THE FUTURE OF STATISTICS EDUCATION FROM THE PERSPECTIVE OF EDUCATIONAL PRACTICES IN NEW ZEALAND

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Since the invention of calculators and computers decades ago, information technology has advanced rapidly, and the need for statistics education has increased dramatically. However, with the recent advancement of research in AI, the necessity of education itself has been questioned, and statistics education is no exception. Therefore, in this paper, the author proposes how to adapt statistics education to the Digital Age. To achieve this objective, the author focused on New Zealand, which is one of the most developed countries in terms of statistics education, and analysed their educational practices. As for the best direction for statistics education, the author contends that decisions based on statistical processing, which AI is incapable of making, should be pursued amid the global challenge of an interdisciplinary approach.

INTRODUCTION

The invention of calculators and computers was a matter of great consequence in the history of mathematics education. When education for all aimed at cultivating literacy comprising of the 3Rs (reading, writing, and arithmetic) began, the biggest goal was to enable students to perform calculations, especially in mathematics education, which dealt with arithmetic (cf. Schoenfeld, 2016). However, with the invention of calculators and computers, which lead to instant calculation answers at the push of a button, the practical usefulness of being able to perform calculations nearly disappeared. This era became the first crisis for mathematics education. What saved mathematics education from this crisis was human selection, interpretation, and judgment. Although calculators and computers can display answers, they do not perform anything more than calculations at all. As a result, only calculation results continued to be accumulated like dust. These accumulated calculation results were stored in a new space called the Web and big data was formed in the form of the Internet. The human role emerges as an effort to resolve a problem by selecting necessary information from big data, interpreting the selected data (calculation results), and judging them. Selecting, interpreting, and judging relies on a person's sense of values and ethics (cf. Bishop, 1991; Ernest, 2012), and therefore, it can be said that these inquiries can only be performed by people and not by calculators and computers. Henceforth, statistics education related to data processing increased in importance and gained more attention.

Furthermore, today we can see further science and technology development, and people's lives can be said to have become abundant very much. Artificial intelligence (AI), in particular, is one of the biggest results in developments of science and technology (cf. Newell & Simon, 1972; McCorduck, 1979; Newell, 1983; Glymour, 1986). With deep learning, based on the latest AI research, there are many aspects of human work that can be performed by AI. One of those potential jobs is teaching. As long as there is curriculum, a humanoid equipped with artificial intelligence, even if it is not human, seems to be able to teach students. In other words, curriculum takes on the meaning of "teacher-proof curriculum." This high development of AI brings into question even the idea of education itself. Statistics education, which saved mathematics education from the first crisis, is not exempt from this, and currently mathematics education is facing the era of meeting its second crisis (e.g., Schoenfeld, 1981, 2016; Balacheff, 1993; Greenberg, 2000; Garrido, 2012). In this paper, the author discusses how this second imminent crisis should be dealt with.

OBJECTIVE AND RESEARCH QUESTIONS

This paper aims to propose how statistics education should be adapted for the digital age it faces. The research questions to achieve this objective are as follows: 1) What's suggestion does New Zealand give for future statistics education? 2) How is statistics education being implemented in one New Zealand school? 3) How should statistics education be adapted for the digital age?

