STUDENTS' PERCEPTIONS OF THE FUTURE RELEVANCE OF STATISTICS AFTER COMPLETING AN ONLINE INTRODUCTORY STATISTICS COURSE

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ABSTRACT

Statistics educators have long recognized the importance of empowering students with statistical thinking skills that could be applied beyond the classroom. However, there is a dearth of research on how students deem statistical topics as having practical future relevance after they complete introductory courses. Focusing on student interest in and perceived value of statistics, this study reports findings from a qualitative study that examined students' written reflections to explore the nature and extent of the perceived future relevance of statistics among undergraduate students who completed a first-year introductory statistics course online. Findings show that students deemed statistics topics as important if they could be applied to their everyday lives or their academic- and career-related interests. We conclude with recommendations for instructors of introductory statistics courses that enroll students with diverse interests and goals.

Keywords: *Statistics education research; Attitudes toward statistics; Introductory statistics; Online course*

1. INTRODUCTION

Within the statistics community, there has been a significant emphasis on bridging the theory-practice gap by making statistics more relevant and practical. A core value of the Statistics Society of Canada (2016) is to "help develop public awareness of the value of statistical thinking and the importance of statistics." Similarly, the American Statistical Society (2016) acknowledges the importance of statistics in public policy and human welfare. Statistics transcends the classroom walls and holds value in the daily lives (Pierce & Chick, 2011) and future careers of students (Gal & Ginsburg, 1994). Statistics educators are therefore working to develop students who will "take what they learn and apply it to the real world" (Wroughton, McGowan, Weiss, & Cope, 2013, p. 50). This is evident in the existence of a sizable body of research on the use of context-specific resources such as games, stories, sports and humour to teach statistics (for examples, see Baglin & Huynh, 2015; Gates & Bolton, 2015; Hourigan & Leavy, 2016; Lomax & Moosavi, 2002).

Introductory undergraduate statistics courses are critical because they often represent students' first and potentially only contact with statistics in university. As Ramirez, Schau and Emmioğlu (2012) have noted, most students take one statistics course as part of their undergraduate degree, challenging instructors to empower students with statistics skills that will be useful in their professional and daily lives in that single course. Students who have positive perceptions after enrolling in statistics courses are more likely to effectively utilize statistics beyond the classroom (Shiau & Ismail, 2014). By developing the understanding that statistics is practical rather than abstract, students are also more likely to pursue and apply statistics in future (Schau & Emmioğlu, 2012). It is therefore imperative to ensure that students leave introductory statistics courses with a heightened interest, positive perceptions and

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the ability to connect various topics to real-life contexts. The current study investigates these themes in the context of an online introductory statistics course.

A notable feature of the current study is the fact that it was conducted in an online course context. Although the goal of this paper is not to investigate course format, exploring online teaching and learning is important because online course offerings are growing rapidly in universities and colleges across the world (Mills & Raju, 2011; Payne, 2008). This trend, which is expected to continue (Ray, Metros, & Powell, 2018), is partly driven by increasing demand for higher education (Bandara & Wijekularathna, 2017). Several benefits have been linked to teaching statistics online, including the ability to promote effective student learning using multiple tools such as “case studies, video demonstrations, instructor’s notes, mini projects, online discussion forums” (Yang, 2017). As Shotwell and Apigian (2015, p. 2) have noted, the “majority of studies” have suggested that there exist “no differences in performance outcomes between online (or hybrid) and traditional courses.” Thus, online statistics courses create avenues for effective student learning.

Students’ affective outcomes toward statistics have been explored by many researchers at different levels and contexts (e.g., Gundlach, Richards, Nelson, & Levesque-Bristol, 2015; Paul & Cunnington, 2017; Schau & Emmioğlu, 2012; Zhang et al., 2012). There have even been a number of instruments developed to assess student attitudes toward statistics. Nolan, Beran, & Hecker (2012) conducted a detailed review of 15 of these instruments and Carmichael et al. (2010) presented a theoretical model and described the development of the Statistical Literacy Interest Measure (SLIM) that can be used to measure younger students’ interest in statistical literacy. One of the instruments reviewed in Nolan et al., the Survey of Attitudes Towards Statistics (SATS; Schau, Stevens, Dauphinee, & Del Vecchio, 1995), has been used extensively to assess students’ attitudes towards statistics in multiple contexts (e.g., Hannigan, Hegarty, & McGrath, 2014; Paul & Cunnington, 2017; Sarikaya, Ok, Aydin, & Schau, 2018; van Es & Weaver, 2018). Although we did not measure student attitudes in the current study, two attitude components highlighted within the SATS (i.e., Value, or “attitudes about the usefulness, relevance, and worth of statistics in personal and professional life,” and Interest, or “attitudes about the difficulty of statistics as a subject”) align well with the goals of the current study. Through analysis of students’ written reflections, we aimed to explore the nature of related outcomes further by examining how students express their perceptions about statistics in their own words. In particular, this study addresses the following research question in the context of an online introductory statistics course:

