USING CENSUS AT SCHOOL AND TINKERPLOTS™ TO SUPPORT ONTARIO ELEMENTARY TEACHERS' STATISTICS TEACHING AND LEARNING

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This paper outlines the successful professional development workshops provided by Canada's National Statistical Agency, Statistics Canada, for the Census at School program. Workshops for this international in-class online survey program help teachers develop statistical knowledge and teaching competencies. Workshop participants develop more positive attitudes toward statistics teaching and learning through hands-on exploration. Furthermore, by analyzing the Census at School data with TinkerPlots™ dynamic statistical software, participants learn to use technology to maximize statistical learning.

INTRODUCTION

In the Canadian province of Ontario, teachers trained for the elementary level are generalists. However, as is true in many other locations, these teachers tend to have more experience and expertise in language arts than in mathematics. For instance, an American study found that "many teacher-candidates enter elementary teacher education seriously deficient in understanding of the mathematical and scientific content they will be expected to teach students" (Stoddart, Connell, Stofflett & Peck, 1993, p. 238). This study also found that, due to a lack of content knowledge and conceptual understanding, teacher-candidates tended to teach mathematics in a very procedural manner, focusing on rules and formulas. This traditionalist manner of teaching was replicated regardless of how unsuccessful the teacher-candidates found the practices when they were students (Stoddart et al., 1993). Furthermore, elementary teachers often have anxiety-filled relationships with mathematics due to their own negative experiences as students (Buxton, 1981).

Teachers' understanding of the mathematics they teach can play a significant role in student achievement. An important area of study is teachers' mathematical knowledge for teaching, defined as "mathematical knowledge used to carry out the work of teaching mathematics" (Hill, Rowan, & Ball, 2005, p. 373). Mathematical knowledge for teaching goes beyond knowledge of the discipline of mathematics and includes such skills as being able to provide clear mathematical explanations and analyze students' mathematics work. Hill, Rowan, and Ball's (2005) study of primary teachers found that teachers' mathematical knowledge for teaching positively predicted student gains in mathematics achievement.

It is vital to address these issues in order for teachers to improve their pedagogical practices in mathematics and statistics. Teachers first need to increase their own mathematical knowledge for teaching. Some suggest that teachers need to personally experience learning through innovative practices before they can implement them with students (Makar & Confrey, 2004). One such initiative that assists teachers in learning about the teaching of statistics is Statistics Canada's Census at School professional development workshops.

THE CENSUS AT SCHOOL PROGRAM

Census at School is an in-class online survey project for students aged 8 to 18 (www.censusatschool.ca in English or www.recensementecole.ca in French). The survey questions cover a broad range of school subjects, such as mathematics, health, environmental studies, and social studies. As such, the program has many cross-curricular applications. There are two questionnaires, in order to have age-appropriate questions–one for elementary students (Grades 4 to 8) and one for secondary students (Grades 9 to 12). The Census at School questionnaires feature some questions that are similar to those on the Census of Canada, such as number of people living in household, number of languages spoken, and mode of transportation to school. Several questions involve measurement, such as arm span, height, and wrist circumference. Some of these measurements are recorded in centimetres whereas others are recorded in millimetres, which allows for a teaching opportunity about conversions. There are

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also two interactive questions in which students complete a reaction timer test and a memory game; for these questions, students' times to complete the questions are recorded. Thus, the questionnaire results in both numeric and categorical data for analysis.

Once all students enter their data anonymously into the national database, the class results can be retrieved for analysis. Class results are provided in spreadsheet form and can be easily downloaded into statistical software programs. Each class dataset can be analyzed separately or compared to a variety of other datasets. The previous years' Canadian summary results, provided as totals and separated by sex, are available on the website as percentages for categorical data or raw number means for numeric data. Furthermore, random datasets of other Canadian Census at School participants can be retrieved for comparison.

