Statistical Software in Canadian University Courses

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Abstract

Two controversial topics related to the teaching of statistics to psychology students are a) when to introduce statistical software, and b) which statistical software package to use. Although this controversy has existed for decades, no study exists which empirically evaluates the use of statistical software in psychology statistics courses. To address this lack of empirical evidence, the current research looked at the use of statistical software in statistics classes from every university with a psychology program in Canada. Researchers collected data from 321 statistics courses offered to psychology students at 65 Canadian universities and coded the type of statistical software used (if any) in each course. Results show that just over half of all universities introduce software at the introductory level. Point-and-click software is most popular, with SPSS being the most commonly used statistical software package. While there is a considerable amount of variability in when and which software is introduced to students, these data can hopefully be used to inform future research on best practices in the teaching of statistics.

Statistical Software in Canadian University Courses

Over the past few decades the recommended methods for analyzing data in psychology have become much more involved. As the methods used to analyze data in psychology become more extensive, so too should the statistics material taught to psychology students. Statistics courses are often the primary resource that psychology undergraduate and graduate students use to learn the skills necessary to analyze their data. Statistics courses are required by almost every psychology program (Stoloff et al., 2010), and thus what students learn paves the way for how they will approach statistical problems in their future research endeavours. The challenge in evolving these courses is incorporating the required novel material in a thorough manner, while at the same time maintaining an appropriate level and focusing on the practical aspects of data analysis.

One facet of this problem is the teaching of statistical software in psychology courses. Statistical software plays a major role in almost all psychological research; it is rare (hopefully nonexistent) that psychologists conduct hand calculations to analyze their data due to the availability of software that makes these computations faster, easier and with fewer mistakes. Teaching statistical software to psychology students provides them with the necessary skills to succeed in both academic and applied careers that they may pursue after obtaining their degree (Appleby, 2018), with a greater number of students entering graduate school from programs offering more experiences with statistical software (Stoloff, Good, Smith & Brewster, 2015). Statistical software may also make it easier to learn basic statistical concepts by providing concrete examples and visualizations not possible with hand calculations. Ferreria, Kataoka and Karrer (2014) found that high school students were better able to learn basic probabilistic concepts when taught using statistical software (specifically the R statistical package). Students were able to work more autonomously by running their own simulations of data sets, allowing them to develop a

deeper understanding of basic probability than in a typical lecture setting. Additionally, statistical software allowed instructors to make use of a broader range of examples than is possible with coin flip or draw of a standard playing card, two common examples used to teach basic long-run probability. Thus, it is beneficial that psychology students are introduced to statistical software as part of their training. This raises questions about how these types of software should be taught within statistics courses in psychology departments.

Universities generally do not have to adhere to the same curriculum requirements as do elementary and high schools. In other words, there are very few standards regarding what must be taught to students at each level of their degree. While this can be beneficial to institutions and individual instructors, as it allows them the freedom to teach their students using whatever method and tools they feel would increase the learning experience of the students, it can also make it difficult for them to ensure that their courses are keeping students competitive with their peers at other universities. Statistics courses are a great example of this issue; instructors often vary greatly on the emphasis they place on null hypothesis testing, their coverage of correlational (e.g., regression) vs. mean difference (e.g., ANOVA) methods, the amount of time spent on visualizing data, and, the focus of this research, whether or not they use statistical software in their courses.

Currently, professors wishing to know whether and/or which statistical software packages are being used to teach statistics courses in psychology must rely on anecdotes from colleagues as very little formal information is available in journals, books or on the web. Although knowing how other instructors are teaching statistics does not tell us which method is best, it provides valuable information on which to base discussions and make informed decisions. In this paper, we provide the first formal report on the use of statistical software in the teaching of statistical courses in psychology departments in Canada with the goals of providing valuable information for discussions

regarding the use of statistical software, allowing for comparisons between future and present use of statistical software, and guiding recommendations regarding the use of statistical software.

