Attitudes toward Statistics and Statistical Literacy of Public Senior High School Students

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ABSTRACT. Statistics has proven its usefulness in research over centuries to produce quality insights and data-driven decision-making. Learning statistics not only rely on cognitive but other factors such including attitude as well. This descriptive-correlational research determined the attitudes toward statistics in the components of affect, cognitive competence, value, difficulty, interest and effort, and statistical literacy of 200 public senior high school students selected through stratified random sampling. The SATS-36© developed by Schau et al. (2003) was used to determine attitudes, while a researcher-made questionnaire was utilized to measure statistical literacy. Using descriptive statistics and inferential analysis, student's attitudes toward the subject were established positively in value, interest, and effort components. In contrast, a negative attitude was exhibited in the components of affect, cognitive competence, and difficulty. Students' statistical literacy was found to be low in all areas and as a whole. Among the six components of attitude, the value component showed a significant relationship and predicted students' statistical literacy. Thus, the most vital component of attitudes toward statistics is value.

1.0. Introduction

Statistics is the science of collecting, organizing, analyzing, interpreting, and presenting data (Doane et al., 2020) and relies not only on students' intellectual capability but also on non-cognitive factors, such as attitude, perception, interest, expectation, and motivation (Ashaari et al., 2011). Statistics, alongside probability, is a pre-requisite of Practical Research 2 in the Philippines' K-12 curriculum, covering random variables, sampling methods, distributions, the population mean and proportion, hypothesis testing, and correlation and regression analysis.

Students perceived statistics courses to be daunting (Aslemand, 2018). Taking a statistics course remains a problem, and coping with statistical concepts to obtain the necessary knowledge of the course is challenging (Haines, 2015). In the aforementioned problem, the role of attitudes in the light of statistics courses was acknowledged (Leong, 2006). Attitudes toward statistics comprised students' affect, cognitive competence, value, difficulty, interest, and effort (Ramirez et al., 2012).

Attitude assessment provides students and teachers with insights and measures the effectiveness of learning objectives, i.e., statistical literacy (Carnell, 2008). Statistical literacy involves interpreting real-life problems using statistical tools and is useful in research. The research goal is to solve problems using a system of gathering data to make useful decisions (Kabir, 2016). Consequently, researchers should understand statistics and use statistical tools in their research. One should know the importance of statistical tools and their use in their research or surveys (Begum & Ahmed, 2015).

Challenges were experienced by the researcher while helping the Grade 12 students with their statistical data analysis and interpretation of their research outputs. It was noted that most of the students found statistics to be a complicated subject, and they were not knowledgeable on its application to research. Likewise, the researcher has observed that students were slightly unaware of the statistical tools to be used in their particular statement of the problem, making them wanderers about statistical tools in research in their college years.

Previous studies focused on determining attitudes toward statistics (Aslemand, 2018; Schau et al., 2003; Vanhoof et al., 2011; Khavenson et al., 2012) using various scale measures, but most utilized undergraduate students taking an introductory statistics course. This study adds up to the current body of knowledge of associating attitudes and statistical literacy utilizing senior high school

students where a dearth in the literature was found. Emmioglu and Capa-Aydin (2012) suggested more research on the practical significance of attitudes on students' statistical literacy after taking their course.

Hence, the study assessed the degree of attitudes toward statistics and level of statistical literacy of Grade 12 students in public school. Furthermore, the study served as a baseline for determining the status of statistics learning of public senior high school students. The findings of the study served as determinants in designing a workbook on statistics applied to research.

2.0. Framework of the Study

The study theorizes that attitude influences statistical literacy anchored on the Expectancy-Value Theory of Eccles et al. (1983).