One of the most interesting elements of Census at School is that it is an international project. The program began in the 2000/2001 school year in the United Kingdom, and students in South Africa, Australia, and New Zealand now also participate. The 2007/2008 school year marks the fifth year of Canadian participation. Some questions on the Canadian survey are common to all participating countries; this allows students to make fascinating comparisons with children around the world by retrieving international datasets.

PROFESSIONAL DEVELOPMENT WORKSHOPS

In order to educate teachers about the Census at School program, Statistics Canada has developed professional development workshops for practising teachers and teacher-candidates. Statistics Canada employs regional education representatives around the country, including the author of this paper, to conduct free professional development workshops about Statistics Canada's educational resources. Each school year in Ontario, approximately 100 Census at School workshops are conducted with teachers and teacher-candidates, including approximately half the province's faculties of education. Although presenters conduct Census at School workshops in many ways, the workshops generally include the following aspects: a guided tour of the website, hands-on data collection with the Census at School survey, and analysis of the class dataset using a data analysis software program, typically TinkerPlots™ (Konold & Miller, 2005). Below, I provide a more in-depth view of how I conduct workshops.

Each workshop begins with an introduction of the presenter and participants, in order to make a personal connection. When making my introduction, I make participants aware that I am a certified teacher, so they view me as an educational colleague rather than a government employee. Participants share their names, the grades and subjects they teach, their familiarity with Census at School and TinkerPlots™, and their expectations for the workshop. By learning about the participants, the presenter can tailor the workshop to their needs.

One way workshops have improved to better meet participants' needs is by altering the order in which the information is presented. For instance, in the first workshops I conducted, participants began by completing the Census at School survey and TinkerPlots™ data analysis after a very brief explanation of the project, and then the workshop finished with a more detailed overview of the website. However, this did not work very well because the participants were in 'analysis mode' and wanted to continue exploring the data. Now, I begin with an explanation of the project, focusing on how Census at School can be used to cover several curricular outcomes and aid in statistics teaching. This is followed by a detailed demonstration of the website, in which participants learn how to register and are exposed to the provided teaching resources. Participants are then given a few minutes to explore the more than 20 Census at School learning activities and then are shown how to retrieve international data.

Participants complete the survey online as though they are students and I am their teacher. Participants receive a handout in which they can record their measurements, which makes data collection much easier than running back and forth between measurement stations and the computers. I circulate during this time, answering questions and providing tips for conducting the survey. Participants find these tips, which I have learned through my experience leading these workshops, very helpful when they conduct Census at School with their students.

Participants who finish their data entry before their colleagues use this extra time to explore the site in more depth. Class results are displayed on the overhead projector as they are submitted. The class results are available only to teachers due to privacy issues, and there are a

few ways to deal with this issue, which I explain to the participants. In workshops, I usually log into my teacher account at each participant's computer. Another option is to provide students or participants with the email used to create the account and the password provided by Census at School. Finally, the class dataset can be saved on a shared school drive.

Participants are then shown how to import the class dataset into TinkerPlots™. From the online spreadsheet of the class results, the internet icon (e.g., the blue 'e' for Internet Explorer) simply needs to be dragged and dropped onto the TinkerPlots™ workspace to import the data. I provide the participants with a brief overview of TinkerPlots™, such as how to view the data in different ways, and the key features of the graphing capabilities. This introduction provides the participants with an overview of all tools they will need but allows them to explore on their own while they complete a step-by-step introductory exercise.

I close the workshop by thanking the participants, informing them that Statistics Canada provides free in-class Census at School workshops, and then passing out the evaluation forms to be completed anonymously. The time allotment for a typical three-hour workshop is 20 minutes for introductions, 30 minutes for the website overview, two hours for data collection and analysis, and 10 minutes for completing the evaluation forms.

ANALYZING CENSUS AT SCHOOL DATA WITH TINKERPLOTS™ SOFTWARE

Census at School presents an excellent opportunity to incorporate technology into statistics education. According to the National Council of Teachers of Mathematics (2000), "Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students' learning" (p. 11). Furthermore, technology use is explicitly featured in the Grades 1 to 8 Ontario Mathematics Curriculum documents, with Census at School noted as a key resource for collecting primary data. For instance, in both the Grade 7 and Grade 8 Data Management and Probability strands, curriculum expectations state that "Students will collect and organize categorical, discrete, or continuous primary data… (e.g., electronic data from… Census At Schools [*sic*])… using a variety of tools (e.g., graph paper, spreadsheets, dynamic statistical software)" (Ontario Ministry of Education, 2005, pp. 107, 118).