To what extent are students interested in statistics and perceive it as having value (i.e., what are students’ perceptions about the future importance, relevance and usefulness of statistics) after completing an introductory statistics course online?

This question is important because literature suggests that a common challenge that plagues introductory statistics courses is the lack of interest on the part of students (Keeley, Zayac, & Correia 2008; Lee 2007). The current study, then, aims to shed light on how pedagogy in introductory statistics courses may be tailored to improve student perceptions of the future relevance of statistics and hopefully, their overall interest in statistics.

2. LITERATURE REVIEW

Understanding student attitudes towards statistics is a multifaceted/multidimensional task. Eagly and Chaiken (2007) refer to an attitude as “an individual’s propensity to evaluate a particular entity with some degree of favorability or unfavorability” (p. 583). In the context of statistics education, students’ attitudes are manifested in positive, neutral and negative responses to resources, people and objects that relate to their learning of statistics (Chiesi & Primi, 2010). Attitudes towards statistics consist of “affective (emotions and the motivation related to the classes and examinations), cognitive (beliefs and knowledge about the ability required to learn statistics and about the discipline) and behavioral (action tendencies in studying and the performance in examinations) components” (Coetzee & Merwe, 2010, para. 4; Schau et al., 1995).

Student attitudes towards various courses have implications for their learning experience. As Schau, Millar, and Petocz (2012) have noted, the impact of attitudes towards statistics on academic behaviors and outcomes of students has become clearer to statistics educators. Mills (2004) hinted that literature tends to suggest that students generally have negative attitudes towards statistics. Student attitudes are especially important in statistics education because course content tends to be challenging, requiring students to engage in critical thinking, analysis and interpretation (Peters et al., 2013). This results in students often perceiving statistics as uninteresting and challenging (Sotos, VanHoof, Van den Noortgate, & Onghena, 2007).

Because of the multifaceted nature of student attitudes towards statistics, a number of researchers have developed instruments to characterize and measure students' attitudes toward statistics (Nolan et al., 2012). For example, Schau et al. (1995) designed The Survey of Attitudes Towards Statistics (SATS-28, and later SATS-36) as a comprehensive instrument for measuring student attitudes towards statistics. SATS has been used in many different educational contexts (see Hommik & Luik, 2017 for examples). SATS-36 consists of 36 individual items that are assessed under six major attitude components (see https://www.evaluationandstatistics.com for details of the survey). These six attitude components include Affect, Cognitive Competence, Value, Difficulty, Interest and Effort. Although the intent of the current study was not to measure student attitudes, our work relates to two of these six attitude components; specifically, Interest and Value. These are defined as follows:

- Interest: This refers to the extent to which students are interested in statistics. It captures the extent to which students are willing to communicate statistical information, their desire to use statistics and to understand statistical information and their general interest in learning statistics.
- Value: The value component captures ways in which student perceive statistics as being useful, relevant and worthy in their personal and professional lives. This includes its perceived relevance to students' future careers and perceptions of employability. It also captures perceptions of the use of statistics in everyday life situations and beyond the work environment.

Most studies that have used the SATS have attempted to measure these attitude components. For example, Schau & Emmioğlu (2012) used the survey to examine students' attitudes before and after they enrolled in introductory statistics courses across the United States. Whereas most of the other attitude components remained similar, they observed a decrease in the Value and Interest components.

Another example of an instrument that has been developed to measure a specific affective outcome (namely interest), but for younger (i.e., middle school) students, is the Statistical Literacy Interest Measure (SLIM; Carmichael, Callingham, Hay, & Watson, 2010). In developing SLIM, Carmichael et al. (2010) proposed three elements of interest: reflective, importance and curiosity.

