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# CHAPTER I THE PROBLEM AND ITS BACKGROUND

## Rationale

This paper would like to investigate the effect of using R (R Core Team, 2020) with RStudio (RStudio Team, 2016) as statistical computing tool to the performance of BSED Mathematics and BS Mathematics students in their data management class by means of flexible learning.

The researcher’s interest on this topic started when he did his master’s thesis on rainfall prediction on agriculture using mathematical modeling. He was looking for a software that is economical (if not free) to be used in his data analysis. That time, his wife had a collaboration research project with the UP School of Statistics headed by the former Dean Dr. Erniel Barrios. This gave the researcher the opportunity to meet the members of the team who are seasoned and high-caliber statisticians. He did not waste time. He took the chance to inquire about his master’s thesis, and so Dr. Barrios introduced the researcher to R, which UP School of Statistics uses for free – it is open source and anybody can access it without even buying a license. Dr Barrios was even so generous enough to give the researcher e-materials for the use of R.

As a result, even though the researcher first coded his analysis in Mathematica, he was later able to code his thesis in R using RStudio. With much enthusiasm to learn RStudio, he was able to explore more the field of time series analysis. Then, he was able to use it as a statistical computing tool for multiple linear regression. Later, he found himself using RStudio in making handouts, examinations, and even reports as a teacher, and answering homework, doing computations, and also making reports as a student. During his course work in his Doctor of Philosophy course, they used SPSS. He compared the use of SPSS with the use of RStudio. He found out that every computation in SPSS has a counterpart in RStudio.

“R is a language and environment for statistical computing and graphics” (R Core Team, 2020). R is open source and can be used in a wide array of statistical (linear and nonlinear modeling, classical statistical tests, time-series analysis, classification, clustering, etc.) and graphical techniques that can be extended with the use packages. Currently there are 16,732 packages available for various statistical computations and other tasks. According to the R Core Team; “One of R’s strengths is the ease with which well-designed publication-quality plots can be produced, including mathematical symbols and formulae where needed”. R has recently gained popularity in universities and research institutes and is currently 8th in the August 2020 TIOBE’s index from being 20th last year mainly due to its being open source and its use in the COVID 19 research and analytics (Whitney, 2020).

On the other hand, RStudio has made the use or R easy, manageable, and even more extensible. “RStudio is an integrated development environment (IDE) for R” (RStudio Team, 2016). It is also open source. RStudio includes a console, syntax-highlighting editor for direct code execution, as well as tools for plotting, history, debugging and workspace management. Furthermore, RStudio has integrated support for version control systems like Git (Chacon & Straub, 2020) that can lead to the use of GitHub (GitHub, 2020); a website that host code repositories for collaboration. Recently, RStudio cloud (RStudio Team, 2020) was created to support the use of RStudio directly from the web browser without the hardware hassles which is designed for instructors and students for the purpose of teaching and learning data science with RStudio.

RStudio presents a very powerful and economical tool to teach, learn, and practice statistics. However, it is quite surprising that the popularity of R and RStudio among academicians in the province is very minimal.

In a different point of view, the practice of statistics is computational. Statistical computing software are mainly used to do statistical computing. With the emergence of data science as a field due to big data, machine learning and powerful computers that are no longer expensive all brought about by the 4th industrial revolution, it is very fitting to consider how statistics education should adapt to these changes and be relevant in the practice of statistics. In this regard, in 2005, Franklin et al. (2007) put forth the Guidelines for Assessment and Instruction in Statistics Education (GAISE) Report recommending a framework for statistics education both in the k to 12 and college level. In 2016, the GAISE College Report ASA Revision Committee (2016) revisited the effectiveness of the framework and still found it effective. The framework is now the standard in statistics education in the United States and in many countries that adopted it (Zeiffler, Garfield, & Fry, 2018).

In the GAISE report, one noteworthy recommendation is “the use of technology to explore concepts and analyze data” (GAISE College Report ASA Revision Committee, 2016, p. 3). Studies have shown that the use of technology can really improve statistics education; equipping learners with relevant data skills and effective powerful tools in this era where data is very much abundant (Chance, Ben-Zvi, Garfield, & Medina, 2007; Chance & Rossman, 2006; Çetinkaya-Rundel & Rundel, 2017; Doi, Potter, Wong, Alcaraz, & Chi, 2016; Harraway, 2012; Stander & Dalla Valle, 2017). However, when it comes to software used in doing statistical computing and teaching statistics, there is no single statistical computing tool that fits all statistical tasks (McNamara, 2018). Nonetheless, introductory statistics students should be taught a common statistical computing software such as SAS, SPSS, or R, enthusing them to continuously learn statistics technology since statistical tools are diverse and eventually evolve through time (Gould et al., 2018). Moreover, Gould (2010), N. J. Horton et al. (2015), N. J. Horton (2015) and Hardin et al. (2015) pointed out the importance of developing among students – with the use of statistical computing software – data management skills in introductory and second courses in statistics.

In our country, leading universities are addressing this issue and have already integrated the use of technology in their curriculum for statistics education. The University of the Philippines for example uses a number of software in its introductory statistics courses and statistics courses (e.g. R with RStudio, Python, SAS, SPSS, Stata, MS Excel, QGIS, ArcGIS, Gephi, yEd Graph Editor, and more). Most of the software used are open source.