Statistical Software Use in Statistics Courses in Psychology

The first question regarding the teaching of statistical software is how and when to introduce these skills in statistics courses. One option is to teach theory and hand calculations first, solidifying this knowledge before moving on to teaching students to conduct these calculations using software. Another option is to teach both hand calculations and software use at the same time. In the past, researchers have made recommendations about when to introduce software based on findings from both students and instructors. Based on data from students in an introductory statistics class, Rosen, Feeney and Petty (1994) suggested that statistical software be introduced in later, rather than introductory, courses. Bartz and Sabolik (2001) found that for departments that did not include statistical software in their introductory statistics courses, instructors were often hesitant to introduce both statistical concepts and computer methodology in one course, for fear of leaving struggling students behind. However, it is important to consider that today, computer-based learning is more prevalent at all levels of education than it was at the time these studies were conducted, so these results should likely be revisited.

The next question, if a decision to adopt statistical software is made, is which software package(s) to teach psychology students. Options range from menu-based software such as SPSS to programming-based software such as SAS or R (The R Core Team, 2015). The growing trend in psychological research, particularly in quantitative research, is to use programming-based software, with R being a popular choice (The JASP Team, 2015). However, although programming-based software packages like R are becoming more popular, and are more popular in the workforce, SPSS is still the go-to statistical software package in psychology research (Mucheon, 2018). Bartz and

Sabolik (2001) found that 59% of their sample of departments using computers in the introductory statistics courses used SPSS. However, many recent advances in statistics have not been incorporated into the software (e.g., Bayesian statistics, propensity score matching, robust approaches) and thus other more actively maintained statistical software packages have started to gain momentum (The JASP Team, 2015). In addition, although SPSS makes it easy to run analyses using a point-and-click method, it is very expensive and thus students are unlikely to have access to the software on their personal computers or in future positions or research endeavours. Other programming-based software packages, such as R and SAS, have done a better job of keeping up with modern analytic methods. However, SAS, like SPSS, is commercial and therefore it is expensive and access to the software in future endeavours is often lacking. R is unique in that it is an open-source software package so it is free to users and can also be customized with user contributed functions, which allows for greater availability of novel and complex analyses. Although there is a steeper learning curve associated with learning syntax-based software like R (R Core Team, 2015), recent research has found that the experiences of students using R in undergraduate classes is generally positive (Counsell & Cribbie, 2016).

The lack of data on the teaching of statistical software makes it hard to recognize trends in instructional methods, regarding both the level at which software is introduced and the types of software packages that are taught. While few researchers would argue with the claim that psychology departments offer more training in statistical software now than they did 20 years ago, the academic community lacks formal records of how the teaching of statistical software has changed over time. Thus, there is a need for such data to be collected in order to track these changes and analyze trends.

The present study summarizes how statistical software is currently taught at Canadian universities. We sought to determine at what level software is being introduced in statistics courses offered to psychology students, and what software is being used at each level of instruction, by collecting data from all Psychology departments at public universities in Canada. Because no previous data set of this type exists, all of our analyses were exploratory; we did not form any directional hypotheses regarding the relationship between any of our collected variables. Our only formal hypothesis was that there would be a great deal of variability regarding when statistical software is first introduced. The purpose of this study is largely descriptive – while all of the researchers associated with this project have their own opinions regarding when and how statistical software should be taught to undergraduate psychology students, our goal is not to make recommendations, but rather to inform instructors and other researchers of how statistical software is currently being integrated into relevant courses. It is our hope that this descriptive information can be used to meet the needs described above – to provide instructors with information to inform their own teaching practices, as well as serve as a starting point to track trends in the teaching of statistical software over time.

Method

Universities

A complete list of universities was compiled from Universities Canada (2016), a non-profit organization that represents the 97 public universities across Canada. All universities were included if they had a psychology department which taught statistics courses and course information could be obtained via websites or by emailing instructors or administrators. Secondary and satellite campuses were coded as separate universities.