The Expectancy-Value Model (EVM) demonstrated that the Expectancy-Value Theory (EVT) had been used to understand how expectancies and values affect achievement performance. The three most regularly used expectancy-value factors in statistics education are expectancies for success, task difficulty, and task value. Expectancy for success applies to students' self-concepts about their capability to perform statistics triumphantly. Task difficulty leads to students' perceptions of the challenges of statistics. Task value highlighted students' perceptions of the importance of doing statistics successfully. Expectancy for success and subjective task values are aligned reciprocally and are similarly correlated to achievement-related decisions. Eccles and colleagues conceptualize value (called Subjective Task Value) as a "super-construct" that cannot be measured. However, it incorporates numerous measurable elements, including students' interest in (interest) and enjoyment from (effect) engaging in a task, the importance a student attaches to the task and the usefulness of the task to students' futures (Value), and how much work it will take to perform and succeed the task.

In addition, Eccles et al.'s EVT covers the constructs of task difficulty (Difficulty) and self-concept of abilities (Cognitive Competence). Numerous experiments have discovered congruence between the attitudes toward statistics (SATS-36©) and the Expectancy-Value Model's constructs for the latent variable attitude. Eccles et al. (1983) agree that attitudes are made up of many dimensions; that is, attitudes consist of distinct constructs. Ramirez et al. (2012) concluded a congruence between affect and EVM affective reactions and enjoyment value, cognitive competence and EVM abilities, self-concept and expectancies, value and EVM attainment and utility value, difficulty and EVM task demands perception, interest, and EVM interest value, and effort and EVM relative cost. Sorge and Schau (2002) demonstrated the usefulness of implementing this model to understand statistics success by demonstrating indirect pathways from difficulty to affect, and therefore achievement, through cognitive competence (Hood et al., 2012).

Eccles et al.'s EVT relates to this study indicating that students are more likely to achieve more in tasks that they value in broad terms and in which they anticipate to do well. In statistics education, these tasks involve, for example, valuing statistics, striving hard to acquire the skills and to succeed, and applying statistics in life. In other words, Eccles's EVT asserts that students' beliefs about how adequately they do the task (affect, cognitive component, and difficulty) and how much they value that task (value, effort, and interest) are linked and predict any students' achievement-related results including statistical literacy.

3.0. Methods

This study utilized a quantitative descriptive-correlational research design to determine and correlate students' attitudes toward statistics and statistical literacy. The study engaged the 200 Grade 12 students from public senior high schools of Negros Occidental as the respondents of the study with the subsequent reasons they took statistics and research subjects, which are the core subjects of interest of this study. Stratified random sampling was applied in identifying the number of samples in each school for randomization on selecting respondents wherein the whole population was divided into strata. In this study, the strata were the schools, and the lottery technique was used to select the respondents.

The study utilized two different types of questionnaires, one of which was a standardized test. At the same time, the second one was a researcher-made test questionnaire. The standardized questionnaire on the Survey of Attitudes Toward Statistics (SATS-36©) created by Schau et al. (2003) consisting of 36-item questions using a 7-point scale ranging from strongly disagree to strongly

agree was used to establish the degree of students' attitudes toward statistics on the following components: affect, cognitive competence, difficulty, value, interest, and effort. Some items of the SATS-36© are negatively phrased so these items' scoring was reversed. The internal consistency of the SATS-36 in the Russian sample was 0.94 (Khavenson et al., 2012). Moreover, several studies provided high internal consistency for the six attitude components of the SATS-36©. Based on these studies (Carnell, 2008; Emmioglu, 2011; Tempelaar et al., 2007; Verhoeven, 2009), the Cronbach's alpha coefficients for the six components of SATS-36© were as follows: 0.80 to 0.82 for Affect, 0.77 to 0.85 for Cognitive Competence; 0.77 to 0.88 for Value; 0.68 to 0.79 for Difficulty; 0.80 to 0.90 for Interest; and 0.76 to 0.80 for Effort.

In ensuring the validity of the instruments, the researcher-made test questionnaire was subjected to an evaluation by ten jurors. Items that surpassed the content validity ratio of 0.62, established by Lawshe (1975), were retained. At first, the researcher-made 60-item was subjected to a validity test. Of which, 44 were considered valid, higher than or equal to the suggested content validity ratio. Moreover, these 44 items went through item analysis. Those discrimination index higher or equal to 0.30 were accepted to complete the allocated items per area, totaling 30 items. Lastly, the instrument underwent reliability testing. The 30-item test for reliability administered to 30 Grade 12 students was 0.902 using KR 20. KR20 was the appropriate tool since the research instrument consists of dichotomous data such as correct answers and wrong answers.