In the province, some universities have acquired SPSS to teach statistics courses. On the other hand, some still use calculators to do and teach statistical computing. Unfortunately, both setups do not lessen the gap between statistics education and statistical practice. In reality, most institutions to which graduates from these universities get employed cannot afford SPSS. The use of SPSS requires a paid license. One can choose MS Excel as an alternative; however, its functions are limited (Biehler, Ben-Zvi, Bakker, & Makar, 2013).

Now, the entire world is under the devastation of COVID 19. We are in a public health emergency and everyone is concerned with public safety. Measures taken by the government have drastically changed the normal state of practice in all offices. In the education sector, face to face classroom set up is no longer being practiced. The Commission on Higher Education implemented flexible learning to cope up with this situation (Commission on Higher Education, 2020). However, instruction through flexible learning is very challenging. The Commission on Higher Education stated in the guidelines that “the main objective should be to provide learners with the most flexibility on the learning content, schedules, access, and innovative assessment, making use of digital and non-digital tools” (p. 3). Teachers need to be creative in order to device new ways to be effective in implementing flexible learning.

Data management in the general education subject Mathematics in the Modern World is an introductory statistics course. The teaching of data management can really be challenging in this situation; with flexible learning. It is very crucial to make the students’ learning experience meaningful and relevant since data management is very useful in a world where data is really abundant. The use of software in the data management class should not be compromised. The use of software will introduce the student to and equip the student with powerful tools that will really help them give meaning to data they will encounter in their jobs and daily lives. To reiterate this, the textbook used in Mathematics in the Modern World at Nueva Vizcaya State University (NVSU) states that going through Data Management, students should be able to:

1. Use a variety of statistical tools to process and manage numerical data;
2. Use the methods of linear regression and correlation to predict the value of a variable given certain conditions; and
3. Advocate the use of statistical data in making important decisions (Reyes et al., 2018, p. 83).

However, the use of software in teaching statistics has become even more challenging than ever with flexible learning. This can be attributed to the fact that not all students can afford a laptop or a desktop, poor internet connection to no internet connection, and pedagogical challenges brought about by the previous two.

In this context, in an attempt to improve statistics education and the practice of statistics in NVSU, to provide a powerful tool to teach and practice statistics to future statistics teachers in the province, and to provide an alternative way of teaching statistics during the implementation of flexible learning in times of pandemic, the researcher will introduce the use of R with RStudio to the BSEd Mathematics and BS Mathematics students in their data management class. Then the researcher will see if there is a significant change in their performance in the class. Finally, the researcher will identify themes and categories that will anchor the study to the bigger context of statistics education and thereby serve as departure points as basis for policies that will lead to curriculum, instruction and assessment development with respect to statistics education in NVSU specially with flexible learning.

## Statement of Objectives

To adapt to the changes in technology brought about by the 4th industrial revolution, to be abreast with the global community when it comes to statistics education, in an attempt to bridge the gap between the statistics education and the practice of statistics, and to address the pedagogical challenges brought about by flexible learning in teaching statistics in times of pandemic, RStudio as a statistical computing tool in learning data management will be introduced to BSEd Mathematics and BS Mathematics students of NVSU. The objectives of the researcher after gathering profile variables, employing a two group counterbalanced measures design, and letting the students share their stories and narratives in using and not using RStudio in their data management class through essay are:

1. To determine the performance of the students before and after using and not using RStudio in their data management class.
2. To determine the effect of using RStudio in the performance of students in their data management class.
3. To describe the experiences of the participants in using and not using RStudio in their data management class.
4. To identify departure points as basis for policies that will lead to curriculum, instruction and assessment development with respect to statistics education in NVSU specially with flexible learning.

## Hypotheses

Test of hypothesis for the difference in the mean scores of the students when grouped according to using and not using RStudio.

H0: There is no significant difference in the mean scores of the students when grouped according to using and not using RStudio.

Ha: There is significant difference in the mean scores of the students when grouped according to using and not using RStudio.

Test of hypothesis for the difference in the mean scores of the students when grouped according to course.

H0: There is no significant difference in the mean scores of the students when grouped according to course.

Ha: There is significant difference in the mean scores of the students when grouped according to course.

Test of hypothesis for the difference in the mean scores of the students when grouped according to topic.

H0: There is no significant difference in the mean scores of the students when grouped according to topic.

Ha: There is significant difference in the mean scores of the students when grouped according to topic.

## Significance of the Study

***Department of Science and Technology Science Education Institute (DOST-SEI).*** This study will contribute to their rich repository of researches in the field of science education: mathematics. It will serve as a basis for pioneering works in integrating RStudio in the curriculum of statistics education in the province of Nueva Vizcaya.

***University Administrators.***

***Faculty members teaching statistics.*** This is also important to faculty members who teach statistics and do research since it gives them a glimpse of what is happening in statistics education and in practice.

***Students.*** This study is significant to students for them to be able to see the practicality and applicability of other statistical software like R using RStudio.

***Future Researchers.*** Future researchers who would like to do research in the field of statistics education will find this study useful to cite. It can also serve as a basis for related studies.