- Reflective: This element relates to whether students state they are interested in statistics that arises in specific situations as well as their desire to reengage with statistics in the future.
- Importance: Importance captures whether students are reporting that they are engaging in statistics because it is necessary for school or their life goals.
- Curiosity: The curiosity element relates to students expressing an interest in learning more about statistics

Again, we did not measure student interest or attitudes in the current study. Rather, we examined students' written reflections to explore the nature of these types of affective outcomes. Having said this, even though our student group was older (our students were university-level instead of middle-school level), themes related to the "Importance" element of interest as characterized by Carmichael et al. are related to our research question.

As noted earlier, attitudes towards statistics have implications for student motivation and performance. Positive attitudes towards statistics are important for student success and willingness to use statistics in future (Emmioğlu & Capa-Aydin, 2012). Further, research has drawn explicit links between student attitudes towards statistics and statistics anxiety (DeVaney, 2010; Finney & Schraw, 2003; Onwuegbuzie, 2000). Statistics anxiety refers to "feelings of anxiety encountered when taking a statistics course or when doing statistical analyses…" (Cruise, Cash, & Bolton, 1985, p. 92). Statistics anxiety affects the performance of students negatively (Chiesi & Primi, 2010; DeVaney, 2010). Carnell (2008) suggests that negative ideas about statistics tend to be more prevalent in introductory statistics courses, where students often possess negative attitudes and believe statistics is irrelevant. The ability of students to apply statistics to the real world works against statistics anxiety and uninterest by making statistics more relevant (see Neumann, Neumann, & Hood, 2010; Wilson, 1999).

The current study acknowledges the importance of understanding these attitudes at the individual (subjective) level. The aim of this study is to explore the nature of the positive attitudes of Value and Interest that exist among students upon completion of an introductory statistics course. By exploring these positive attitudes on an individual level in a qualitative way, we may be able to capture strategies for making introductory statistics courses more relevant and interesting.

3. METHODS

This section outlines the methodological details of the study. We start by providing details of the study participants and the course context within which the study was conducted. The study design and data collection procedures are then outlined. We conclude with an in-depth description of the data analysis protocol.

3.1. COURSE DESCRIPTION AND RESEARCH PARTICIPANTS

The current study was conducted in the context of a first year online introductory-level statistics course offered by a Department of Statistics and Actuarial Science at a Canadian university. The course, which is entitled Introduction to Statistics (STAT 1024) was hosted on an online learning management system (Sakai). STAT 1024 is a standard introductory statistics course for non-majors offered in a variety of formats (i.e., lecture, flipped and online) to offer students flexibility. Our study focused only on the students enrolled in the online section. To enroll in the course, students should have successfully completed a high-school (Grade 12) mathematics course or an introductory university-level mathematics course. Because the course is required by many faculties, students came from the Social Sciences, Health Sciences, Sciences and Business. Because it is a first-year course, most students were in their first year and were approximately 18 years old. However, there were a few upper-year students who enrolled to fulfill a statistics requirement prior to graduating. The course content and structure is similar to many first statistics courses taught in universities across Canada and abroad. The major topics covered in the course included data summaries, basic probability rules, experimental design, sampling design, confidence intervals, hypothesis tests, simple linear regression and correlation. The course textbook (Moore, Notz, & Flinger, *The Basic Practice of Statistics*, 7^{th} Edition) was supplemented with other online resources such as discussion forums for Q&A (i.e., Question and Answer) and discussion activities, interactive and non-interactive videos produced by the instructor, open educational resources such as web applets to demonstrate statistical concepts (see https://www.causeweb.org/cause/ for an excellent collection of resources), automatically graded self-tests and ongoing online support from Teaching Assistants. Even though the course was online, the course was designed to facilitate student engagement with their peers through structured discussion activities, their instructor and Teaching Assistants through the discussion forums and email, and with the material, through videos, practice problems and textbook readings. The assessments in the course included a final exam (50%), 4 online quizzes (24%), 4 discussion activities (20%) 10 online self-tests (5%) and a course structure quiz to ensure the students were familiar with the course and course policies (1%). Although there was not a statistical computing component to the course, *R* (see The Comprehensive R Archive Network (CRAN) at https://cran.r-project.org/) was used to summarize and analyze data for all examples so students gained experience interpreting *R* output.