Courses

Statistics courses taught in the 2015-2016 academic year were targeted for inclusion, however if information regarding the current courses was not available then the most recent available course information was recorded (with the oldest data used coming from the Fall semester of 2013). Full year courses were counted as two separate courses for weighting purposes. In order to maintain independence of observations, only one version of each course from each institution was recorded, even if multiple sections were offered by different instructors. In the case that different sections of a course contained differences regarding any of the coded variables, the answers most representative of all of the sections were recorded.

Course level. Each course was categorized by researchers as either introductory, intermediate or graduate. Introductory courses were defined as the first course (or set of courses) in statistics taken by undergraduate psychology students. These courses are typically meant to be taken in the students' second year of study (although some were aimed at first- or third-year students) and are required for psychology majors. Intermediate courses were defined as higher level statistics courses typically taken in psychology students' third or fourth year of study. These courses are typically optional courses, although many are required by universities for honours or research-specialist students. One key differentiating factor is that these courses require introductory courses as a prerequisite. Graduate courses were defined as any course aimed at students enrolled in a graduate program in psychology.

Software packages

Researchers recorded every software package introduced at any point in each course. From here, each course was categorized as using point-and-click software, syntax-based software, or both.

Software type. Each software package was categorized as either point-and-click or syntax-based. This distinction was based on the primary use of each software package; for example, SPSS

gives users the ability to write syntax, however it is most commonly used as a point-and-click package. Other examples of point-and-click software are Excel, AMOS, SYSTAT, HLM and G*Power. Examples of syntax-based software are SAS, R, and Mplus.

Department/Class Size

Information was also collected on class size and psychology department size. Class size was defined as the maximum number of students permitted to enroll in a course. Psychology department size was defined as the number of full-time faculty in the department.

Results

Information was obtained from 65 Canadian universities. Of these 65 universities, 46.15% (N = 30) have a graduate program in psychology, while the remaining 53.85% (N = 35) only offer an undergraduate program. Data from a total of 321 classes were recorded; after accounting for duplicates, we were left with 236 unique courses. Of these courses, 93 were introductory, 62 were intermediate, and 81 were graduate. Eighty-one percent of these courses used some kind of statistical software – 72% of undergraduate courses, and 100% of graduate courses. Further, 16% of the classes used more than one software package

Number of Courses per University

All universities offered at least one statistics course to psychology students (M = 3.63 SD = 2.04), with some institutions offering up to 11 one-semester undergraduate and graduate courses. All of the universities with undergraduate programs offer at least one undergraduate course in statistics, and all of the universities with graduate programs offer at least one graduate course in statistics. The median number of statistics courses offered at both the undergraduate and graduate levels is 2. See Table 1 for more detail regarding the number of courses offered at each level.

Introducing Statistical Software to Students

Fifty-nine percent (38/65) of universities introduce statistical software in an undergraduate introductory course. All but three of the remaining 27 universities introduce software in an intermediate course; more specifically, these three universities do not offer a statistics course beyond the introductory level (or, in even other words, statistical software is not introduced in any classes at these schools).

Relationship between class size, department size, and introduction to software. Further analyses were run to determine whether class size or psychology department size was related to the level at which psychology students were first introduced to statistical software. Logistic regression analyses (introductory/intermediate level introduction of software as the outcome) showed no statistically significant relationship between class size, $\exp(\beta) = 0.99$ (0.99, 1.01), $z = -0.68$, $p = .499$, or department size, $\exp(\beta) = 0.98$ (0.96, 1.01), $z = -1.21$, $p = .225$, and the level at which software was introduced. In other words, at what level software is introduced does not appear to depend on the number of students in the class or the size of the department.

Statistical Software Packages Adopted

SPSS is by far the most commonly used statistical package, with 68.23% of all courses that use statistical software (81.48% introductory, 81.36% of intermediate and 55.56% of graduate courses) using this package at some point over the course of the semester. R and Microsoft Excel were the second and third most commonly used software packages, used in 19.49% and 6.36% of courses, respectively. Compared to undergraduate courses, graduate courses show much more diversity in the software packages they use – the introductory and intermediate courses collectively used seven different statistical packages, while the graduate courses collectively used 14 - which corresponds to the broad range of statistical concepts that graduate courses cover. See Figures 1-4 for a complete breakdown of the statistical packages used at each level of study.