During the professional development workshops, Census at School class datasets are analyzed using TinkerPlots™, a dynamic statistical software program for elementary-level students by Key Curriculum Press. Graphs can be easily made by selecting the attribute(s) to display and then choosing a graph type. Data points can be dragged to divide the data into categories. The ease of constructing graphs in TinkerPlots™ allows for rapid hypothesis testing by visual means, which may help participants to quickly develop inferential reasoning.

TinkerPlots™ displays measures of central tendency on the graph by simply clicking on the mean, median, and mode buttons. The number and percentage of responses corresponding to each attribute can similarly be displayed on the graph. By default, TinkerPlots™ places attributes on the axes in alphabetical order, which is not always the best manner in which to display the data. Attribute names can be easily dragged into a more logical order, which provides a teaching opportunity about data presentation.

For the overwhelming majority of participants, the Census at School workshop is their first experience with this software program. Regardless of the participants' initial comfort levels with technology, they tend to find TinkerPlots™ very user-friendly and intuitive in structure. For instance, one participant noted, "TinkerPlots is an AMAZING program! There are way more things to do in statistics than when I was in school. I think students would have a blast analyzing the class data and plotting the info on the computer." Fun, user-friendly data analysis software programs such as TinkerPlots™ complement the Census at School project greatly. It is vital to have an easy way to analyze the Census at School class datasets so that teachers do not become overwhelmed and abandon the project before completing data analysis.

DATA COLLECTION

At the conclusion of each workshop, participants anonymously complete evaluation forms that include both open-ended and closed questions about the workshop and presenter. The evaluation form begins with six open-ended questions, five of which ask the participants to complete statements with their opinions (the statements are, in order: 'I came expecting…', 'I

learned that…', 'I was pleased that…', 'I was disappointed that…', and 'I suggest that…'). The final open-ended question asks 'What was most useful for you today?'.

The six Likert scale questions are ranked on a five-point scale. The first four questions are ranked from 1 ('not at all') to 5 ('to a large extent'), and are as follows: 'Were you aware of Statistics Canada learning resources prior to the session?', 'Was the information presented clearly?', 'Was the pace of the session suitable?', and 'Overall, were you satisfied with the session?'. The other two Likert scale questions are ranked from 1 ('poor') to 5 ('excellent'), and ask the participant to rate the presenter's 'Knowledge of StatCan resources' and 'Presentation'.

The evaluation form concludes with two questions in which participants select 'yes' or 'no' checkboxes, and then are asked to 'Please explain': 'Will you use these resources for your classroom instruction?' and 'Did the session meet your educational needs?'.

DATA ANALYSIS

I conducted an analysis of a random sample (n = 165) of evaluation forms from workshops conducted in the past two years (2006 and 2007).

The responses to the six qualitative questions were coded in the following manner. First, the evaluation forms were read, in order to gain a preliminary idea of the content. Then, initial codes were formed and counts made of the responses that aligned with each code. The number of codes was reduced by combining similar categories and placing categories with very few responses into 'Other'. If a participant left a question blank, this was coded simply as 'No answer', as opposed to assuming, for example, for the statement 'I suggest that…', that the participant did not have any suggestions. Questions were only coded as 'no suggestions' (for example) when the participant explicitly indicated this by marking a slash or by writing 'N/A'.

For the six Likert scale questions, mean values were calculated from the scales ranking from 1 to 5. Similarly, the two 'yes/no – explain' questions were coded numerically, with yes being coded as 1 and no being coded as 0, as virtually no participants wrote any explanations.

RESULTS

Below, I will highlight some key findings from my analysis of the random sample of evaluation forms from Statistics Canada's Census at School workshops.