3.2. PROCEDURE

The goal of this study was to allow students to express their personal connections with statistics by identifying the topics in the course which they deemed most important or useful and providing examples of how the selected topics could be beneficial in their future endeavors. We therefore utilized a qualitative research approach, which in the context of education research, has been deemed useful for examining and understanding “the complex behaviors and experiences of individual learners” (Tojo & Takagi, 2017, p. 37). One hundred eleven students were enrolled in the course at the end of the semester. Because conducting and transcribing over 100 interviews was not feasible, discussion forums on the online learning management system (Sakai) were used for data collection. The discussion activity from which the data were collected was an assessment built into the course so students had to participate to earn their grades regardless of whether or not they were participating in the research study. At the beginning of the semester, random groups, each consisting of approximately 8–10 students, were created for the discussion activity component of the course (four structured discussion activities spread throughout the course). They participated in the discussion activities in separate group discussion forums. The last activity from which data were collected was a reflection activity which prompted students to discuss the following broad question with their group members:

> Identify what you think is the most important (or interesting or useful) topic you have learned in statistics, and (a) share it with your group, (b) explain why you chose it as the most important (or interesting or useful), and (c) provide examples of how you think you might use or benefit from this knowledge or skill in the future.

Having group interaction enhanced the richness and clarity of the responses. For example, students would often ask their peers to clarify their perspectives, whereas in other cases, the ideas of some students were precipitated by previous discussions. These interactions can be likened to 'probes and prompts' in qualitative interviews, which refer to verbal or nonverbal cues used by interviewers to elicit information or clarifications and enhance the quality of the data (De Leon & Cohen, 2005; Lopez et al., 2015).

This discussion activity ran for the last two weeks of the semester. After ethics approval was obtained at the end of the semester, an Educational Researcher contacted students by email inviting them to participate in the study. Due to concerns of non-response bias and given the low-risk nature of this project, the Research Ethics Board agreed to an assumed consent (or opt-out) approach for recruiting participants. All but one student's data was included in this analysis. To anonymize the written reflections, the Educational Researcher assigned numeric pseudonyms to participants (e.g., Student 23, Student 45).

3.3. DATA ANALYSIS

As mentioned earlier in the paper, a qualitative approach was used. Due to the diversity of responses, we commenced the analysis by conducting an exploratory inductive coding. This first review of the student narratives (i.e., their discussion postings) was aimed at grouping responses based on similarity and generating well-defined categories or areas under which all the data could be coded. In other words, we wanted coding categories to emerge from students' narratives. This step involved reading students' responses to identify and group recurrent themes and trends based on similarity (Schatz, 2003; Strauss & Corbin, 1990; Thomas, 2006). After this step, the authors discussed the preliminary coding and came to a consensus on the thematic structure for the data analysis (i.e., how to categorize data during the analysis). It was observed that the areas in which students could see themselves using statistics in future was the most consistent feature of student responses. Hence, we used these areas as coding categories. It is noteworthy that coding saturation was reached after approximately 60% of responses were inductively coded. This refers to a point at which further coding generates no new insights (see Fusch & Ness, 2015; Guest, Bunce, & Johnson, 2006).

Through the inductive coding process, it was observed that students identified three broad areas within which they could see themselves utilizing statistics in future, namely: everyday life, their disciplines of specialization and future careers. Students also discussed the application of these statistical methods to varying degrees of depth, which we categorized as 'mentions' and 'in-depth discussions.' Whereas the former refers to instances where students merely acknowledged that certain statistical topics would be useful in certain future scenarios, the latter involved students providing tangible examples, calculations or scenarios to demonstrate how they could see themselves practically utilizing statistics in future. We coded for depth because we wanted to know the extent to which students could establish links between their understanding of statistical topics and specific practical applications.

The next step involved formulating a structure for coherently coding all responses. For a response to be coded, it had to be in the context of a specific application (i.e., discipline, career, everyday life or other) and reflect a certain depth of discussion (i.e., mention or in-depth). These statistical applications are defined in Table 1, and the coding structure is shown in Figure 1.