Type of software package used

Point-and-click software packages are used much more frequently than syntax-based software in undergraduate courses; 91% of introductory courses that use software, and 81% of intermediate courses, only use point-and-click software. In contrast, 40% of graduate courses only use point-and-click software, with 37% only using syntax-based software, and 23% using both types of packages. See Figure 2 for a complete breakdown of the type of software package used at each level of study.

Discussion

The data show that just over half of all universities introduce statistical software to psychology students at the introductory level of statistical study. Additionally, regression analyses showed no evidence that this decision is related to class size or psychology department size. Our results supported our hypothesis that there is a great deal of variability regarding when statistical software is introduced, suggesting that this is a potentially contentious issue. As previously stated, past research has shown that it may be beneficial to teach students hand calculations first before introducing statistical software to conduct the same analyses. However, these studies were conducted at a time before most students had access to statistical software at home, and our data could reflect the growing need for students to be able to conduct analyses using software. Almost all statistical calculations in psychology are conducted using software, raising the question of whether it would be beneficial to teach hand calculations and software use at the same time, rather than waiting to introduce software later in their training. Future research should investigate the extent to which learning hand calculations before software provides benefits to students over and above learning both simultaneously.

The data also show that point-and-click software is taught in undergraduate courses much more frequently than syntax-based software, with SPSS being the most common software package used. Syntax-based software is often seen as too difficult for students first learning to use statistical software, coming with too steep of a learning curve to be taught at the same time as novel statistical concepts (Anglim, 2013). An implication of these results may be that straightforward point-and-click software is a more appealing choice for instructors who acknowledge that statistics courses are already a challenge to many psychology students. In addition, it is also possible that many of the instructors that use point-and-click software in their courses do so because that is the software that they are most familiar or comfortable using. However, graduate courses are almost as likely to use syntax-based software, or a combination of both types, as they are to use point-and-click software. While there is no previous data available allowing us to track trends in software use, these data suggest that graduate course instructors tend to adopt syntax-based software, potentially because of their capabilities for more complex analyses. Does this imply that there would be a benefit to teaching syntax-based software at the undergraduate level so that there is greater coherence between undergraduate and undergraduate teaching? Future research can investigate how software package choices change over time. Additionally, since our data do not speak to the effectiveness of each type of software, future studies should look into the benefits that each type of software has on student learning outcomes.

It is important to reiterate that these data only show how statistics is currently taught to Canadian psychology students. They do not provide any information about the best methods to teach statistics, the best time to introduce undergraduate students to statistical software, or the best software packages to teach psychology students. What these data can tell us, however, are the current trends in the teaching of statistical software. They serve as a starting point for future studies

to make recommendations about the best ways to train future members of our discipline. With previous research linking statistical software usage to enrolling in graduate school and being better prepared for careers in psychology (Appleby, 2018; Stoloff et al., 2015), all of this future research is extremely valuable. With quantitative methodologists constantly improving the methods available to psychology researchers, it is important that our statistics courses are also evolving so that psychology students can receive the best statistical training possible.

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Table 1: Number of statistics courses at each university by degree type.

	Number of Statistics Courses								
Degree type	0	1	2	3	4	5	6	7	8
Undergraduate	0	9	30	19	6	1	0	0	0
Graduate	0	5	15	6	1	0	1	0	2

