TEACHING STATISTICAL PROBLEM SOLVING IN VOCATIONAL EDUCATION

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Abstract: As our society is moving towards information economy, vocational education programs should equip students with the skill able to search, use and analyse information. Although the rapid and continuous development of information technology can ease the computational burden of data analysis, statistical analysis of data is not a simple task that acquires statistical practitioners having specific knowledge and skills to deal with statistical problems.

Education of statistical practitioners is specifically concerned with preparation for improving performance in applications of statistics in industries such as finance, manufacturing, etc. This advocates learning problem solving skills which require practice in thinking about, implementing and evaluating solutions to statistical problems. In this paper, the author wants to discuss the roles of vocational education in education and society; and to explore how to educate statistical practitioners to solve statistical problems in real-life projects.

INTRODUCTION

Many jobs today require labour with formal training and preparation for initial job entry. One of the fundamental purposes of vocational education is to provide each student with competent skills for employment. These skills should meet the needs of the local labour market and the competency standards accepted by industry (Hall, 1991).

Improving problem solving performance at work is an important aim for vocational education. Thus, the vocational curriculum focuses on a practical approach rather than a theoretical approach. Their learning activities usually include tutorials, laboratory and workshop practice sessions in addition to lectures. The students learn how to use tools and practical techniques to perform tasks; and how to solve problems in work environment effectively (Nasta, 1994).

As our society is moving towards information economy, information literacy becomes an essential skill mandatory of today’s work as well as living. Hence, vocational education programs should equip students with the skill able to search, use and analyse information. Although the rapid and continuous development of information technology can ease the computational burden of data analysis, simply using information technology as an analytic tool without genuine statistical understanding of data may lead to inaccurate results and/or invalid conclusions. As a matter of fact, analysis of massive amounts of data is not a simple task that acquires statistical practitioners having specific knowledge and skills to deal with statistical problems.

Statistical practitioners provide statistical support and services to various government departments as well as industries such as, finance, manufacturing and so on. For instance, they can provide financial analysts with expected returns and statistical measures of variability of returns in their investment portfolios. Education of statistical practitioners is specifically concerned with preparation for problem solving performance at statistical works. They are encouraged to play an active role of learning rather than the role of passive recipients of teaching. This advocates learning problem
solving skills which require practice in thinking about, implementing and evaluating solutions to statistical problems. In this paper, the author wants to discuss the roles of vocational education in education and society; and to explore how to educate statistical practitioners to solve statistical problems in real-life projects.

THE ROLE OF VOCATIONAL EDUCATION IN EDUCATION

The primary purposes of vocational education are pre-employment training, retraining for new or different jobs or upgrading the skills of a workforce. Each person can have access to advance to his or her highest potential consistent with his or her ability, interest and desire and the needs of society.

A vocational education college needs to promote links and liaison between vocational education and the employers in industry. The co-operation between the college and the employers should be maintained in a well-informed level. If the employers want their future employees with certain specific skills in order to cope with job requirements in our technological society, there should be a channel to communicate with the college. Thus, the college can ensure that training or future education program meets the needs of the local labour market (Hall, 1991).

Vocational educational helps students develop attitudes about the personal, social, psychological and economic significance of work. They are taught attitudes conducive to workplace discipline. They should be made aware of their roles in the world of work. They learn how to relate to characteristics of economic activity with their careers or jobs. Curriculum planning for vocational education can be based on the nature of society (Olson, 1973).

The education process should involve the students actively rather than allocating them the role of passive recipients of teaching. Learning should be directly relevant to the active interests and concern which students will face in their out-of-school life. This implies a progressive increase in student control and autonomy.

The vocational curriculum usually has an emphasis on a practical approach and includes laboratory work and workshop practice. The students learn to use tools and practical techniques to perform tasks in a field of occupations. Vocational curriculum is planned to recognize the fact that skills and related technical knowledge vary in content and depth for each job requirement. Therefore, all students after completing their vocational education are able to work effectively (Nasta, 1994).

THE ROLE OF VOCATIONAL EDUCATION IN SOCIETY

Our technological society expects that everyone can have the opportunity to earn and enjoy a good living. For instance, people enjoy advanced technologies in communication such as, mobile telephone, facsimile machine, personal computer, satellite television and so on. In our technological society, vocational education are able to:- improve and promote economic, social and intellectual growth; make contribution to a nation's asset; promote career awareness and prepare youth for employment (Shoemaker, 1971).