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VIRTUES OF ATTENTION TO NEW ZEALAND FOR FUTURE STATISTICS EDUCATION

First, for research question 1, although there are many countries implementing statistics education, the author focuses on New Zealand in particular for this paper. There are two reasons for this. First, it is one of the world's most advanced countries in terms of diversification. New Zealand, which received a large number of its immigrants from colonial nation England, is said to have a longer history as a multi-ethnic/multicultural nation than any other country, despite having a history of just over 70 years as a nation. New Zealand has the appearance of a high-quality welfare state supported by the spirit of mutual assistance in which everyone has equal rights and responsibilities, and it has been the first to implement numerous pioneering social policies (i.e., the world's first women's suffrage, the world's second elderly pension law, the world's second social security law, community welfare law for disabled persons, and anti-nuclear policy). New Zealand has a wealth of experience as a multi-ethnic/multicultural nation and it is considered to utilize its direct experience with various conflicts between ethnic groups and cultures (i.e., tensions between the indigenous Maori and British immigrants) and implement policies before tension erupts. The spirit of mutual assistance in which everyone has equal rights and responsibilities also impacts the educational community and this spirit is apparent throughout the entire curriculum. It would be meaningful for every nation worldwide feeling the impending pressures (forces) of globalisation and internationalisation to take note of education in New Zealand as a leading country (a country that has faced unification as a nation along with multi-ethnic/multicultural diversification).

The second reason the author chose New Zealand is because it is one of the world's leading countries for statistics education. In the 2007 revised mathematics curriculum, the subject name became "mathematics and statistics," and revisions were made to emphasize statistics. Furthermore, a New Zealand statistics education researcher developed the PPDAC cycle, which is the theoretical framework for statistical inquiries and an indispensable part of statistics education research. Even from the fact that all grades and educational practices in New Zealand's current statistics education programs are being taught with the PPDAC (Problem-Plan-Data-Analysis-Conclusion) cycle methodology (cf. Wild & Pfannkuch, 1999), the author believes that this has enhanced statistics education.

This paper obtains suggestions from New Zealand for the two reasons stated above.

EDUCATIONAL PRACTICES IN NEW ZEALAND

In order to collect basic data to answer research question 2, the author visited a school in Auckland, New Zealand, for a week (from 27 February to 3 March 2017) because the Head of Mathematics and Statistics Department spoke Japanese, and observed educational practices without participating in them. The paper examines the educational practices given to the thirteenth grade (final grade in upper secondary school). The students in this school are divided into different classrooms depending on their chosen route or degree of progress, and I was allowed to observe the highest educational practice for those wanting to progress to the university.

The theme of the educational practices was time series. In the statistics educational practices of the school, they spend from a month to a month and a half on learning one theme. In New Zealand, the new academic year starts between the end of January and the beginning of February. As such, the educational practices that this paper examines were on the first theme for the thirteenth grade, and the week the author observed was the final week in the five-week period dedicated to time series. The school adopted the achievement levels set by the New Zealand Qualifications Authority (NZQA) as the learning objectives. The learning objectives of the educational practices on time series that the author observed were as follows: 'Investigate time series data, with statistical insight involves integrating statistical and contextual knowledge throughout the statistical enquiry cycle, and may include reflecting about the process; considering other relevant variables; evaluating the adequacy of any models; or showing a deeper understanding of models' (NZQA, 2017, p. 2).

The teacher performs two roles in the educational practices in New Zealand. The first is 'to facilitate students' exploration activity'. Most of the lesson time was allocated to students' exploration, and the teacher observed how the students were engaged with the activity and responded to students who requested the teacher's attention by raising their hands. The second is 'transmission of knowledge to the students'. Some of the questions the students asked were not solvable without new statistical knowledge. In that case, the teacher not only responded to the student who raised the question, but also explained the new statistical knowledge to the whole class. For example, when making a future prediction by analysing time series data, a student was not sure of the method needed to express, in the numerical form, the value that she could plot on the graph. In this instance, the teacher shared the statistical knowledge of regression lines with the whole class. In New Zealand, exploration of data is performed using statistical knowledge in order to further explore statistically. In other words, statistical knowledge is a tool for statistical exploration. Consequently, the role of the teacher in New Zealand, ‘to transmit knowledge to the students’, is more accurately described as ‘to transmit knowledge to the students unilaterally’. Whether or not this is a general role of the teacher in educational practices in New Zealand is not clear, but this was indicated by the educational practices observed by the author. In addition, in the educational practices in New Zealand, the students were given a single task: ‘to explore data and to write up a report’. The basic datasets were provided to the students, but if different information was required during the exploration, the students would look for it on the Internet by themselves. In other words, because the students took the initiative in deciding which data to focus on from the given datasets, as well as what to explore, they engaged with the exploration on their own volition. In reference to the other role of teacher, ‘to facilitate students’ exploration activity’, the teacher is required to have a depth of knowledge in order to respond to the students who are engaged with different levels of exploration.