The researcher asked for approval for the conduct of the study in five different schools of a school district in Negros Occidental through a letter addressed to the school principals. After obtaining the approval for the conduct of the study, the researcher proceeded to select the targeted respondents. Then, the researcher selected the enumerators to administer the instruments to the respondents, where the hard copies of the instruments were inserted in the students' module. The data collected were then analyzed to extract results and interpretations from them.

For the problems requiring descriptive statistics, such as the degree of attitudes toward statistics and the level of students' statistical literacy, mean and standard deviation were used. Meanwhile, Kolmogorov-Smirnov was used in deciding on the normality of the data before establishing the appropriate statistical tests to determine if the data gathered were normal or not. Since the result of Kolmogorov-Smirnov favored non-normal data, the statistical tool used in determining significant relationships was the Spearman rho. Lastly, in establishing the predictor/s of statistical literacy, Multiple Linear Regression Analysis was utilized.

4.0. Results and Discussion

Degree of attitudes toward Statistics

Table 1 shows the degree of attitudes toward statistics of public senior high school students. The results revealed that students have a negative attitude in the components of affect (M=3.960, SD=0.769), cognitive competence (M=3.968, SD=0.665), and difficulty (M=3.546, SD=0.715). This means that they do not like and feel scared, feel that they are not competent in learning, and feel that it is difficult to understand statistics. On the other hand, students tend to have positive attitudes toward the subject statistics in the components of value (M=4.356, SD=0.802), interest (M=4.543, SD=1.268), and effort (M=4.641, SD=1.173). This means that students feel that statistics is useful in their lives and future careers, are interested in the subject and exert effort to learn statistics.

The results emphasized that although they want to learn statistics because they found it useful in their life and career in the future; however, their competence might be insufficient to hurdle the subject. They are interested and willing to exert effort, but they are hesitant as they find the subject difficult. This can happen probably because of the nature of statistics, where many complex formulas and theoretical concepts need to be studied and learned.

The negative attitude in the affect component conforms to the findings of Hood et al. (2012) that students felt somewhat negatively toward the subject. Contrary to the result, Tempelaar et al. (2007) and Bond et al. (2012) stated that students found positive feelings about statistics, making them enjoy statistics, leading to a lack of fear or insecurity about the subject and having a positive attitude about their ability to perform statistics. Furthermore, the result of negative attitude in the difficulty component agrees with the revealed findings of Bond et al. (2012) and Hood et al. (2012), stating that students perceive statistics as a difficult subject.

A positive attitude in the value component revealed in this study supported the findings of Carmona et al. (2005), Hood et al. (2012), and Tempelaar et al. (2007), emphasizing that students had a favorable outlook about the subject statistics and implying that students trust statistics for their educational and future occupational lives. The positive attitude in the interest component confirmed the findings of Bond et al. (2012) that students find statistics interesting. These results indicate that students are more interested in applied topics than abstract concepts (Caldeira & Mouriño, 2010). The same results were found in the effort component in the study of Bond et al. (2012) and Tempelaar et al. (2007), where students have a positive attitude on the effort they give towards learning statistics; hence, they are willing to spend more time doing statistics.

Table 1. Degree of Attitudes toward Statistics

Component	Mean	SD	Interpretation
Affect	3.960	0.769	Negative Attitude
Cognitive Competence	3.968	0.665	Negative Attitude
Value	4.356	0.802	Positive Attitude
Difficulty	3.546	0.715	Negative Attitude
Interest	4.543	1.268	Positive Attitude
Effort	4.641	1.173	Positive Attitude

Level of statistical literacy

Table 2 shows the level of statistical literacy when taken as a whole and in terms of random variables, sampling and sampling distribution, estimation of population means and population proportion, hypothesis testing, and correlation and regression analysis.