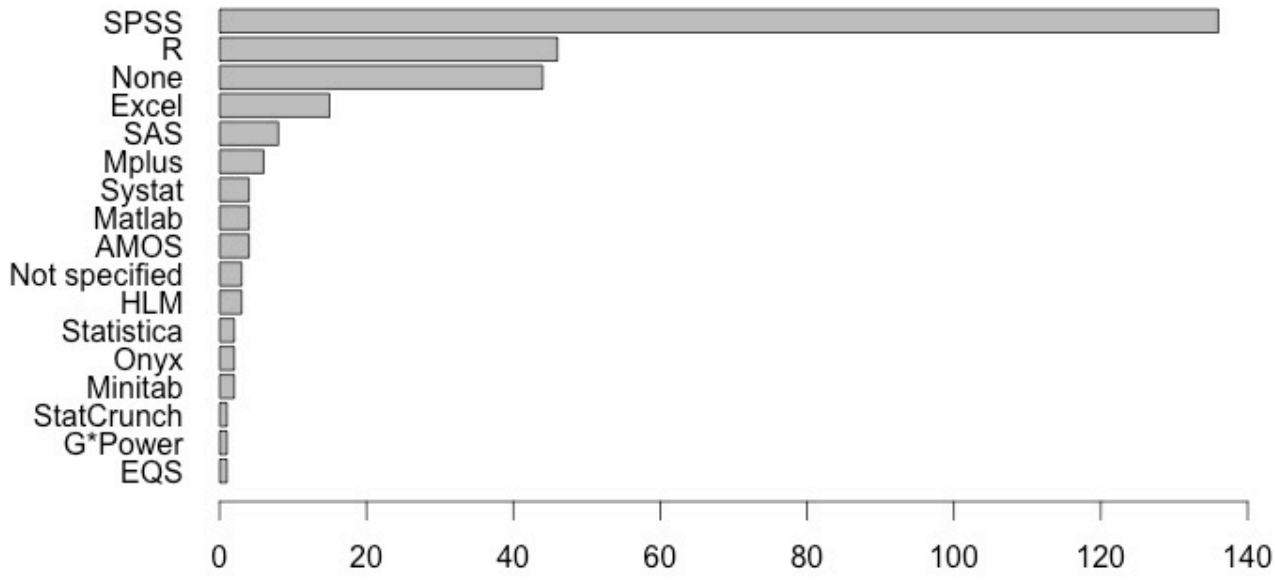

Figure 1: Total number of courses using each software package.

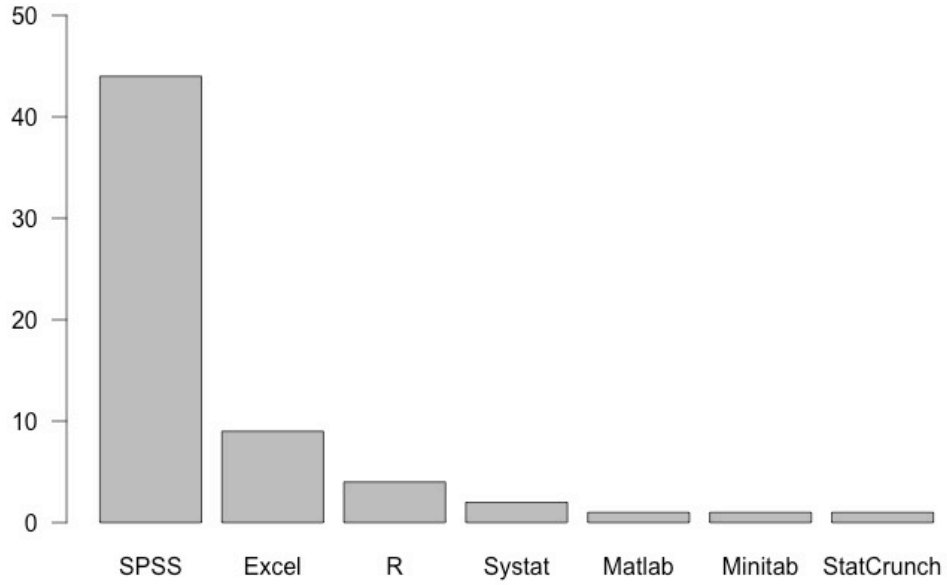

Figure 2: Number of introductory courses using each software package.