## Scope and Delimitation

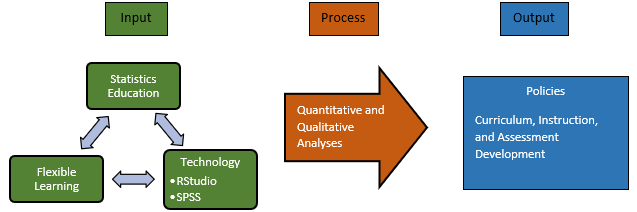
The focus of the study is to see the effect of using RStudio to the performance of students in their Data Management class. The respondents will be the BSEd Mathematics and BS Mathematics students taking up Mathematics in the Modern World in the first semester of school year 2020-2021 at Nueva Vizcaya State University Bayombong Campus. The study will also identify themes and categories that will anchor the study to the bigger context of statistics education and thereby serve as departure points as basis for policies that will lead to curriculum, instruction and assessment development with respect to statistics education in NVSU specially with flexible learning.

## Conceptual and Analytical Framework

Using RStudio in teaching statistics with flexible learning, four concepts were identified.

1. Technology Pedagogy Content Knowledge (TPCK) (Mishra & Koehler, 2006). According to Mishra and Koehler, the introduction of new technology reconstructs the dynamic equilibrium among technology, pedagogy, and content knowledge. Flexible learning has changed the face of using technology in education. In this situation, it is very critical and important that teachers should rethink their technology, pedagogy and content knowledge.
2. Guidelines for Assessment and Instruction in Statistics Education (GAISE) College Report 2016 (GAISE College Report ASA Revision Committee, 2016). The report enumerated six recommendations: 1) Teach statistical thinking. 2) Focus on conceptual understanding. 3) Integrate real data with a context and purpose. 4) Foster active learning. 5) Use technology to explore concepts and analyze data. 6) Use assessments to improve and evaluate student learning. It is with these recommendations that statistics education can be improved. However, it can be really challenging to adopt these recommendations with flexible learning.
3. Reproducibility. The use of RStudio actually promotes reproducibility since it is a tool designed for reproducible research (Gandrud, 2020). The use of RStudio will help teachers create reproducible documents and analysis that can be easily reproduced by students. Reproducibility will play a huge role in overcoming the pedagogical challenges posed by flexible learning in teaching statistics.
4. Bridging the gap between tools for learning and doing statistics (McNamara, 2015). This has been the challenge in statistics education through the years. And it can be even more challenging now with flexible learning. RStudio can help with this with its capabilities for reproducible research. RStudio is designed for statistics education and also for the practice of statistics.

Statistics education is currently under flexible learning. In this study, technology will be integrated to statistics education. Figure 1 shows the analytical framework of the study. The analytical framework is input process output. The interaction among statistics education, flexible learning, and technology will be the input. Then through quantitative and qualitative methods, policies on curriculum, instruction, and assessment development will be the output.



**Figure 1.** Analytical Framework

## Definition of Terms

**statistics education** - refers to the curriculum, instruction, and assessment in the teaching and learning of statistics.

**RStudio -** “R is a language and environment for statistical computing and graphics” (R Core Team, 2020). R is open source and can be used in a wide array of statistical (linear and nonlinear modeling, classical statistical tests, time-series analysis, classification, clustering, etc.) and graphical techniques that can be extended with the use packages.

**Performance of Students -** Student performance may be assessed along a variety of dimensions such as the scores in the pre-test and post-test.

**Data Management Class** – Data management is a chapter in the course content of the general education subject, Mathematics in the modern world.

**Flexible Learning** - Flexible learning for higher education institutions involves a combination of digital and non-digital technology, which according to CHED, doesn't necessarily require being connected to the internet. Flexible learning “ensures the continuity of inclusive and accessible education when the use of traditional modes of teaching is not feasible, as in the occurrence of national emergencies.”

# CHAPTER II REVIEW OF RELATED LITERATURE

## The Necessity of Statistics Education and its Current Landscape

The book entitled *International Handbook of Research in Statistics Education* edited by Ben-Zvi, Makar, and Garfield (2018) offers a wide array of topics concerning statistics which best fit in this section. The book has three main parts which are interrelated to each other: Part I: Statistics, Statistics Education, and Statistics Education Research; Part II: Major Contributions of Statistics Education Research; and Part III: Contemporary Issues and Emerging Directions.

An article entitled “What Is Statistics Education?” succinctly discusses the nature and necessity of statistics education to all level – from secondary to tertiary up to graduate level. The authors defined statistics education this way:

Statistics education is an interdisciplinary field that is focused on the teaching and learning of statistics. Evolving from the field of mathematics education, which supplied valuable theories of learning, models of conceptual development and change, and methods of qualitative research (e.g., teaching experiments, clinical interviews), statistics education has emerged as an independent area of inquiry and scholarship with its own journals, conferences, organizations, websites, and curriculum standards (Zeiffler et al., 2018).

Based from the definition of statistics education, it is said to be an evolving field from the field of mathematics wherein it is “interdisciplinary” that focused on both “the teaching and learning of statistics” and thereby “emerged as an independent area of inquiry and scholarship”.

Perhaps the next inquiry is, why is statistics education necessary in everyday life and specifically in the curricula as well as how its integration in the curricula will help students abreast with technological pedagogy and skills.