All areas in statistics were found to have low literacy; random variables (M=1.010, SD=1.012) with 33.67% correct responses, sampling and sampling distribution (M=1.340, SD=1.082) with 33.50% correct responses, estimation of population mean and population proportion (M=1.315, SD=1.045) with 32.86% correct responses, hypothesis testing (M=2.765, SD=1.334) with 34.56% correct responses, and correlation and regression analysis (M=2.630, SD=1.261) with 23.91% correct responses. As a whole, senior high students are low in statistical literacy (M=9.060, SD=3.346) with 30.20% correct responses.

The findings indicated that students ranked lowest in correlation and regression analysis, which is the last topic discussed. Teachers might not reach these topics as they have limited time to finish the course. As described in the K-12 curriculum, Statistics and Probability was taken only for one semester, which might not be enough to tackle the statistics and the probability part of the course. The spiral approach was designed in the mathematics curriculum of the K-12; it is then important to master the fundamental knowledge to progress to the next competency. Since students were not able to master random variables, they have not mastered the next topics. With this, teachers play a big role in realizing the mastery of the lessons learned. Their role is to develop instructional materials focused on students' interests and applied to their lives instead of theoretical concepts.

Doukhan and Guedet (2019) indicated that students could produce explanations in a realistic scenario using random variables. However, they are unprepared to study theoretical definitions. Yolcu (2012) supported the findings where most students could not correctly distinguish the term "samples" presented in the situation. In the area of estimation of population mean and population proportion, the result is supported by the findings of Wang et al. (2017), stating that students perform poorly in the literacy of confidence interval. Refugio (2017) evaluated students' statistical literacy in confidence intervals as low. Students understand confidence intervals by selecting correct procedures and performing computations correctly rather than giving the interpretation. He added that certain experiences of students in learning statistics should be linked to the outside classroom setting. More findings were indicated by Aslemand (2018), where students must determine the difference between two points to measure deviations from the mean and the z-score. Fidler and Cumming (2005) discovered that students erroneously interpret p-values twice as often as they erroneously interpret confidence interval, while the study of Castro-Sotos (2009) showed marginally lower numbers of students with such hypotheses testing misconceptions. In correlation and regression analysis, the results obtained were supported by Baharun et al. (2017), indicating that a low number of students can completely interpret correlation and regression analysis. They hoped that improving statistics

educators' teaching practices may help students gain a better understanding of interpreting the correlation and regression analysis.

Table 2. Level of Statistical Literacy

Area	Mean (%)	SD	Interpretation
Random Variable	1.010 (33.67)	1.012	Low
Sampling and Sampling Distribution	1.340 (33.50)	1.082	Low
Estimation of Population Mean and Population Proportion	1.315 (32.86)	1.045	Low
Hypothesis Testing	2.765 (34.56)	1.334	Low
Correlation and Regression Analysis	2.630 (23.91)	1.261	Low
As a whole	9.060 (30.20)	3.346	Low

As supported by Castro-Sotos (2009), the underlying concepts of hypothesis testing should be learned over the years, not weeks. The studies of David and Maligalig (2006), Tabunda (2006), and Reston and Bersales (2008) conformed that problems in teaching statistics exist and could be due to shortage of qualified instructors, scarcity of contextually and locally produced instructional resources, and lack of teaching aids such as computers. Bersales (2010) further revealed that problems exist at all stages of education – primary, secondary, and tertiary.

Relationship between attitudes toward statistics and statistical literacy

Table 3 shows the significant relationship between the components of attitudes toward statistics and statistical literacy. The result shows that a significant relationship was only found between the value component of attitudes and statistical literacy (ρ=0.304, p=0.000). Other components have no significant relationship when associated with statistical literacy.

This study suggests that although students are scared in statistics and have low literacy in the subject, it could not be deduced that there is a relationship between affect and statistical literacy. Thus, whatever feelings they have towards statistics could not affect their literacy in the subject. This result is opposed to the revealed result of Chiesi and Primi (2009), reflecting that students' feelings about statistics are directly associated with statistics achievement. Emmioglu and Capa-Aydin (2012) stressed that statistical literacy was high for those who had positive feelings about statistics. Although there was no relationship between affect and statistical literacy, the result remained that students were scared and stressed towards the subject. Schau (2003) suggested the following approaches in order to alleviate their stress in statistics: teachers should allow students to bring cheat sheet during tests where it includes all the formulas they have learned, and teachers should likewise demonstrate positive attitudes themselves through using humor in class and be supportive to the class and organize their methods in teaching statistics concepts. Teachers should therefore be creative in their methods for students to have a mastery of the topic and make their teacher-student relationship harmonious by creating fun and not dull learning experiences with the students.