For the first open-ended question ('I came expecting…'), the most common response (19.4%) was that the participants had no expectations about the workshop, with an additional 6.7% of participants leaving the answer spot blank. This may have been due to a lack of information disseminated from those who booked the workshop, a lack of understanding of what Statistics Canada does, or even a lack of understanding of statistics. The second most common response (15.8%) was 'to learn about Statistics Canada/the Census/the website', which indicates that these participants were well-informed about the workshop. Disappointingly, but perhaps unsurprisingly, the third most common answer (13.9%) was that participants expected the workshop to be boring. This may reflect a stereotypical view of mathematics and statistics in particular as dull and uninteresting. This certainly does not bode well for presenters who are faced with participants who have such negative, stereotyped attitudes.

The most common response to 'I learned that…' was 'The Statistics Canada website has many useful resources for teaching' (39.4%). Participants are often unaware that Statistics Canada has a division that specifically deals with educational resources. The second most common response was that 'Statistics are fun and interesting' (20.0%), which is a very positive sign–the manner in which the workshop was presented seemed to help alter some of the negative attitudes that participants had when entering the workshop. For example, one participant noted, "I learned that stats are NOT boring! This website is a great resource to make stats fun and enjoyable to kids/teachers alike!" Another finding was that 9.7% of participants learned that 'TinkerPlots is a great/easy to use program'.

For the question 'I was pleased that…', the most common response was 'Statistics Canada has so many relevant, easy-to-use, organized, free resources' (32.7%). Two other frequent responses were that participants were pleased that 'They learned how to use TinkerPlots' (16.4%) and 'The presenter was helpful, knowledgeable, and engaging' (15.8%).

The most common response for ‘I was disappointed that…’ was ‘We didn’t have more time’ (35.2%), with many participants explicitly expressing their desire for a longer workshop, or simply more time to explore the software or website. The second most common response was to leave the answer spot blank (23.0%), with a further 22.4% of respondents explicitly indicating that they were ‘Not disappointed in anything’.

In terms of suggestions (‘I suggest that…’), the most common response was to not answer (31.5%), with a further 10.3% explicitly indicating that they had no suggestions. Directly related to the previous question’s outcomes was the second most common response: ‘The workshop be longer’ (20.6%). Several participants (11.5%) used this space to make positive comments about the presenters or the workshop (e.g., ‘Great job!’, ‘Keep doing what you’re doing!’).

For the question ‘What was most useful for you today?’, the most common response was ‘TinkerPlots’ (27.9%), followed by 20.0% for ‘Everything (all resources)’. The third most common response (15.2%) was ‘Learning to navigate the Statistics Canada website’.

The mean values for the Likert scale questions are summarized in Table 1. The first four questions are ranked from 1 = ‘not at all’ to 5 = ‘to a large extent’, whereas the last two questions are ranked from 1 = ‘poor’ to 5 = ‘excellent’.

Table 1. Mean Values for Likert Scale Questions

Question	Mean Value
Were you aware of Statistics Canada learning resources prior to the session?	1.79
Was the information presented clearly?	4.37
Was the pace of the session suitable?	3.90
Overall, were you satisfied with the session?	4.53
Workshop facilitator’s knowledge of StatCan resources	4.85
Workshop facilitator’s presentation	4.69

Notable in these results is the low mean value regarding prior awareness, which indicates that participants have a lack of awareness about the resources, which aligns with the responses for the open-ended question about expectations. The lowest scoring question regarded the pace of the workshop; thus, the pacing of the workshops has changed, and participants are asked to indicate to the presenter if the pace is too fast or too slow. Other responses were all very positive, which indicates the workshops are successful in motivating participants.

For the ‘yes/no’ questions, every single respondent (n = 165) answered ‘yes’ to both ‘Will you use these resources for your classroom instruction?’ and ‘Did the session meet your educational needs?’. This positive feedback is very meaningful, as the goal of the workshops is to help educators bring interesting methods of teaching statistics into the classroom.