The discussion of the book article “What Is Statistics?” by Wild, Utts, and Horton (2018) directs our attention to the nitty-gritty of statistics and how this field is important in our day to day life given the advent of technological advances that produce rich data. For example, the authors argue that “In today’s data-rich world, all educated people need to understand statistical ideas and conclusions, to enrich both their professional and personal lives”. Thus, with this context of today’s world where data is accessible everywhere from mass media especially social network such as Facebook, it can be said that “the widespread availability of interesting and complex data sets and increasingly easy access to user-friendly visualization and analysis software mean that anyone can play with data to ask and answer interesting questions”. Statistics is vigorously gaining importance and recognition in today’s society.

Other authors also recognize the necessity of statistics:

“Statistics is a central tool in moving science, economics, politics, schools, and universities forward”. Quantitative information is omnipresent in media and in the everyday lives of citizens worldwide. Data are increasingly used to add credibility to advertisements, arguments, or personal and professional advice. Therefore, there is a growing public and policy consensus that being able to provide reliable and persuasive evidence-based arguments and critically evaluate data-based inferences are crucial skills that all citizens of the twenty-first century should have (Ben-Zvi & Makar, 2016).

In addition, “statistical methods are used in almost all knowledge areas and increasingly are used by businesses, governments, health practitioners, other professionals, and individuals to make better decisions” (Wild et al., 2018). This is true wherein based on my observations, most government and private agencies rely on statistical methods through surveys to make policies, laws and even programs that are geared towards communities and nation’s development.

In this case then, academic institutions also integrated statistics in the curricula thinking that “probably no academic subject is more useful to both working professionals and informed citizens on a daily basis than statistics” (Wild et al., 2018). On this note, we can say then the impending necessity of statistics in the educational system. For instance, the book article “International Perspectives on the Teaching and Learning of Statistics” posits:

Being able to provide sound evidence-based arguments and critically evaluate data-based claims are important skills that all citizens should have. It is not surprising therefore that the study of statistics worldwide at all educational levels is gaining more attention. The study of statistics provides students with tools, ideas and dispositions to react intelligently to information in the world around them. Reflecting this need to improve students’ ability to think statistically, statistical literacy and reasoning are becoming part of the mainstream school and university curricula in many countries. As a consequence, statistics education is becoming a thriving field of research and curricular development (Ben-Zvi & Makar, 2016).

However, “the rapid development of data science… provides challenges for statistics educators in determining learning goals, and opportunities for statistics education researchers to explore what instructional methods can best achieve those goals” (Wild et al., 2018). Moreover, the said article also points out present challenges of statistics education especially to students:

What are the areas where statistics may need to adapt to be relevant to data science? In addition to pedagogy and content, technology is a key realm. While the Guidelines for Assessment and Instruction in Statistics Education (GAISE) K-12 (2005) and College (2016) reports encouraged the use of technology (which, on a more positive note, is now widespread in most courses), hundreds of thousands of high school students still use calculators rather than computers for their analyses, limiting their ability to move beyond simple calculations or gain any sense of realistic workflows that they might encounter in the real world. But much worse, it also narrowly constricts their vision of what statistics is and can be and neglects the huge potential of the visual sense for gaining insights from data (Wild et al., 2018).

Given these challenges of statistics education in terms of pedagogy and content, one factor to consider is technology: most students use calculator over computer in statistical analyses. Aside from this, statistics can be seen in both perspectives wherein “despite the increasing awareness of the importance of statistical literacy, statistics has been viewed by many students as difficult and unpleasant to learn” (Ben-Zvi & Makar, 2016). On the other hand, “many university instructors find statistics and research methods courses equally frustrating and unrewarding to teach” (ibid.). Not only that, “in schools, mathematics teachers often view statistics as a marginal strand in the mathematics curriculum and therefore minimize or ignore its teaching” (ibid.). Hence, it is no wonder how one article describes the dilemma of learning and teaching statistics wherein “many countries still lack sufficient resources, updated curriculum materials, effective professional development of teachers, and current technologies, infrastructure essential to carry on the reform movement in statistics education” (MacGillivray, Martin, & Phillips, 2014).

With this background on learning and teaching statistics, as well as on issues of statistics in researches, it is hope that this preliminary study will somehow fill in the gaps as pointed out in different literature. This is where my study would like to investigate.

### A Brief History of Statistics Education

The book entitled *The Teaching and Learning of Statistics: International Perspectives* edited by Ben-Zvi & Makar (2016) and The book entitled *Third International Handbook of Research in Statistics Education* edited by Ben-Zvi et al. (2018) are useful in this section as these books trace the history of statistics education in the international perspectives. Along with the development of statistics are the books’ discussions of challenges posed in the field of statistics. These books are collaborative work where authors came from different parts of the world. Given this background of the book where author-contributors are from different countries, hence tracing the historical background of education statistics is better understood.

#### The Global Perspective on Statistics Education

The book article “What Is Statistics?” by Wild et al. (2018) present the global perspective of statistics education as it traces its beginning across Western Europe who were influenced by the Renaissance Period “by the rise of science based on observation of the natural world” wherein “the statistical analysis of data is usually traced back to the work of John Graunt”. In addition, “another fundamental thread involved in building modern statistics was the foundation of theories of probability, as laid down by Pascal (1623–1662) and later Bernoulli (1654–1705), which were developed to understand games of chance”. The probability analyses were then “later applied to social data by Quetelet (1796–1874), who with notions such as the “average man” was trying to arrive at general laws governing human action, analogous to the laws of physics”. But then, during the French Revolution “when there was a subtle shift in thinking of statistics as a science of the state with the statists, as they were known, conducting surveys of trade, industrial progress, labor, poverty, education, sanitation, and crime”.