Even though students perceived that they had insufficient knowledge about statistics and that their statistical literacy was low, the result revealed no significant relationship between cognitive competence and statistical literacy. Thus, whether students view themselves as having enough knowledge on the subject does not affect their statistical literacy. Contrary to the results of Chiesi and Primi (2009), Dempster and McCorry (2009), and Emmioglu (2011), which recognized that the higher the students' cognitive competence, the higher their statistical literacy. Students' perception of not having enough knowledge and low statistical literacy could be attributed to some factors. Lalayants (2012) recognized that poor or negative attitudes toward statistics could create barriers for learners in grasping statistical concepts. However, locally contextualized instructional materials

can aid students' cognitive competence (David & Maligalig, 2006; Tabunda, 2006; Reston & Bersales, 2008). They furthermore suggested having qualified instructors to teach statistics.

The result revealed that when senior high school students tend to view statistics as useful in their personal life and professional life in the future, the higher is their statistical literacy. This result was supported by the study of Watson (2006) that students who lack inspiration about statistics through application in their real-life score worse in their statistical literacy. However, this study also revealed that even though the students value the importance of statistics in their life, this was not enough to have high statistical literacy. This could be attributed to teachers' teaching methods and instructional materials not purely focused on the practical applications of the topics and making them locally contextualized (David & Maligalig, 2006; Tabunda, 2006; Reston & Bersales, 2008).

In terms of the relationship between difficulty and statistical literacy, this study revealed no significant relationship. This result means that whether students felt the subject was difficult does not affect their statistical literacy. Even though there was no relationship, students still viewed statistics as difficult, as supported by the study of Bond et al. (2012) and Hood et al. (2012). This difficulty could be because complex calculations of the subject were required. Hence, there needs to be less emphasis on calculations and more on understanding the statistical interpretations (Utts, 2003).

The findings of the study showed that there is no significant relationship between interest and statistical literacy. This means that students' interest, whether they enjoy the subject or not, does not affect their statistical literacy. This result is in discordance with the result of Emmioglu (2011), which indicated that statistical literacy was high for those who had more interest in statistics. The result of this study indicated that although there is no significant relationship between interest and statistical literacy, students still have an interest in learning the subject. To capture students' interest in learning statistics, Carnell (2008) and Leong (2006) suggested that teachers choose engaging tasks that encourage investigation and are relevant to their lives. Caldeira and Mouriño (2010) indicated that students are more interested in applied topics than abstract concepts.

The result of the study revealed that there is no significant relationship between effort and the statistical literacy of students. This implies that whether students exert effort or not, this could not affect their statistical literacy. The study agrees with Bond et al. (2012) that students have a positive attitude toward learning statistics; hence, they are willing to spend more time doing statistics. Since students are hopeful that they can exert effort in learning statistics, Sorge and Schau et al. (2003) suggested that teachers assess students' attitude at the beginning of their course and provide continuous support to their students. Through this, students' willingness to learn statistics would not fade away as they have some support they can rely on.

Table 3. Relationship between Attitudes toward Statistics and Statistical Literacy

Component	R	df	p
Affect	-0.110	198	0.120
Cognitive Competence	0.003	198	0.964
Value	0.304	198	0.000**
Difficulty	-0.053	198	0.454
Interest	0.132	198	0.062
Effort	0.116	198	0.101

Note: the relationship is significant at $p \leq 0.05$

Predictors of statistical literacy

Table 4 displays the predictor variables of statistical literacy: affect, cognitive competence, value, difficulty, interest, and effort. Multiple regression indicated a jointly significant effect between the variables affective, cognitive competence, value, difficulty, interest, and effort [$F(6, 193)=6.777$, $p = 0.000$, $R = 0.417$, $= 0.174$)]. However, when taken individually, only value component [$\beta = 0.383$, $t(199) = 5.451$, $p = 0.000$] has a significant effect on the dependent variable, statistical literacy. Thus, value predicts the statistical literacy of senior high school students where the general formula of the

results was statistical literacy = 3.117 + 1.600 [of Value]