Table 1. Definition of future statistical applications that were developed from inductive coding and used for the analysis

Statistical application	Definition
Practical life skill	Practical life skill applications of statistics involved students discussing the use of various statistical topics in their day-to-day activities. This includes but is not limited to the use of statistics in: (1) predicting the outcome of sporting events, (2) managing personal finances, (3) using statistics to make health choices, (4) choosing courses in school among others.
Discipline specific	Discipline specific applications of statistics involved students relating specific statistical topics to their discipline of specialization which was mostly aspirational, e.g., an aspiring chemistry student discussing how they could see themselves applying specific statistics topics when studying some aspects of chemistry in future.
Career specific	Career specific applications of statistics involved students discussing specific topics as potentially useful in their future careers. Like discipline specific applications, this cluster of discussions was generally aspirational. An example was an aspiring medical doctor discussing how they would use statistics to determine whether they should perform a surgery or not.
Other	Whereas the above-mentioned clusters of applications were developed by reading approximately 60% of student responses, we still recognized that new applications could emerge in the analysis process. This category was therefore created to capture all responses that did not fall under the three dominant responses above.

Note. Discipline and career specific applications are combined in the analysis because they were often discussed in tandem, making them difficult to separate.

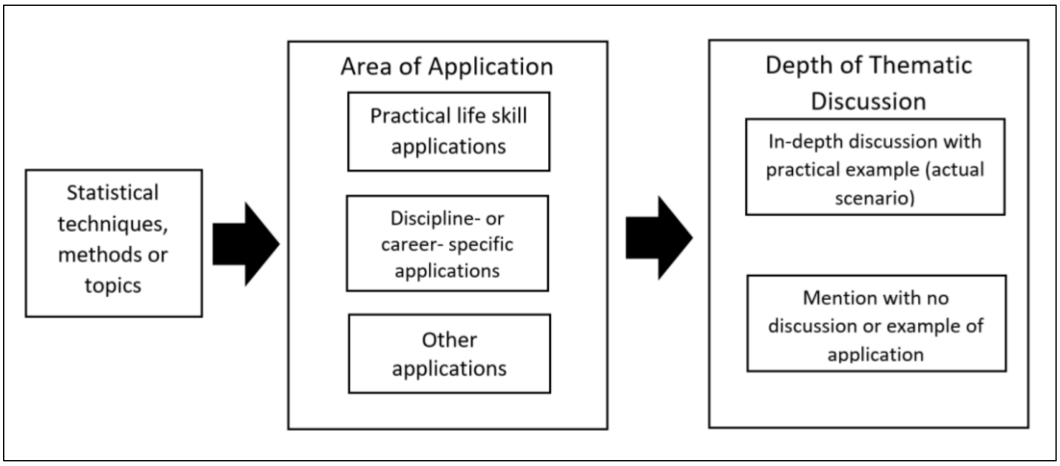

Figure 1. Summary of analytical structure

All the data was then imported and analyzed in NVivo 10, a qualitative analysis software package. NVivo makes it possible to import large parcel of texts, create coding categories (Nodes) and drag parcels of texts into these coding categories as they emerge in the analysis process. The structure of coding that was used in NVivo for this study is shown in Figure 2. In the case of the current analysis, the major nodes consisted of statistical applications (practical life skill, discipline, career, other), and sub-nodes under each of these major nodes captured the depth of discussion (in-depth or mention). While reading student discussions, the parcels of text that pertained to a statistical application and reflected a certain depth of discussion were dragged into their corresponding nodes. The software also automatically generated the number of instances which were coded (see References column in Figure 2). This allowed for more systematic and coherent analysis and helped minimize errors that could arise from coding texts manually (Bazeley & Jackson, 2013).

Nodes

Name	Sources	References
Application of Statistical Techniques & Concepts	20	226
(DS) Discipline and Career Specific Application	20	101
DS- Mention	18	62
DS- Indepth Discussion	18	39
(PL) Practical Lifeskill Application	19	104
PL- Indepth discussion	16	56
PL-Mention	16	48
(OA)Other Applications	9	21
OA- Indepth discussion	7	14
OA-Mention	6	7

Figure 2. Coding structure that was used for the data analysis in NVivo 10

4. RESULTS

In this section, we first provide a descriptive account of the frequencies of responses that were coded. This is followed by a presentation of student perspectives on the potential future application of statistics. Figure 3 presents a summary of the distributions of responses which were obtained following the coding. Many of the responses fell under the practical life-skill category (47%), but the number of discipline and career-focused responses were not far behind (43%). Only 9% of responses fell under the “Other” category. Practical life-skill responses possessed more in-depth explanations compared to mentions. Conversely, the number of mentions within the “discipline or career specific” category were almost twice more than in-depth explanations. These patterns lead us to suspect that students connected more deeply with statistical topics that had practical life skill significance. We also speculate that the lack of depth in a majority of discipline and career specific responses stemmed from respondents having little experience in their disciplines when taking the course or an attempt to be sensitive to their group’s diversity by avoiding detailed discussions which may not be relevant to their peers.