Secondary school output has in recent years grown much faster than employment opportunity. Government, therefore, needs to handle the problems of slow growth and youth unemployment. Theoretically speaking, the problems can be remedied by vocational education because it serves to adjust the rate of youth unemployment in labour market. Lower rate of youth unemployment will be found if more youth are engaged in full-time vocational education. Hence, vocational education programs are designed to prepare youth for an entry-level occupation (Organisation for Economic Co-operation & Development, 1983).
As the society with more people with higher skill levels, human resources become the product of vocational education. It is to provide practical help to employers wishing to improve their training efforts; deliver and develop training system in local industry. This improves competencies and abilities of employees. In this way, employers can improve their productivity and the quality of products they manufacture. As a consequence, this may improve their enterprise. Thus, vocational education makes contribution to a company's asset as well as a nation's asset in general.

STATISTICAL PROBLEM SOLVING

Many vocational education programs aim at teaching students how to solve problems in workplace. This is a practical and efficient learning approach when the students are placed in a problem situation (Gagne, 1985). Problem solving is another form of learning because students have also learned something new after completing their problem solving tasks (Tolman, 1959). It requires the students to discover the higher-order rule with minimum assistance.

Education of statistical practitioners in vocational education level is specifically concerned with preparation for improving performance in applications of statistics in industries such as finance, manufacturing, etc. Thus, a statistics curriculum should be built around problem solving skills so that statistics learners will be more easily to transfer their skills from learning environment to work environment. Practice in solving statistical problems is helpful in producing competent statistical practitioners because such practice is able to: enhance the learning process; reinforce statistical concepts and techniques; provide an environment of construction participation; and improve statistical thinking and reasoning. Helping students master the problem solving skills is an instructional objective.

Problem solving involves a set of events in which students use previously learned rules to achieve a goal. The acquisition of previously learned rules is essential but not sufficient (Francis, 1990). Problem solving requires intellectual skills, organised verbal information and cognitive strategies. Intellectual skills refer to the rules, principles, and concepts that are required for operations. Organised verbal information helps problem solvers understand the problem and carry out a validation of the answer. Cognitive strategies enable the student to select appropriate information and skills and to decide when and how to apply them in attempting to solve the problem (Gagne, 1985).

To discuss the statistical problem solving process, the following example based on the topic of regression analysis is presented. Regression Analysis is one common technique employed to solve statistical problems. Its concepts were taught in lecture session and computer laboratory sessions gave students hand-on practice experience. On completion of this topic, students were expected to build up a regression model that could be used for prediction. Without solving problems on their own, they were unable to have an overview of statistical problem solving process. Therefore, their teacher (i.e., the author of this paper) asked each of his students to do a mini research project that was data-driven and problem-oriented. Each project was completed on individual basis under their teacher’s supervision. In this way, each student took more active role in his or her own learning and was less reliant on his or her teacher. Each student was required to: 1) propose his or her own project title; 2) identify the aim of the project; 3) set the research objectives; 4) collect the relevant data; 5) analyse the data by using the regression technique; 6) do statistical computations by using SAS (Statistical Analysis System) software; and 7) submit a written report on his or her own research findings.

Students would be active to participate in topics that interest them when they could identify their own topics. For example, one student could propose “Analysis of Electricity Consumption in Hong Kong” as the topic. Each of their project titles was required their teacher’s approval in order to avoid
duplication of project title and/or work.

In attempting to solve a problem, problem understanding is prerequisite because crucial to successful problem solving is the organised verbal information employed to translate verbal statements into specific directions for statistical operations (Francis, 1990). This guides a problem solver to construct his or her own representation of the problem so as to achieve the goal of the problem. So that, students had to put down a problem statement that outlined the aim of the problem. They should also clearly state the objectives of their project to be achieved.

Although the problem statement and the objectives provided clues associated with previously learned rules and strategic planning of problem finding, students could hardly complete their problem solving tasks in their projects, without having some guidelines of model building. For this reason, the strategy for building a regression model given by Neter et al. (1996) was discussed in lecture and computer practice sessions. The strategy requires regression modellers to:- 1) compile data; 2) check four assumptions: correct functional form, homoscedasticity, independence and normality; 3) check multicollinearity; 4) detect outlying and influential observations; 5) build a tentative model based on five model selection criteria and three model selection procedures; and 6) check model validity.

