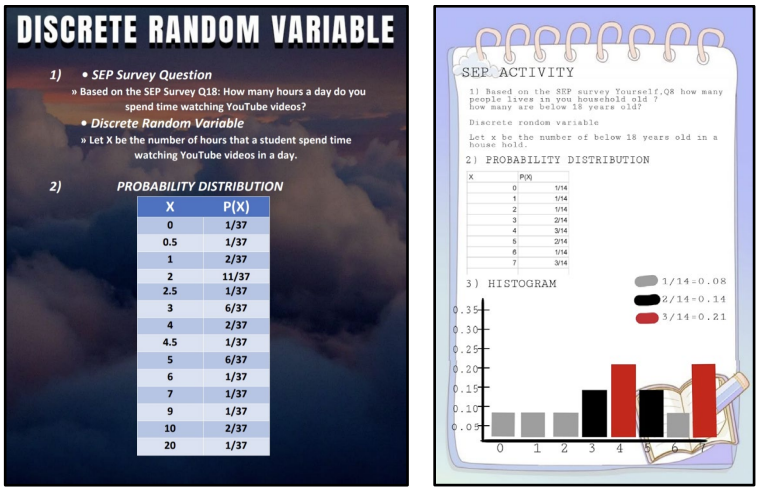


Figure 5.1 Students' output in the SEP activities integrated into their lessons.

The usage of SEP was high for both sections. Overall, **89.55%** of the students were able to completely answer the SEP survey. This resulted in the two sections having a sufficient amount of their own class's data that they could use for examples and activities in their Statistics & Probability subject. At the end of the quarter, a voluntary feedback gathering phase was implemented in which approximately 75% of the students were able to participate. The results showed that about 75% of the STEM students and 67% of the ABM students found the process of accessing and answering the SEP Survey easy and convenient. Moreover, the majority of students from both sections reported positive and favorable feedback in terms of relatability of data, interest in analyzing their own class's data, and usability in teaching and learning concepts in statistics. Some students even indicated that they could already think of possible research topics based on the SEP data for their thesis projects.

6. Conclusion and Recommendations

With the goal of enriching students' experiences and increasing their engagement in learning statistics, the authors have developed and deployed *Senso Eskwela Pilipinas* (SEP), a freely

accessible platform that allows for the collection, storage, and access of authentic, relevant, and relatable data from students all over the Philippines. SEP aims to motivate students in various grade levels to deal successfully with data as they analyze not just any arbitrary datasets, but those that are contextually relevant to them, thereby increasing their interest and engagement in the learning process.

While SEP has been developed based on the existing CensusAtSchool programs, SEP has been designed to gather interesting data that can resonate with students based on their uniquely Filipino experiences and their interests as children or teenagers. In addition, the survey design takes into consideration the most essential learning competencies (MELCs) prescribed by Philippines' Department of Education as well as the least learned competencies that have been reported from a needs assessment performed with some public schools.

Given that improving statistical literacy among students may likely result from well-planned activities given by the teachers, the SEP platform also includes teaching guides and accompanying student worksheets. The materials provide examples of learning activities that use different SEP data. The teaching guides may also provide teachers with ideas to innovate or create new tasks that are appropriate for their objectives.

The enhancement of data collection together with the creation of meaningful learning activities for students is work that is still being pursued. More innovations are in the pipeline for SEP, such as extending the material for undergraduate level statistics, updating existing survey questions, and creating a mobile app version. Furthermore, it is worthwhile to study the extent to which SEP improves the learning competencies and skills of students in the areas of statistics and probability.

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Appendix 1. SEP Activity on Mean

One activity that uses data sets from Senso Eskwela Pilipinas (SEP) is called *Advantages and Disadvantages of the Mean*. Students are asked to compute the mean of and make graphical representations of different data sets from SEP. The activity aims to help students get insights on how well the mean can serve as a measure of central tendency. The activity is outlined below.

1. Students are asked to compute the means for the following two data sets:
    a. Age in months (Question 4);
    b. Length of hand (Question 5).

    Sample data sets from SEP (random samples) are presented in Tables 1 and 2.

Table 1 Random sample of size 28 for SEP Question 4 (Age in months)

195	196	190	188	192	196	198	189	194	192	192	194	199	194
189	200	190	194	201	187	197	195	196	200	187	200	199	186

Table 2 Random sample of size 28 for SEP Question 5 (Length of hand, in cm)

17.5	16	15	17.5	16	16	19	21	18	19	11.5	17.5	20.5	22
17	19.5	20	18.5	19	19	18.5	16.1	18	19	19.8	19	18	18

2. For each of the two datasets above, students are instructed to make a graphical presentation of the data together with the mean they have computed.
    One possible graphical representation is to plot the data points and the mean on the real number line.
3. Students are then asked: "Based on your graphical presentations, how effective is the mean as a measure of central tendency for the two data sets?"
    The two data sets are expected to have small variance; thus, students are expected to notice that the mean is an effective centrality measure.
4. Students are then asked to repeat #1 and #2 for a data set on Magic Age (Question 31).
    A sample data set from SEP (random sample) is presented in Table 3.

Table 3 Random sample of size 28 for SEP Question 31 (Magic Age)

17	18	19	17	17	289	18	16	18	17	16	16	18	18
18	15	17	18	15	17	18	15	19	19	17	18	18	18

5. Students are instructed to remove the largest data point from their Magic Age data set. They then repeat #1 and #2 for this new data set.
6. Based on #4 and #5, students are asked the same questions as in #3.
    The Magic Age data set is expected to have extreme values. Thus, students might notice how the mean is not very near to many of the values because it is increased by the extreme value/s. Moreover, removing the largest data point from a Magic Age data set will significantly affect the mean. This can help students realize the sensitivity of the mean to extreme values.

Appendix 2. SEP Activity on Confidence Intervals

Another activity that uses data sets from Senso Eskwela Pilipinas (SEP) is called *Confidence Interval for the Population Mean*. Students are asked to answer the question "Do Grade 11 students sleep for at least 8 hours, on the average, on a weekday?" To answer this question, the first compute the sample mean and sample standard deviation of a data set then they proceed to construct confidence intervals on the population mean. The activity is outlined below.

1. Students are first asked to generate a random sample of size 20 from the SEP population of Grade 11 students for SEP Question 24: "How many hours a day do you spend sleeping during a weekday?"
   A sample data set from SEP (random sample) is presented in Table 4.

Table 4 Random sample of size 20 for SEP Question 24 (Hours of sleep)

5	9	8	7	4	7	6	6	5	6	7	7	7	8	8	4	8	7	5	6

2. Students are asked to compute the sample mean (point estimator) and sample standard deviation. They are then asked to answer the question "Do Grade 11 students sleep for at least 8 hours, on the average, on a weekday?" based on these.
3. Students are then instructed to construct a 95% confidence interval for the (SEP) population mean. They are then asked to answer the same question as in #2. Moreover, they are specifically asked "What does the confidence level of 95% imply? What does the interval represent?"
4. Optionally, students may be asked to repeat steps #1-#3 but this time, using a random sample of size 40 and then constructing a 99% confidence interval.
   A sample data set from SEP (random sample) is presented in Table 5.

Table 5 Random sample of size 40 for SEP Question 24 (Hours of sleep)

5	6	8	5	7	7	7	8	6	8	8	8	7	6	8	6	8	8	8	8.5
7	6.5	5	4	10	6	8	8	7	6	9	8	5	7	7	5	6	6	5	7