Some episodes from a student’s exploration (hereafter, Student A) in the educational practice the author observed are discussed here. Student A focused on the time series data of wine consumption in New Zealand from the given datasets, and based on the time series graph (Figure 1), posed the question, ‘why did wine consumption, which was on the rise for several years, decrease in 2007 and 2008?’ In order to solve this question, she investigated New Zealand’s social situation in around 2007 and 2008. After this investigation, she expected that the reason for decrease of wine consumption in 2007 and 2008 was related to financial crisis. Then, Student A focused on next question, ‘why did wine consumption, which was on the rise for several years, decrease in 2011?’ She then started the exploration. A hypothesis that the earthquake in Christchurch in 2011 could be a factor was formed and, as shown in Figure 2, she performed an online search with the terms ‘wine’, ‘decreased’, ‘trend’, ‘2011’, and ‘christchurch earthquake’ in order to determine if the hypothesis would hold. Next, Student A hypothesised that the climate might be a factor, and performed another search on the Internet. Student A also noted that wine consumption in New Zealand was highest in 2010, and explored the question, ‘why was consumption highest in 2010?’ In this exploration, the Internet was used again, and, as shown in Figure 3, a search for the question ‘why did wine consumption in New Zealand increase in 2010’ was performed in Google Scholar, a search engine for academic articles. In other words, Student A