Another significant thread in the development of statistics is the statistical graphics where “the first major figure is William Playfair (1759−1823), credited with inventing line charts, bar charts, and the pie chart” that it was considered the “period from 1850 to 1900 as the “golden age of statistical graphics””. Significant statistics organizations were formed during this century like the Royal Statistical Society in 1834 as the London Statistical Society (LSS), and the American Statistical Association, formed in 1839.

During the 1900, statistics paved way to more developments:

Another wave of activity into the 1920s was initiated by the concerns of William Gosset, reaching its culmination in the insights of Ronald Fisher with the development of experimental design, analysis of variance, maximum likelihood estimation, and refinement of significance testing. This was followed by the collaboration of Egon Pearson and Jerzy Neyman in the 1930s, giving rise to hypothesis testing and confidence intervals. At about the same time came Bruno de Finetti’s seminal work on subjective Bayesian inference and Harold Jeffrey’s work on “objective” Bayesian inference so that by 1940 we had most of the basics of the theories of the “modern statistics” of the twentieth century. World War II was also a time of great progress as a result of drafting many young, mathematically gifted people into positions where they had to find timely answers to problems related to the war effort. Many of them stayed in the field of statistics swelling the profession. We also draw particular attention to John Tukey’s introduction of “exploratory data analysis” in the 1970s; this is an approach to data analysis that involves applying a variety of exploratory techniques, many of them visual, to gain insight into a dataset and uncover underlying structure and exceptions (Wild et al., 2018).

Conversely, along with the development of statistics is the formation of local, national and international associations and conferences in different parts of the world solely dedicated on statistics “whose overall mission is to promote the understanding, development and good practice of statistics worldwide” (MacGillivray et al., 2014). Example of these are The International Association for Statistical Education (IASE) is one of the Associations of the International Statistical Institute (ISI) which was founded in 1885, then the first international round table on statistics education was held in 1968, and the first International Conference on Teaching Statistics (ICOTS) was held in 1982” (ibid.). Way back then, statistics continues to thrive as the IASE organizes satellite conferences to the biennial ISI World Statistics Congresses (WSC), statistical education strands within the WSC, and international round tables every 4 years. Nonetheless, in order to promote statistics at its core, there are also options of publishing one’s researches wherein “IASE offers an optional double-blinded refereeing process and publishes proceedings, now online” (ibid.).

#### Local Perspective: The Philippine Context

One literature most relevant to this section is the paper “The Teaching of Statistics in The Philippines: Moving to A Brighter” by Bersales (2010) of the University of the Philippines. Bersales traces the development of statistics in the Philippines in the year 1953 when “Statistical Training Center was established under a bilateral agreement between the Philippine government and the United Nations” with the observation of the first board of directors of the Philippine Statistical Association that “staff doing statistical work then did not have formal training in statistics as well as college education offered only three units of elementary statistics and there were no undergraduate and graduate programs in statistics in the Philippines”. And so, the Center offered its first academic program, Master of Arts in Statistics, instituted in 1954. During the years of 1953-1969, the degree offering of Statistics in the country has gained momentum where the Center offered MS and PhD courses as well as “faculty for the center were recruited and sent to American universities to earn their MS degrees and/or PhD degrees”.

Later, the Center was formally turned over to the University of the Philippines in 1963 and in 1998, the Center was renamed The School of Statistics, which “provided more recognition in the university of statistics as a discipline separate from mathematics” and more academic programs were instituted in other universities in the Philippines such as University of the Philippines Los Baños (UPLB), Polytechnic University of the Philippines (PUP), and Mindanao State University – Iligan Institute of Technology (MSU-IIT).

The year 2000 onward, Bersales describes as the technology years where “the importance of computer software and hardware in the practice of statistics gained recognition”. This means that learners and teachers need to be abreast with these changes yet “the teaching of statistics was modified and enhanced with technology but the enhancement did not come fast since access to facilities was available only to a few as well not all teachers were trained in the use of software and hardware”. Bersales even recognized that these challenges of statistics in the Philippines “is still existent up to the present”. The author also points out that in 2006, “nineteen academic institutions were already offering statistics programs from B.S. to PhD” and graduates became in demand in private and government institutions.

With this development of statistics in the Philippines, Bersales and some authors reports some problems of teaching statistics in the Philippines:

lack of good quality statistics books, lack of qualified teachers in statistics, inadequate facilities such as computer laboratories to aid in teaching statistics, teaching methods that do not enhance students’ learning of statistics. Additional problems were identified during the teacher training of the Philippine Statistical Association: lack of recognition of statistics as an important course in their respective colleges, dearth of local reference materials that have passed the review of a panel of experts, teachers’ need for more hands-on practice on handling data, unavailability of statistical software in their colleges, lack of qualified statistician as member in research/thesis advisory committee (Bersales, 2010).

These problems are also true in our university, NVSU, though we are not offering Statistics degree program but college students especially BSED major in Mathematics are required to get statistics subjects. Thus, this preliminary study is geared towards program development (i.e. existence of computer laboratories equipped with open-source statistical software dedicated to mathematics major students and policy formulations and integration (streamlining of university’s budget for statistics packages, programs and development).