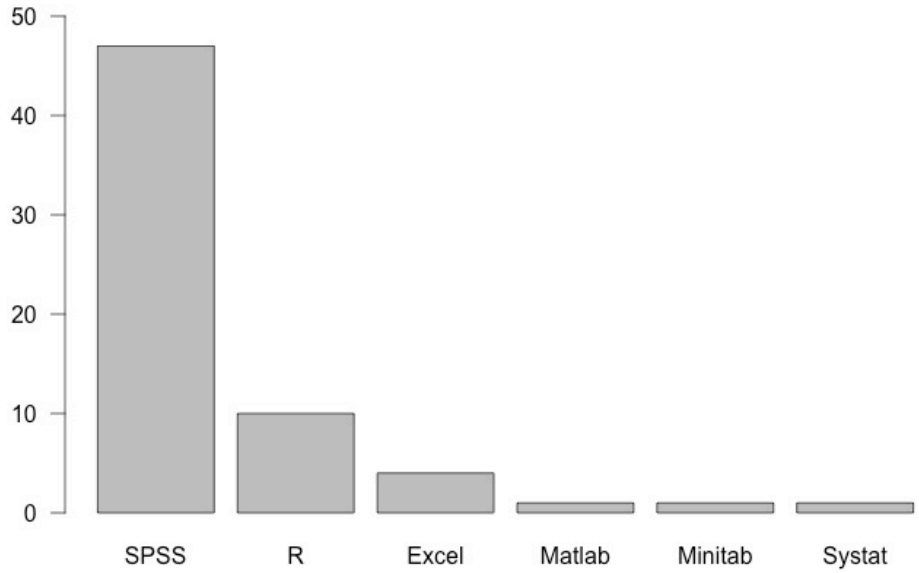

Figure 3: Number of intermediate courses using each software package.

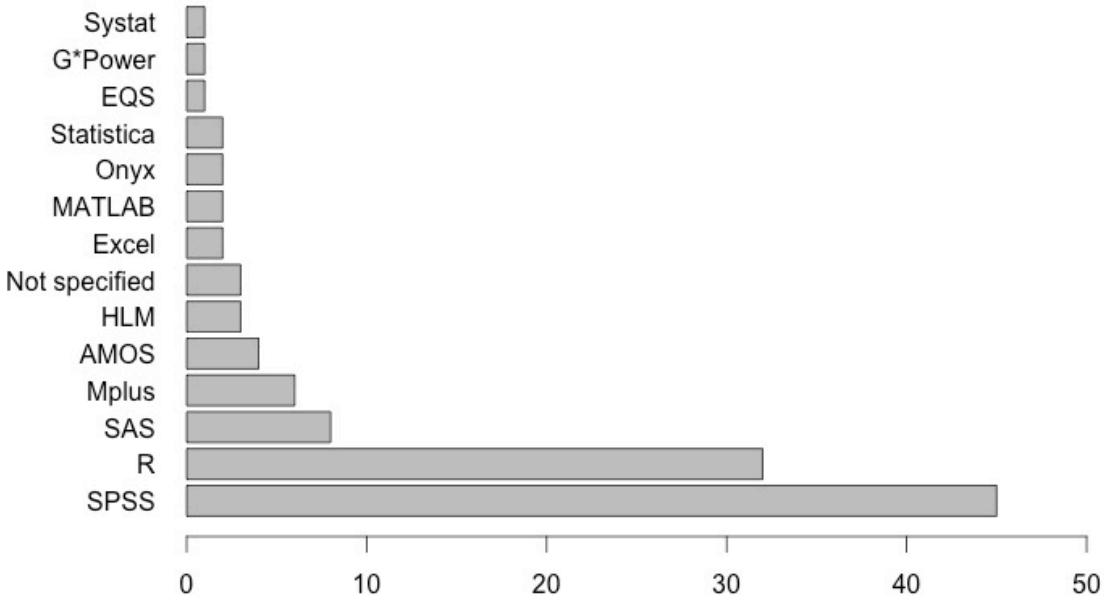

Figure 4: Number of graduate courses using each software package.