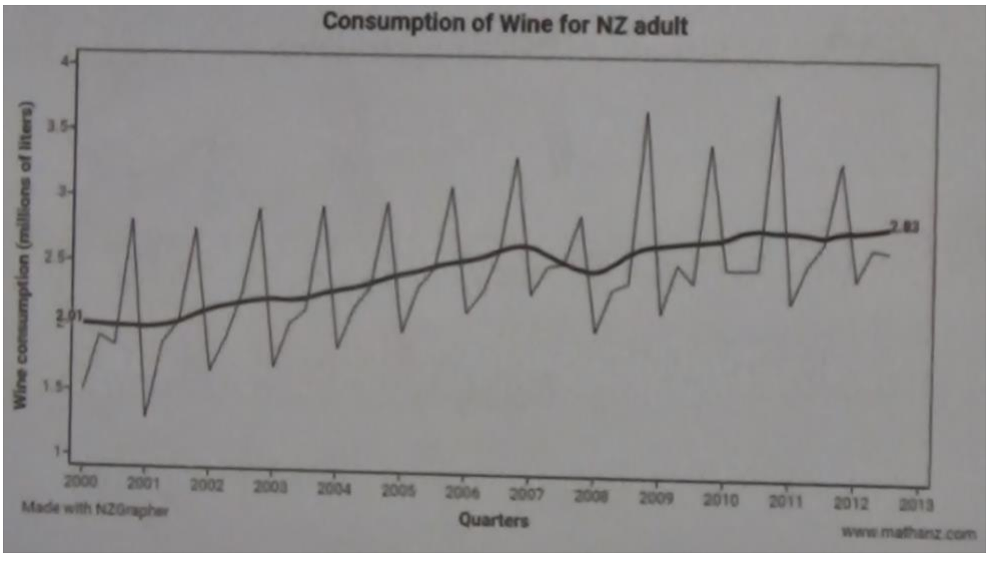

Figure 1. A screen shot of time series graph student A made

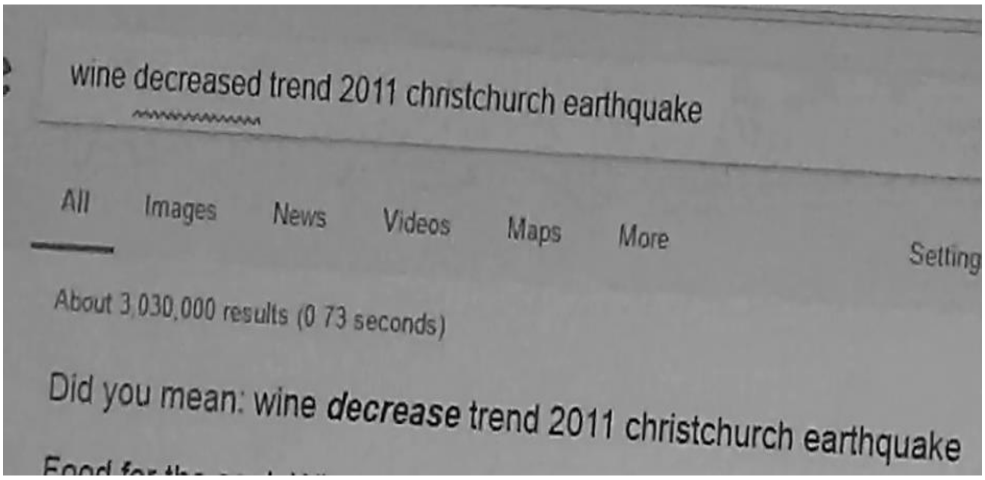

Figure 2. A screen shot of student A's search 1

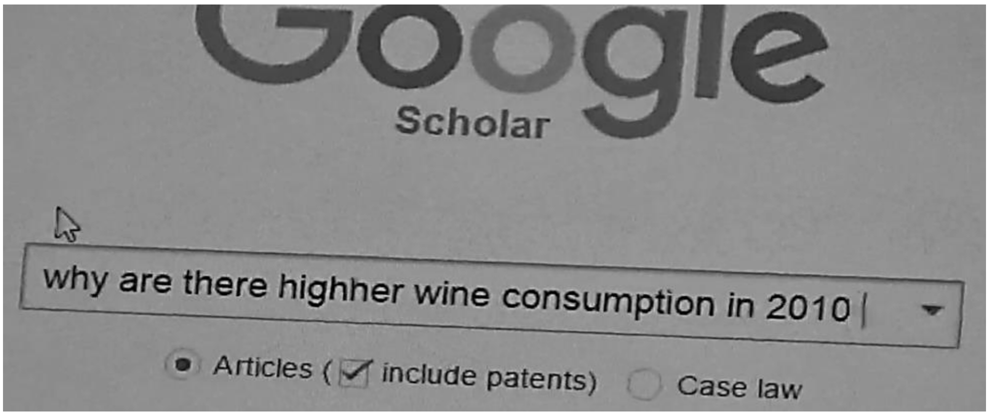

Figure 3: A screen shot of student A's search 2

searched for academic articles on wine consumption in New Zealand. Student A continued with the exploration using a variety of academic articles.

The above described Student A's exploration. Activities for looking into the historical and geopolitical background of New Zealand using the Internet and Google Scholar are not very meaningful for statistics education. However, as the author saw with Student A's exploration, investigating the historical and geopolitical background of New Zealand society in order to analyse the time series data on wine consumption in New Zealand is important in acquiring statistical literacy that is suitable for today's world. Therefore, it is very likely that the approach to history and geopolitics will become a factor in the statistical inquiry cycle, which involves the use of the Internet. This is because the Internet is now the main method for acquiring information and knowledge in contemporary society. Research into the 'questioning the world paradigm' (Chevallard, 2015) which investigates by means of the Internet which is used by the general public in mathematics education has begun to be pursued. In statistics education, too, Ben-Zvi (2007) has looked into exploration using Wikipedia, the Internet-based encyclopaedia.