## RStudio in Teaching Statistics

There are many statistical software that can be used in analyzing data. One most prominent software used in universities is the SPSS. Though, SPSS is widely used, it can be said that it is expensive that one has to buy its license. Hence, an alternative to this is looking for a statistical software that is open-source and free. One of these is the R using RStudio (RStudio Team, 2016).

One example of how RStudio is used in teaching statistics is the article “Supporting Data Science in the Statistics Curriculum” by Loy, Kuiper, and Chihara (2019). Their study “describes a collaborative project across three institutions to develop, implement, and evaluate a series of tutorials and case studies that highlight fundamental tools of data science – such as visualization, data manipulation, and database usage – that instructors at a wide-range of institutions can incorporate into existing statistics courses”. What is interesting in this study was the use of R statistical software. The authors argue that “while R is certainly not the *only* choice, we believe it is the *best* choice when adding these topics to existing statistics courses” (emphasis, original).

In addition to this, the authors also identified six (6) reasons in choosing “R tutorials and case studies to help students develop facility with statistical software for data management and visualization”:

1. R is one of the most popular programming languages in the world (Cass, 2017).
2. R was developed by statisticians for statistical analysis, making it is a natural choice for a statistics course. Additionally, there is less overhead required for tasks, such as data visualization than in Python (another popular language for data science), especially when using packages, such as mosaic and ggformula, which are designed to be easily accessible to people with no programming background.
3. R is open source, so students are learning a toolkit that will still be accessible to them after they complete the course.
4. RStudio is consistent across operating systems, eliminating the need for multiple sets of instructions. This is not the case with other software packages – even Excel is not identical across platforms. Additionally, your institution can set up an RStudio Server for your students to ensure that everyone has exactly the same version of R, the necessary R packages, and even datasets (Çetinkaya-Rundel & Horton, 2016).
5. R makes reproducibility easy. For example, if you share your dataset and R Markdown document, then your analysis can be easily rerun by another researcher.
6. Graphics, data, and RMarkdown files are easy to export into other formats.

Given these benefits of RStudio, however, the authors also emphasize two (2) common pitfalls in using R. These are the following: 1) First, the error messages produced by knitting an R Markdown file are often harder to decipher than the errors produced within code chunks; 2) Second, students often have trouble reading their own data into R within R Markdown documents if they do not save the data in the same location as the .Rmd file. Though the authors point these pitfalls, what is good about it, is they also recommend solutions by “providing zip files containing the RStudio project and all associated files so that students can simply open the project and start working through creating a GitHub repository for the labor assignment containing the necessary file and using DownGit”.

In relation to the use of R software, another interesting article “Teaching with R – A Curse or A Blessing?” by Gomes and de Sausa (2018) explains the advantages and disadvantages of R to undergraduate and graduate students of Mathematics and Social Sciences using an online module. Gomes and de Sausa (2018) argue that “although the advantages of R are well-known (free, open source, continually updated by experts), it is not the first choice among college students, especially those not majoring in mathematics or statistics”. The authors contend that “a problem that appears when teaching R is that once the great potential of the software is understood, the temptation is to focus immediately on more advanced analysis, which adds frustration for beginning learners of R”.

Aside from this, the authors also discuss two possible reason why teaching with R could be a blessing or curse: 1) possible reasons for this resistance to R, whether the learners are undergraduate or graduate students or even other teachers from a variety of areas of science, is the fact that, teachers tend to emphasize a wide range of commands and programming lines from very early on, making learning R a slow and frustrating task; 2) learning R may be seen as similar to learning a foreign language… then a student with no skills or practice in statistics or programming languages should be able to learn R.

In their discussion of their pilot study with R to undergraduate and graduate students, they found out that “the problematic issues focused more on their comprehension of the R language”. Another reason is “the individuals’ varying degree of knowledge, both technological and scientific, and in particular their overall knowledge of certain statistical principles”. Hence, in order to address these problems, the authors proposed an online module using Facebook.

Interestingly, with these innovations and variations in teaching R with students, the results show that “students served to encourage greater implementation of the use of free software, namely R, in the pedagogical practices of teachers and in their daily life”. Not only that, the way the authors present the online module through Facebook environment “contributed to promoting greater student participation in the learning process, one that is more focused not only on their autonomous work, but also on the development of their abilities to work as a team”.

Hence, Gomes and de Sausa (2018) conclude that teaching with R could be a blessing if the right buttons of activities and even academic environments blend well. This is true as they conclude that “starting this process even at an early stage in school will most certainly contribute not only to the improvement of teaching methodologies, but also to the promotion of statistical literacy among students and teachers”.

## Synthesis

Carefully chosen related studies for this paper can be categorized into three themes such as :1) the history of education statistics; 2) the necessity of technology in statistics education and 3) the use of open access and free software in statistics such as RStudio.