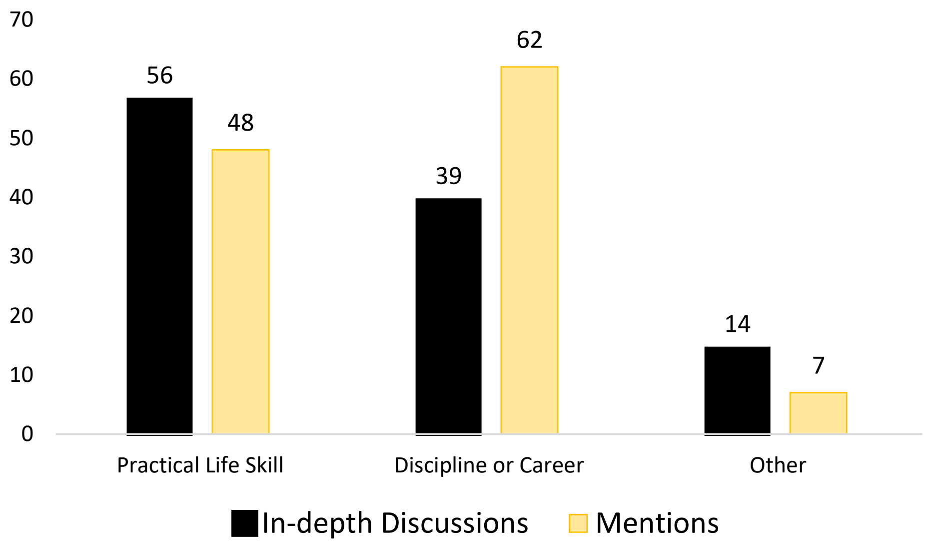

Figure 3. Frequencies of potential future statistical applications and depths of discussions

The following discussion of student perspectives is presented under three major areas, representing the three broad statistical applications that emerged from the coding (i.e., practical life skills, discipline and career and other applications). Under each area, the results are organized under subsections representing the most dominant themes that emerged from students’ discussions.

4.1. PRACTICAL LIFE SKILL APPLICATIONS OF STATISTICS

Under the area of practical life skill applications, students discussed different ways in which they could see themselves using statistics in their future everyday lives. The key themes that emerged in this area included the usefulness of statistics for

(1) making critical life choices (e.g., health and safety, financial management),
(2) engaging in everyday entertainment (e.g., playing games, following sports events, gambling),
(3) evaluating and tracking personal progress in various aspects of life (e.g., academic performance), and
(4) critically appraising everyday information (e.g., media reports and opinion polls). An overarching theme that sums up these responses is the idea that statistics constitutes an integral part of their day-to-day lives.

Application of statistics in making critical life choices Concerning students' discussions around using statistics to make critical life choices, emerging subthemes focused mainly on the application of statistics in aspects of their life such as financial decision-making and health. Concerning using statistics to make personal health-related choices, students claimed they could see themselves applying statistics in future when confronted with surgery choices, medication decisions, dietary choices and childbirth. Major statistical topics that were identified as relevant in these contexts included Simpson's paradox, probability and correlation. In terms of utilizing statistics to discern health conditions which could impact unborn children, one student, for instance, acknowledged the value in using probability to predict the possibility of genetic or hereditary diseases. The student asserted that "because I myself have a heart condition, I could definitely see myself visiting a genetic counselor (as my own parents had) to check how likely it would be to conceive a child with the same condition" (Student 80).