THE FUTURE OF STATISTICS EDUCATION

Through the observation of educational practices in one teacher in New Zealand school and the author's analysis of New Zealand curriculum, it can be suggested that statistics education should not only handles data but also involves the contextual thinking. The contextual thinking means that students think what kinds of data should be used, how to interpret the data processing, and so on. AI involving deep learning can classify, but cannot prepare new variables of data, interpret and judge (cf. Matsuo, 2015). Moreover, AI can calculate and solve so complex problem, but show not the process but the result of calculation and solving. This is because AI plays a role of only talented calculator and the sense of values or ethics in humans is needed in order to capture the background of data. In order to do so, students have to acquire knowledge on various disciplines and use the interdisciplinary approach. This is one of the current issues in statistics education all over the world.

Since statistics deal with contingency, unlike mathematics, what is researched is mainly topics that are mathematically imprecise. Therefore, the development of strict logical thinking capabilities in teaching statistics is important; even more important is the cultivation of decision-making capabilities. Since in today's society 'highly developed intellectual and social skills such as responding to "problems without correct answers" by collaborating with others as human beings, workers or citizens, and the ability to keep learning throughout one's life is required' (Ishii, 2014, p.6), the development of decision-making capabilities is an urgent challenge of today. Decision-making capabilities in teaching statistics can be described as an ability to determine one's view or future behaviour by mathematically formulating phenomena containing contingency, generating and searching data. When making decision on our behaviour, we are significantly influenced by individually held values, which lead to thinking without strict logic. This type of thinking is not focused upon in the field outside of statistics, and the development of strict logical thinking is often pushed forward. However, making an argument is a very subjective action and in order to convince others of the validity of one's argument, one needs an ability to think and produce convincing proof; this cannot exist in strict logical thinking.

In addition, During the period of 100,000 years since humankind migrated from the African continent to the Eurasian continent, human beings have developed agriculture, formed societies such as cities and states, engaged with industrialisation brought about by Industrial Revolution, and now are forming an information society at a breath-taking speed (cf. Ito, 2007). Humankind has been engaged with a variety of reforms. Seen from a different angle, it can be said that humankind has always sought for progress and achieved it. In other words, humankind has an inherent ability to reflect critically – not being content with the present, reflecting on the present and engaging and self-reflection and improvement. However, precisely because critical thinking is inherent in human nature, it has not been studied until recently at the level of research into mathematics education (cf. Skovsmose, 1994). Due to advances of information technology and the spread of the Internet, we now live in ubiquitous society (information-communication society) in which information can be obtained from everywhere (cf. Machida, 2003). One of the benefits of this development is that human beings can now obtain answers from the Internet without going out to find information or searching for it. This, at the same time, threatens to undermine human nature. Thanks to the Internet, we can know what we want know instantaneously but opportunities to critically evaluate information thus obtained have decreased. Also if the long process of society and culture formation by human beings is projected on a timeline, the process is divided into six in the following order: Human Revolution, Agricultural Revolution, Urban Revolution, Spiritual Revolution, Scientific Revolution and Environmental Revolution (cf. Ito, 2007). Human Revolution denotes the birth of humankind; the reason why pre-Environmental Revolution and post-Environmental Revolution is distinguished is because of anthropocentricity. In the pre-Environmental Revolution period, the aim of a revolution was always to benefit humankind. On the other hand, the Environmental Revolution which is forecast to take place in the future, human beings will be forced to think about their base called the environment because the base itself has started to show a sign of strain due to its long endurance of processes of benefitting human beings (cf. Obama, 2017). As a consequence, it is now necessary to look back societies and cultures humankind has formed so far and to reflect on them in our society which has reached the critical point of anthropocentricism (cf. D'Ambrosio, 1994). It follows, therefore, that we need to place a particular focus on cultivating critical thinking which is part of human nature.

CONCLUSION

There is a limitation in this paper. The reliability of the observed and collected data is not sufficient because the author observed only one teacher at only one school in New Zealand. Therefore, the author needs to observe other educational practices and collect other data. Another future work to be done is to develop current curriculum of statistics education using interdisciplinary approach. Moreover, a lot of teaching experiments using this curriculum will need to be implemented in various countries.

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