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Analysis of College Students' Misconceptions of Quantitative Research in Social Sciences in China: Implications for Teaching

Xiangmei Li, Quanli Li, Qiuxiao Wang

School of Politics and Public Administration, Guangxi Normal University, Guilin 541006, China

Abstract: Research design is essential in regard to obtaining objective reliability for social science research. However, some social sciences students may be prone to many misconceptions regarding the understanding of quantitative research and application of statistics, which threatens the credibility of the research. To understand and potentially alleviate this problem, we examined 25 research projects and interviewed 10 undergraduate students who participated in quantitative methodology courses in social work and social welfare in a university in mainland China. This study aimed to explore students' misconceptions about quantitative research methods and statistical analysis. The results show that common misconception include but not limited to the following aspects: (1) taking research topics as research questions; (2) no clarification of sampling procedure in data collection and no random assignment in experimental research project; (3) no explanation of the validity and reliability of the construct measures; (4) violations of the assumptions of statistical tests; (5) misuses of statistical methods; and (6) misinterpretation of statistical findings; and (7) little consideration of research ethics. The findings indicate that institutes, educators, and students should make consorted efforts to improve the understanding of quantitative research methods and enhance statistical literacy of undergraduates in social sciences in China.

Keywords: Quantitative research methods; Misconceptions; Social sciences; Undergraduate students.

1. Introduction

Research design is the basis for cultivating the use of quantitative methods to analyze social phenomena. Statistical literacy is regarded as the ability to interpret, evaluate, and communicate statistical information and it is essential to prove the soundness of conclusions in all scientific research (Wallman, 1993). However, as there is a lack of understanding of fundamental statistical concepts, obtaining the wrong results from statistical analysis or misinterpreting the analyzed results are still common in social science research (Rosenbaum, 2009). Quantitative research is one of the main research methods used in the empirical research in social sciences. The purpose of social science research is to explore and explain human behavior and social phenomena, to reveal the patterns behind them, to seek solutions to social problems, and to promote social progress.

Additionally, in quantitative analysis, statistical methods are used to solve research questions. Data analysis permeates nearly every industry in modern society, and statistical literacy is becoming increasingly important across industries. In China, an increasing number of universities have started to give attention to improve the empirical research ability of students in social science disciplines. However, many students still encounter great challenges in doing quantitative research as a result of insufficient training in methodology and statistics. To help understand and potentially alleviate this problem, we have analyzed students' misconceptions about quantitative research methods as well as statistical analysis in China.

2. Research method

This study aims to explore undergraduate students' misconceptions about research design and statistical analysis in social work and social welfare in one university China. Our analysis sample included research design projects conducted by undergraduate students within the discipline of social welfare and social work (n = 40). Besides, we interviewed ten students for their holistic experience of learning during one semester of their undergraduate research training. Based on experience in discussing about their research projects and interviewing with the students, we aimed to further explore their misconceptions about quantitative research method and statistical analysis.

3. Results

(1) Misconceptions concerning research question

In some projects, there are no research questions, and the students only proposed the research topic they want to study. A research topic is normally a broad and overarching subject matter or area. Quantitative research is a structured approach of collecting and analyzing data from various sources to explore the patterns, associations, or causality between variables. It includes descriptive, comparative or relationship-based research. Some students take research topic as their research question in quantitative study. For example, to one project plans to study the development social welfare in China. A research question narrows down the scope of the study.

(2) Misconceptions concerning data collection

High-quality data is the foundation for statistical analysis. Researchers should provide sufficient information regarding sampling frames, sampling methods, instrument design, and control of data quality. The following sections describe the misuses in sampling methods and measurement tools respectively. Some studies describe sampling methods incorrectly. In a parametric testing study, the sample data are assumed to be drawn from a random sample of the population and that the data are representative of the population. However, the research adopted a convenient sampling method, in which not all unit in the population has an equal chance of

participating in the study. The law of large numbers is inapplicable, and the sampling error cannot be determined and controlled. Therefore, it is impossible to explain the extent to which the statistical value of the sample is suitable for the population.

Second, when using experimental research design, many studies do not know how to use random assignment. According to the principle of randomization, participants should be randomly assigned so that each participant has an equal chance to be assigned to the experimental group or the control group. The confounding factors that affect the outcome variable can be balanced, which makes the experimental group and the control group comparable. Some studies used experimental methods without matching participants. Therefore, whether there is a difference between the two groups before the experiment remains unknown. Students could not collect data using probability sampling in survey research, or have random assignment in experimental research, which are crucial for data quality.