For manageable workload for collection and processing of data, each of the students had to compile a set of real data containing one dependent variable, five independent variables and eighty observations. They were asked to collect real data because the context of real data kept them actively participated in the statistical problem solving process (Cobb, 1987). In order to keep their eyes focused on problem solving tasks, they could use the data compiled and released by Census and Statistics Department of Hong Kong Special Administrative Region. Students were required to prepare and submit their own data set together with a report describing the data context to their teacher. He then checked whether or not the nature of data was consistent with context of the topic. If consistent, an approval was granted. Selection of relevant data required students’ cognitive strategies to justify whether or not the data could be used to achieve the stated objectives.

Before a regression model was built, students had to check four assumptions and the existence of multicollinearity, outlying and influential observations. What students acquired were intellectual skills to check all these. They basically carried out statistical tests to determine whether any of the four assumptions was violated or not; multicollinearity existed or not; and outlying observations or influential observations were detected or not. If any of the statistical tests failed, remedial work should be done. How the remedial work to be done was an important issue. For instance, the linearity assumption was violated, how the data to be transformed was a key question. To answer this question, the employment of a cognitive strategy was to guide student’s thinking in finding which parts of the data did not achieve linearity; whether a specific form or pattern of data was recognised; and what form or pattern of the data appeared to be. All of these suggested what data transformation the students should try. Successful data transformation relied on cognitive strategy of a problem solver as well as the nature of data.

To save tedious and laborious computations in data analysis, students made use of SAS software to build the best regression model. Forward Selection, Backward Elimination and Stepwise Regression were the three rule-based model selection procedures. The acquired intellectual skills were to justify the significance levels of entry and removal. Then, SAS would take care of the rest of the procedures and came up with a final regression model. These three procedures were not necessarily to provide the best model but they could serve as screening procedures especially for a large set of data. Using five model selection criteria: $R^2$; $s^2$; the length of the prediction interval; C statistic; and PRESS acquired students to possess intellectual skills and cognitive strategies to build the best regression model. Although selection of the best model relying on each individual criterion was stated, strictly using these criteria might come up with many probable models. Consequently, no regression model was built. For the situation like this, students should study how each of the selection criteria might
affect the importance of an independent variable. They should employ their cognitive strategies to justify the practicality and the usefulness of the model when the model was built on their own. This also took parameter estimation and parsimony into consideration. They should keep their eyes and minds open to the computer output as the modelling process is dynamic. Through model building, they could eventually develop critical thinking and evaluative skills that would allow them to have success in the workplace.

For successful problem solving, the problem solver must find ways of checking or validating the answer (Gagne, 1985). This procedure is important because problem solvers should assure correct answer. Similarly, model validation is a mandatory part of the model building process (Neter et al., 1996). So that, the students should check up on the model in the sense of plausibility and usability of the regression model. In carrying out model validation, organised verbal information enabled students to perform residual analysis for overall model fitting.

The whole process of problem solving was incomplete not until writing a report. Writing statistical report is one of the job duties of a statistical practitioner so as to communicate analytical results to non-technical audience in a clear and concise manner. In addition, report writing is able to focus on the internalisation and conceptualisation of subject material; encourage creativity; and enhance the ability of communication (Radke-Sharpe, 1991). The students therefore were required to submit their reports because report writing was a part of statistical training.

CONCLUSION

Improving problem solving performance at statistical works is essential in an information age because analysis of massive amounts of data acquires statistical practitioners having specific knowledge and skills to deal with statistical problems. Teachers of statistics must differentiate problem solving from the routine statistical computations. That is, students should not be taught only to use previously learned rules carrying out routine tasks to solve problems but also knowledge and strategies in problem solving. This requires students competence in intellectual skills, organised verbal information and cognitive strategies.

Genuine statistical problem solving takes into account and deals with problem understanding; the translations of problem settings into statistical operations; evaluation/validation of the results; and dissemination of the results. The learning of problem solving best occurs when students are assigned to solve their own problems. They are more interested in completing their projects when the projects are arising out of application to real-life problems. The teacher's task is to organise appropriate problem solving situations and to ensure the scope of problem is within his students’ capabilities. The students should maintain strategies effective in solving a problem. Their teacher acts a supervisor to assist students in clarifying and then confirming or disconfirming their working steps.

REFERENCES

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