These related studies help me to some extent identify gaps in the literatures and where my study could somehow contribute. For instance, the study of Chance, B., Ben-Zvi, D., Garfield, J., & Medina, E. (2007); Biehler, R., Ben-Zvi, D., Bakker, A., & Makar, K. (2013) and Bersales, L. G. S. (2010) point out the necessity of technology in statistics education by identifying free software that can help students to appreciate statistics in different aspects of academic and everyday life. On the other hand, the studies of Harraway, J. A. (2012), Doi, J., Potter, G., Wong, J., Alcaraz, I., & Chi, P. (2016), and Gomes, D., & de Sausa, B. (2018) highlights the use of flexible learning using online modules and motivational videos intended solely for statistic courses. These methods of online teaching and learning statistics are deemed more important today given the covid-19 pandemic the world is battling right now. This gap is where my study would like to fill in – “The Effect of Using RStudio to the Performance of Students in their Data Management Class Under Flexible Learning”.

**Table 1. Summary of Related Studies Conducted**

| **Author/s and Year** | **Title of the Study/Research** | **Key Findings** | **Locus** | **Method** |
| --- | --- | --- | --- | --- |
| Loy, Kuiper, and Chihara (2019) | “Supporting Data Science in the Statistics Curriculum” | Navigates the fundamental tools of data science such as visualization, data manipulation, and database usage with the use of R statistical software. | Lawrence University and Grinnell College, Iowa, USA | Series of tutorials and case studies |
| Wild, C. J., Utts, J. M., & Horton, N. J. (2018). | What is statistics? | Statistics is vigorously gaining importance and recognition in today’s society especially the widespread availability of interesting and complex data sets and increasingly easy access to user-friendly visualization and analysis software; such that statistical methods are used in almost all knowledge areas and increasingly are used by businesses, governments, health practitioners, other professionals, and individuals to make better decisions  Technology is a key realm, aside from pedagogy and content in advancing data science and management | Not indicated | Literature review |
| Zeiffler, A., Garfield, J., & Fry, E. (2018). | What is statistics education? | Critically examines the nature and necessity of statistics education to all level – from secondary to tertiary up to graduate level, where statistics education as an evolving field from the field of mathematics wherein it is “interdisciplinary” that focused on both “the teaching and learning of statistics” and thereby “emerged as an independent area of inquiry and scholarship”. | Not indicated | Literature review |
| Gomes, D., & de Sausa, B. (2018). | Teaching with R – a curse or a blessing? | Advances the frontiers of R Studio incorporating pedagogical practices of teachers in students’ daily life through online module by using Facebook wherein this kind of academic environment contributed to promoting greater student participation in the learning process, one that is more focused not only on their autonomous work, but also on the development of their abilities to work as a team | University of Coimbra, Portugal | Online Module Designs using Facebook environment |
| Çetinkaya-Rundel, M., & Rundel, C. (2017). | Infrastructure and tools for teaching computing throughout the statistical curriculum | Fills the gap on the idea that working with data requires extensive computing skills and that statistics students should be fluent in accessing, manipulating, analyzing, and modeling with professional statistical analysis software.  computational infrastructure and toolkit which allow pedagogical innovations while minimizing frustration and improving adoption for both our students and instructors. | Duke University, USA | Github  RStudio |
| Ben-Zvi, D., & Makar, K. (2016). | International Perspectives on the Teaching and Learning of Statistics | Traverses the frontiers of statistics as a central tool in moving science, economics, politics, schools, and universities forward, hence, statistics education is becoming a thriving field of research and curricular development | Not indicated | Literature review |
| Doi, J., Potter, G., Wong, J., Alcaraz, I., & Chi, P. (2016). | Web application teaching tools for statistics using R and Shiny | Shiny App Teaching Tools Collection augments publicly available set of accessible, interactive web-based statistics teaching tools, which also provides complete source code for the apps so that users may easily tailor to their own needs.  The app gallery may stimulate ideas on how to present statistical concepts to students, and may even inspire instructors to create a new app of their own design | California Polytechnic State University, USA | Narratives of experiences using Shiny technology both for students and teachers  In-class demonstrations and for lab/homework exercises |
| MacGillivray, H., Martin, M. A., & Phillips, B. (Eds.). (2014). | Topics from Australian conferences on teaching statistics | Points out the dilemma of learning and teaching statistics where many countries still lack sufficient resources, updated curriculum materials, effective professional development of teachers, and current technologies, infrastructure essential to carry on the reform movement in statistics education  Landscapes the power of statistics to life in teaching, but also embedded in students’ and clients’ perceptions  . | Continent of Australia | Literature review  Personal reflections from a statistician, ‘seeing’ through student eyes, visualization and conceptualization of statistical inference |
| Biehler, R., Ben-Zvi, D., Bakker, A., & Makar, K. (2013). | Technology for enhancing statistical reasoning at the school level. | Advances the discussion of various types of technological tools and their benefits, purposes and limitations for developing students’ statistical reasoning, research and practice.  It highlights the future directions for technology in research and practice of developing students’ statistical reasoning in technology-enhanced learning environments. |  | Statistical Inferential  Dynamic data analysis software such as Fathom and Tinker Plots |
|  |  |  |  |  |
| Harraway, J. A. (2012). | Learning statistics using motivational videos, real data and free software | New and free software was devised known as GenStat for Teaching and Learning (GTL Schools and GTL Undergraduate), is menu driven and free in schools, in universities and in homes. GTL covers the statistical techniques in the school curriculum, advanced statistical techniques in undergraduate university subjects, and leads to a commercial version of GenStat for professionals and post graduates. Continuity provided by a comprehensive free package is an innovation beneficial for the transition from school to university and beyond. | New Zealand | Case studies using motivational videos which are deliberately flexible e and relevant for school use or university undergraduate statistics courses. |
| Bersales, L. G. S. (2010). | The teaching of statistics in the Philippines: Moving to a brighter future | Traces the history of statistics education in the Philippine context mapping out the real scenario in this context: lack of good quality statistics books, lack of qualified teachers in statistics, inadequate facilities such as computer laboratories to aid in teaching statistics, teaching methods that do not enhance students’ learning of statistics as well as unavailability of statistical software in colleges | Schools in the Philippines offering Statistics course/s | A roundtable  discussion with teachers of statistics during the 2009 Annual Conference of the Philippine Statistical Association |
| Chance, B., Ben-Zvi, D., Garfield, J., & Medina, E. (2007). | The role of technology in improving student learning of statistics | It provides the introductory statistics teacher who is considering using technology in the statistics classroom with some background of how the technology tools have evolved, a sense of the research findings and open questions on how technology impacts student learning, and specific advice for implementing technology. | Not indicated | Literature review |