(3) Misconceptions concerning variable measurement

The application of statistical methods should be chosen based on the variable type. Researchers should identify the different types of variables they are trying to measure, manipulate and/or control. To ensure the accurate and consistent measurements for the concepts under study, validity and reliability of variable measurement should be taken into consideration. However, some studies fail to test the reliability and validity of scales. Before conducting a survey, the researcher should evaluate the reliability and validity of the measures in the questionnaire. They are the psychometric properties of measurement scales and form key criteria to assess measurement quality. Reliability tests consistency of indicators and validity tests accuracy. A scale with acceptable reliability and validity is the prerequisite for solid research. The reliability and validity of the instruments are not assessed or reported in some projects. Some other studies applied the self-developed instruments, without explaining the scale development process.

Secondly, some projects do not indicate that they should use verified scales to measure construct. Cronbach's alpha is a commonly used method to measure the internal reliability of a scale. But it is worth noting that the sensibility of α is affected by the number of items and the dimensions of the scale. If a scale includes multiple factors, it will reduce the reliability of alpha sensibility. For scales containing multiple items, dimensionality reduction should be performed before using α. KMO test and Bartlett's test should be carried out during dimensionality reduction to judge whether the data is suitable for factor analysis. Some studies only report the α value of the original scale. The original research sample and the population of the current study are different, so the reliability and validity of the measures need to be re-evaluated.

(4) Violations of the assumptions of statistical tests

To draw valid conclusions from inferential statistics, the model needs to meet the testing assumptions. For example, linear regression models need to meet six assumptions (Poole & O'Farrell, 1971): linearity (there is a linear relation between X and the mean of Y); independency (the independent variables Xi are linearly independent of each other); normality (for any fixed value of X, Y is normally distributed); homoscedasticity (the variance of residual is constant for all distributions); the continuous outcome variable; and zero mean error (each conditional distribution of β0 has a mean of zero). The variance inflation factor is an important index to judge multicollinearity among independent variables. Violations or ignorance of the assumptions in regression is quite common. For instance, lack of homoscedasticity test, no report of VIF, no nonnormality test, etc. How to meet assumptions of statistical test could be explained in the research design.

(5) Misuse of statistical methods

An appropriate statistical method is a key premise to guarantee the quality of research. Some studies proposed their statistical methods, which are not appropriate for their project. First, we take the t-test as an example, the most frequently used method in our sample. T-test is mainly used to test the level difference of a single independent variable, which is one of the commonly used statistical methods of inference. Some studies do not consider the type of sample used for the T-test. For example, a study attempts to explore the effectiveness of psychological therapy in the experimental group before and after the experiment. In the research plan, independent sample T-test was proposed to analyze whether there was a statistically significant difference between the data of the experimental group before and after the experiment. In experimental studies, before and after studies on the same subjects are often used to compare the effects of treatment or intervention factors, which is a typical type of self-matching experimental design and does not meet the independent hypothesis of the independent sample T-test. In this case, when the difference meets the condition of normal distribution, the paired sample t-test is more appropriate.

Second, when using correlational analysis, the variable type is not considered. A correlation coefficient measures the extent to which two variables are related. Commonly used correlation coefficients include the Pearson correlation coefficient and Spearman correlation coefficient. Pearson product difference correlation coefficient is used to measure the linear correlation between two continuous variables. If the rank of two variables is used for linear correlation analysis, the Spearman correlation coefficient should be used. It does not require the distribution of original variables and belongs to the non-parametric statistical method, which is suitable for measuring the correlation between fixed variables or ordered variables. Some studies misused the Pearson correlation coefficient to analyze the correlation between two ordering variables.

Thirdly, control variables are not introduced into the multiple regression model in the research design. The inclusion of other factors that affect dependent variables in the statistical model can eliminate the items that interfere with the model. When the regression coefficient of the core independent variable is still significant after the addition of the control variables, the empirical force of our hypothesis is more effective. However, some multivariate linear regression models do not control the interference variables. For example, one paper established a multiple linear regression model in order to analyze the relationship between physical exercise and the life satisfaction of left-behind children. There are only three independent variables in the model: exercise intensity, exercise duration, and exercise frequency. There are confounding factors related to life satisfaction, and the control variables could reduce endogeneity. The absence of control variables will lead to deviation in results.

In addition, the experimental studies in the sample that use t-tests are not rigorously designed. First, the independent sample t-test is performed on control group O1 and control group O2 before treatment, and then the independent sample

t-test is performed on experimental group O3 and control group O4 after treatment. If the difference between the former is not significant, while the difference between the latter is significant, However, some studies were designed according to the first or second method, and the use of the T-test was correspondingly not appropriate.

(6) Misinterpretation of statistical findings

The interpretation of statistical results should be based on the support of statistical data analysis results, not subjective inference. Some students may not have a thorough understanding of statistical principles and interpret the inferred results incorrectly. In t-test, the correlation analysis between variables is obtained. The t-test is designed to determine whether the mean values of two groups of data are significantly different. For example, one study planned to use experimental method to analyze whether attending a social work intervention program has an impact on the depression level of the elderly. The student chose to use paired sample t-test to analyze phycological status of the experimental group before and after the experiment. The T-test is used to compare the means of two groups and could not infer the relationship between the variables.