The findings of this study imply that statistics does not only depend on students' cognitive capabilities, but it is important that they can relate the subject to their lives and their profession someday. Making the teaching-learning process meaningfully applied to real-life could achieve successful learning and aid in the problems in teaching statistics as David and Maligalig (2006), Tabunda (2006), and Reston and Bersales (2008) discussed. The K-12 curriculum combined Statistics and Probability as one subject, which might be not enough to learn them both in one semester, as learning statistics alone requires demanding time due to its complex topics and calculations. Teachers should focus on having locally and contextually produced instructional materials relevant to students' daily lives (Carnell, 2008; Leong, 2006). Lastly, the spiral approach of the curriculum enables students to master the topics on a ladderized approach. This entails that students have fundamental knowledge in order to progress to the next competency. Thus, if they did not have the basic knowledge and skills competence, they would find it hard to master the next.

The result of the study is in discordance with the idea that students, who had optimistic attitudes about statistics felt competent in their statistical ability, viewed topics as less challenging, were involved in statistics, and made a concerted attempt to study statistics, had a high level of statistical literacy (Dempster & McCorry, 2009; Emmioglu, 2011; Hood et al., 2012).

Table 4. Predictors of Statistical Literacy from among the components of attitudes

R	R^2	df	F	p
0.417	0.174	6, 193	6.777**	0.000
Variables	Beta	Std. Error	t	P
(Constant)	3.117	2.403	1.297	0.196
Affective	-0.654	0.360	-1.816	0.196
Cognitive Competence	0.283	0.388	0.728	0.467
Value	1.600	0.293	5.451**	0.000
Difficulty	-0.171	0.376	-0.455	0.650
Interest	-0.007	0.233	-0.029	0.976
Effort	0.233	0.248	0.938	0.350

Note: p < 0.05 **

Overall, negative attitudes toward statistics can create barriers for learners in grasping statistical concepts (Lalayants, 2012). This might affect students' development of statistical literacy (Davis & Mirick, 2015). It is therefore important to look upon the attitudes of students toward statistics in order to assess students' knowledge and help them continuously if they are encountering difficulty or misconception of the subject.

Students' low statistical literacy could be attributed to interconnected factors. The nature of statistics alone requires complex calculations, which make it hard to learn. The K-12 curriculum's spiral approach requires students to master the fundamental knowledge and skills before moving to the next competency. That is why students need to have learned basic knowledge. Moreover, teachers could make instructional materials suitable for learners by making them real-life-centered and emphasizing applied topics rather than abstract concepts (Caldeira & Mouriño, 2010).

Meanwhile, inferential results on the significance of the components of attitudes toward statistics conclude the veracity of Expectancy-Value Theory proposed by Eccles et al. (1983), where value affects students' statistical literacy. As the theory emphasizes, students are more likely to achieve more in tasks that they value. Furthermore, the theory indicates that how much students give importance to that task predicts their statistical literacy. Hence, learning is positively affected when teaching statistics focuses more on applicability than on theory and concept development.

5.0. Conclusion

From the findings of the study, it was concluded that cognition and attitudes toward the subject affect statistical literacy. The most vital component of attitudes toward statistics is value, as it predicted the students' statistical literacy.

The level of statistical literacy of Grade 12 students of selected public senior high schools, in general, is low. Since the mastery of the basics is a pre-requisite to higher statistical knowledge, the

low performance of students shows that they have failed to master the needed competencies during their lower grade level statistics. Aside from this, other factors, such as the delivery of instruction, could be attributed to their low level of statistical literacy. Instruction should focus on concept application rather than merely concept discussion. Instructional materials should focus on real-life application, the scope of the subject, which demands complex calculations and complicated formulas to master, and integration of statistics and probability as one subject in the curriculum, which should require a longer time allotment.

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