DISCUSSION

The participants’ expectations before they began the workshops were generally not positive, likely due to negative associations with the word ‘statistics’. Elementary teacher participants tended to anticipate that the workshops would be either boring or intimidating. However, upon completing the workshops, participants noted changes in their views of statistics. One participant stated: “I came expecting scary statistics like my university statistics… it’s not that scary at all.” Furthermore, participants were pleasantly surprised by how much fun they had while participating in the Census at School activities as ‘students’. This workshop technique allowed participants to quickly realize how much fun and learning students could gain from this experience. Even within relatively short professional development workshops, participants’ fears about teaching statistics appear to have been somewhat allayed. They realize that statistics is neither a boring nor intimidating subject and that Census at School and TinkerPlots™ can make learning statistics fun for students and teachers alike.

CONCLUDING REMARKS

Statistics Canada's Census at School professional development workshops help to ease elementary teachers' fears about teaching statistics. Teachers' worries are further alleviated by the free in-class workshops offered by Statistics Canada, in which representatives will come into individual classes to help lead students through the Census at School questionnaire and subsequent data analysis. This service often provides the incentive that teachers who are not comfortable with statistics need to implement the innovative program.

Through the workshops, teachers hone their own statistical knowledge for teaching through hands-on exploration. As the participants use their own class data, they find it straightforward to perform statistical analyses and explain their results. Similar outcomes resulted from a Census at School unit study in which Turner (2006, p. 23) found that "using real data about the pupils does seem to make the conclusions they draw more meaningful, and it appears easier for pupils to come up with good, sensible reasons for their results." Furthermore, she noted that mathematics skills were better retained because they were learned in context: "They learn the methods because they needed the skills, not as an isolated technique" (Turner, 2006, p. 24). Although Turner's study was conducted with children, similar outcomes were noted with the adult participants in Statistics Canada's Census at School workshops.

Census at School, coupled with data analysis in TinkerPlots™, is an excellent resource to help teachers and teacher-candidates develop positive attitudes toward statistics teaching and learning through the use of technology. Using their own class data allows for much deeper connections and understandings of statistical concepts as they are learned in context. As noted by Census at School proponent Doreen Connor (2002) of Nottingham Trent University, "real data gives real learning" (p. 5).

REFERENCES

Buxton, L. (1981). *Do you panic about maths? Coping with maths anxiety*. London: Heinemann Educational Books.

Connor, D. (2002). CensusAtSchool 2000: Creation to collation to classroom. In B. Phillips (Ed.), *Proceedings of the Sixth International Conference on Teaching of Statistics*. [CD-RM]. Cape Town: International Association for Statistical Education and International Statistical Institute.

Hill, H. C., Rowan, B., & Ball, D. L. (2005). Effects of teachers' mathematical knowledge for teaching on student achievement. *American Educational Research Journal, 42*(2), 371-406.

Konold, C., & Miller, C. D. (2005). *TinkerPlots: Dynamic Data Exploration.* [Computer software]. Emeryville, CA: Key Curriculum Press.

Makar, K., & Confrey, J. (2004). Modeling fairness in student achievement in mathematics using statistical software by preservice secondary teachers. In *ICMI Study 14: Applications and Modelling in Mathematics Education (Pre-Conference Volume)* (pp. 175-180). Dortmund, Germany: ICMI.

National Council of Teachers of Mathematics. (2000). *Principles and standards for school mathematics*. Reston, VA: NCTM.

Ontario Ministry of Education. (2005). *The Ontario Curriculum Grades 1-8: Mathematics (Revised)*. Toronto, ON: Queen's Printer for Ontario.

Stoddart, T., Connell, M., Stofflett, R., & Peck, D. (1993). Reconstructing elementary teacher candidates' understanding of mathematics and science content. *Teacher & Teacher Education, 9*(3), 229-241.

Turner, C. (2006). Height, foot length and threat to woodland: Positive learning from pupil relevant data. *Teaching Statistics: An International Journal for Teachers of Pupils Aged Up to 19, 28*(1), 22-25.