Analysis of variance is applicable to test the significance of the mean differences of two or more samples. The null hypothesis is that the population mean represented by the samples are relative, and the alternative hypothesis is that the population means represented by the samples are not all equal. We cannot compare the sample means and infer it to the population means based on the F-test. However, some students assume that they can directly derive the mean size from the results of analysis of variance. For example, a project intended to use repeated measure analysis of variance to analyze whether there are differences between the depressive symptom level of the elderly co-residing with their adult children and those who lived along. The results of ANOVA analysis in this design only showed the mean and standard deviation of each variable. To further compare the mean size between the two groups, LSD method, SNK method, Bonferroni method, etc., can be used, and Dunnett-t method can be used to test the mean value between multiple groups and a certain group.

Correlation is misinterpreted as causation. There are many factors affecting dependent variables, resulting in the uncertainty of the relationship between the independent variables. Such quantitative relationship of uncertainty is called correlation. Correlation does not imply causation. Three conditions must be met to establish causality: (1) Covariant relationship exists between cause and effect; (2) The chronological relation between cause and effect; ③ Eliminate other possible interference factors. When statistical tests show that there is A correlation between A and B, there are four possible situations: (1) A leads to B; ② B causes A; (3) Both A and B are caused by the third factor C; (4) The observed correlation is accidental and cannot be used for causal inference.

However, some studies use correlation to conclude causality. For example, correlation is often mistaken for causation when regression results are interpreted. The regression results can only explain the association between the independent variable and the dependent variable. Some studies directly infer causality from regression results. For example, a study aimed to use logistic regression model to analyze the influence of family background on the social communication skills of college students. The author attempted to reach the conclusion that family background affects social communication. The result can only support the potential correlational relation between the independent variable and the dependent variable.

(7) Litter consideration of research ethics

Some students fail to take into consideration the research ethics. Research ethics govern the standards of conduct for scientific researchers and researchers should adhere to ethical principles to protect the dignity, rights, and welfare of research participants to guide research designs and practices (Gostin, 1991). In the projects investigated, ethical issues are not clarified. For example, one project aims to explore the delinquency of left-behind children, but the issues including informed consent, anonymity, confidentiality, potential for harm, and results communication are not included into their research plan.

4. Conclusion

Research design and statistical analysis are essential in regard to obtaining objective reliability for social science research. Some social sciences students may lack enough methodological and statistical training to properly design their projects and analyze their data, which threatens the credibility of the research. To encourage a more appropriate use of research methods and statistical techniques to improve the quality of students' understanding in social sciences for the future, we have analyzed the misconceptions regarding research deign and statistical methods and errors in the projects conducted by students in social work and social welfare. The results show that common misconception include but not limited to the following aspects: (1) taking research topics as research questions; (2) no clarification of sampling procedure in data collection and no random assignment in experimental research project; (3) no explanation of the validity and reliability of the construct measures; (4) violations of the assumptions of statistical tests; (5) misuses of statistical methods; and (6) misinterpretation of statistical findings; and (7) little consideration of research ethics.

5. Implications for teaching

More attention should be given to teaching, learning, and the application of quantitative methodology and statistics. Quantitative research is commonly used to provide justification for programs and policies and such research has great potential for misuse even among experienced researchers (Szymanski, 1991). Therefore, not surprisingly, misconceptions in quantitative methodology and statistical analysis are quite common in the projects investigated. To alleviate the problems, based on the findings, we suggest attention should be given to the following aspects in classroom teaching. Specifically, educators should train students on how to identify feasible research questions, how to create sampling frame and design sampling approach in data collection and how to make random assignment in experimental research project. In questionnaire design, the validity and reliability of the construct measures should be considered. In data analysis, the assumptions of statistical tests should be satisfied and appropriate statistical methods should be employed. Statistical findings, in particular causal relationship between variables should be interpreted with caution. Also, students in social sciences should be aware of the ethical issues which are required to uphold standards in

research integrity and quality.

Students may encounter anxiety when taking a methodology course, statistics course, or doing statistical analyses. In this study, we have just listed some common misconceptions held by students. We have noticed during the interviews that it is not rare for social science students to have math phobia, which discourage them from learning and doing quantitative research. Educators should first recognize and evaluate statistical anxiety in the students, balance statistical reasoning with statistical methods, incorporate active learning in class, use realistic data and graphics, and apply teaching techniques in a situated learning environment (Bradstreet, 1996). Effective statistical learning requires concerted efforts. Institutes, educators and students should work together to improve college students' understanding of quantitative research methods and statistical literacy. It serves as an essential step to improve the quality of scientific research of the country.

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