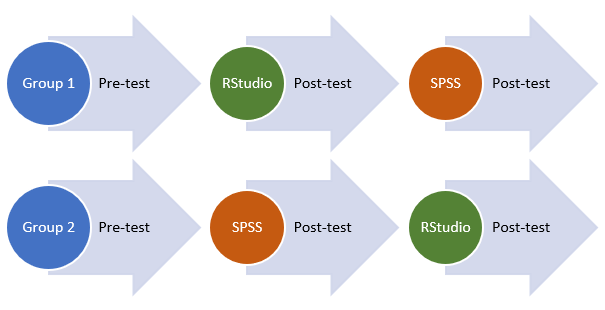


# CHAPTER III RESEARCH METHODOLOGY

## Research Design

The research design will be quasi experimental design. It will employ two group counterbalanced design or 2x2 latin square design. A pre-test will be conducted to both groups. Significant difference between the two mean scores in the pre-test will be determined to ensure that the two groups are comparable. Then group 1 will use RStudio and group 2 will not use RStudio for the first topic. Not using RStudio is the existing method of teaching data management during flexible learning. A post-test will then follow. Then group 1 will not use RStudio and group 2 will use RStudio for the second topic. Another post-test will follow. Figure 2 shows the diagram of the two group counterbalanced measures design to be employed. Both post-tests will be compared to see if there is significant difference in the scores of both groups.

Moreover, mixed-method will be used. This is a combination of quantitative and qualitative methods. Quantitative method will be used through the scores of the students in the pre-test and post-tests. The qualitative method will focus on the narratives and experiences of the participants to come up with categories and themes that will anchor the study to the bigger context of statistics education and thereby serve as departure points to craft policies that will lead to curriculum, instruction and assessment development with respect to statistics education in NVSU specially with flexible learning.



**Figure 2.** Two Group Counterbalanced Measures Design

## Research Environment

The research will be conducted in Nueva Vizcaya State University (NVSU) at Bayombong, Nueva Vizcaya. The vision of NVSU is to become “A premier university in a global community”. Its mission is “to develop an empowered, productive and morally upright citizenry through high quality, innovative, and relevant instruction, research, extension, and entrepreneurship programs adhering to international standards”.

## Subject of the Study

The respondents of the study are first year BSEd Mathematics students and BS Mathematics students of NVSU taking data management class in their Mathematics in the Modern World subject during the first semester of the school year 2020-2021.

## Research Instruments

The researcher will let the students sign a consent form. Then, there will be a survey questionnaire for the profile variables, which will come with the essay question soliciting for the experiences of the students in using and not using RStudio in their data management class. The researcher will make the pre-test and post-test. These tests will undergo validity and reliability. The researcher will write a letter to the President of NVSU through the Vice President of Academic Affairs, the Dean and the Department Chair of the Mathematics Department of the College of Art and Sciences at NVSU asking permission to conduct the research with the said purpose. The researcher will also use the syllabus in Mathematics in the Modern World specially in the part for data management as guide to follow in teaching the topic. The researcher will introduce RStudio as statistical computing tool in the data management class. For those who don’t have laptops or desktops, I will let them use rstudio.cloud. I will also use GitHub as a repository for R codes as instructional materials.

## Data Gathering Procedure

As soon as the research will be approved, the instruments will be finalized. Before conducting the experiment, the researcher will write a letter to the President of NVSU to ask permission. The researcher will then let the students sign the consent form. Statistical tests will be performed to the pre-test and post-test for validity and reliability before conducting the tests. Then the pre-test and post-test will be conducted. Post-tests will be conducted after each topic. Narratives and experiences on using and not using RStudio will be gathered through an essay question to be answered by the respondents. The essay question will also come with the survey questionnaire for the profile variables. The data gathered will then be analyzed and interpreted.

## Treatment of Data

Both descriptive and inferential statistics will be used in analyzing the data. Descriptive statistics will be computed for the profile variables. For the difference in the mean scores of the students when grouped according to using and not using RStudio, according to course, and according to topic, the test procedure will be F-test, and the test statistics will be and the decision rule will be to reject H0 if , otherwise fail to reject H0.

From the narratives and experiences of the students the researcher will come up with categories and themes that will serve as departure points to craft policies that will lead to curriculum, instruction and assessment development with respect to statistics education in NVSU specially with flexible learning.

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