Students also recognized that statistics could be useful in future when confronted with surgery or medication choices. The dominant statistical topic that was discussed in this context was probability. One student indicated that "if we need to do a surgery, we want to know the probability of success before we get the surgery" (Student 77). Whereas similarly, another student noted that "when you are looking at a certain drug for example; doctors usually have a certain percentage that shows the likelihood that the drug is effective" (Student 65); hence, the importance of thinking in the context of probability in such situations. A student who was of the view that statistics was beneficial in drug choices presented an in-depth scenario:

> …the most interesting concept that I've learned about is Simpson's Paradox…. It stresses the importance of taking into account lurking variables in data. This would be especially crucial in many real-life situations. For example, if a drug company was testing two drugs that treated a terminal illness. In the first trial, drug A was successful in 8/10 = 80% and drug B was successful in 70/100 = 70%. In the second trial, drug A was successful in 50/100 = 50% and drug B was successful in 4/10 = 40%. In total, drug A had 58/110 = 53% success and drug B had 74/110 = 67% success. If we were just given the end total success rates, we would be misled into thinking that drug B [was] more effective–end of story. However, when looking at the trials separately, the information is reversed. (Student 37)

Related to health, some students could also see themselves potentially applying various statistical topics to make nutritional choices in future. Probability, significance testing and correlation and causation were the main topics discussed in this context. Acknowledging the importance of statistics in understanding the nuances of (un)healthy food choices, a student acknowledged the importance of using statistics to question nutritional information:

> …. if someone says to not eat or do something because it'll increase your chances of developing a disease, it's important to know what's the exact probability backing the claim and decide whether their statement is personally relevant to you… (i.e., are the claims statistically significant in producing an effect in the general population?). For example, if eating chocolate cake increased your chances of developing cancer by 0.02% (not a statistically significant probability level), would you stop eating chocolate cake for the rest of your life? (Student 95)

The application of statistics in safety-related decisions received a little attention as well. For example, two students discussed the value of probability in predicting extreme weather events and determining the failure rate of indoor smoke detectors, respectively.

Another subtheme that was discussed in the context of using statistics to make critical life choices was the potential to apply various statistical topics to inform financial management and career-related choices. In these contexts, students could see themselves using statistics to evaluate career choices in future (e.g., promotion and salary increase prospects), choose insurance plans (e.g., compare premiums), evaluate stock market investments and manage personal finances. The dominant topics identified as relevant in these discussions included probability, time series plots, descriptive statistics, standard deviations and data visualization.

In terms of using statistics to inform future employment decisions, students identified descriptive statistics and Simpson's paradox as useful in estimating potential salary increases and promotion opportunities prior to choosing jobs. One student, for instance, discussed the utility of statistics for understanding the fluidity of wages, claiming that "the average workers' wage may increase nationally, but the wage of those who obtain a bachelor's degree (or higher) may have shown a decline" (Student 58). The student then made a case for thinking about Simpson's paradox to decipher such nuances which may not be apparent on the surface. The ability to apply descriptive statistics in understanding incomes was discussed by another student:

> …the most important topic I have learned about statistics so far is the descriptive statistics…. the measures of center, spread, and position can be very useful… standard deviation provides insight on how diverse the data set is and how close the data is to the mean, or whether the data is spread out over a wide range. For example: the starting salary at a company can be $70,000. But if the standard deviation was $20,000, then there is a lot of variation in terms of how much money you can make, so $70,000 is not as informative as it may seem…. In the future I will continue to use these measures of tendencies to understand quantities which indicate central values of a data set and how closely the data clusters around these centers. (Student 98)

Regarding the use of statistics for personal financial management, students discussed using statistics to compute insurance premiums, monitor personal expenditures and manage stock investments. Probability, correlations, graph interpretation and standard deviations were among the key statistical topics identified as useful in this context. In one instance, a student who acknowledged that the skills acquired in interpreting graphs would be frequently useful in making stock investment decisions stated that "what I've found to be really interesting or useful in [this course] was being able to decipher graphs…being able to read and understand graphs helped me in terms of the stock market" (Student 2). Relatedly, Student 81 cautioned about the importance of calculating the "probability of earning money" before making stock investments, whereas another student discussed using statistics on the stock market:

> Applying what we learned about determining correlation coefficients and standard deviations in this course can help us make decisions on which stocks to hold in our portfolio and to what extent we would be willing to hedge our risks [at] the expense of rewards. For example, if we have a portfolio with 30% invested in Stock A, which is currently yielding a -8% return and 70% in Stock B, which is currently yielding +5% return, our total portfolio's rate of return would be +1.1% Portfolio rate of return = [.30* (-8%)] + [.70* (5%)] = 1.1%. Since Stock B is more heavily weighted (greater proportion of funds invested) than Stock A, we still managed to generate a positive return of 1.1% on our investment even though Stock B is yielding -8%. Therefore, conditional probability can help us determine which stocks best fit the amount of risk/rewards we want to take on in an entire portfolio of stocks. (Student 33)

In terms of personal finances, the idea of using statistics to manage day-to-day expenses, savings and cash flows was also evident in student discussions, though not very prominent. For example, Student 102 discussed the benefit of displaying data in response to a previous comment from a colleague who was struggling with personal finances as follows: "...with your expenses problem you can use a two-way table to show the distribution of each variable every week or month so you can monitor how much you are spending and where you are spending it the most…" In the context of insurance, students mainly discussed using probability to calculate premiums and the potential of risks (e.g., accidents) prior to settling on plans (e.g., Students 96 and 106).

Application of statistics in entertainment Within the theme of making critical life choices with the help of statistics, students also indicated the potential of using statistics in entertainment- and leisure-based activities. The dominant activities that emerged in these discussions included playing card games, predicting the outcomes of professional sporting events, playing sports, and gambling. The topics that were considered relevant and useful in these discussions included probability, central limit theorem (CLT), Simpson's paradox and distributions.

Regarding playing sports for instance, Student 33 identified probability as relevant to smartly choosing a penalty taker in a soccer game or even aiming the penalty "shot at the area that you feel you will have the highest probability of scoring in" based on the goalkeepers demonstrated weaknesses. Referring to the topics of probability and descriptive statistics, another student who claimed to have watched hockey since age 4 asserted that "I can now more quantitatively compare my favourite players, and more accurately predict outcomes" (Student 29). Student 6, who had watched basketball since age 10 also felt better equipped to understand statistical statements "by commentators." Claiming that the knowledge acquired in the course could help uncover hidden meanings, a student demonstrated the use of Simpson's paradox to understand hockey:

> There are 2 goalies in the NHL who are considered top caliber. Craig Anderson and Jonathan Quick. Over the last 3 years, the following statistics were recorded. JQ (2014): 1083 shots against him, 91.5 save % (2013): 802 shots, 90.2 save % (2012): 1730 shots, 92.9 save %. *mean save %: 91.55*. CA (2014: 1680 shots against him, 91.1 save % (2013): 677 shots, 94.1 save % (2012): 1917 shots, 91.4 save %. *mean save %: 92.2%.* Based on the italicized figures, it is fair to say that Anderson would be the better goaltender based on him having a better and more consistent save % over the last 3 years. However, when the individual shots that were saved by each goaltenders are combined from all 3 years and are divided by the individual shots faced respectively, the results are different. JQ: (990 + 723 + 1607)/ (1083 + 802 + 1730) = 3320/3615 = *91.8% of JQ's shots over 3 years have been saves*. CA: (1530 + 637 + 1752)/ (1680 + 677 + 1917) = 3919/4274 = *91.7% of CA's shots over 3 years have been saves*. Thanks to Simpson's Paradox, it is easier to conclude that over the last 3 years, Quick has been the better goaltender. (Student 13)

As evidenced by the above posting, some students described very detailed examples and even included data summaries. Students may have used the textbook or the internet to locate specific examples or used hypothetical scenarios and numbers to support their responses. No specific guidance or examples were provided with the discussion activity prompt. This particular student (i.e., Student 13) sounds like a hockey fan so presumably is familiar with hockey statistics and where to find them.

Concerning gambling, the emphasis was generally placed on the topic of probability. An example of this occurrence is captured in the following statement by a student: "before we play games with our friend or in the casino, we should calculate the probability of winning first to decide whether we should play or not" (Student 81).

Application of statistics to evaluate and/or track personal progress A major subtheme under the critical life skill theme was the usefulness and relevance of various statistics topics in evaluating and/or track progress in some aspects of students' lives. The key focus of these discussions was around using statistics to evaluate academic progress. Statistical topics that students linked to these applications included central limit theorem (CLT), standard normal distributions, measures of central tendency, *z*-scores and probability. It is noteworthy that these responses focus on academic progress, and are different from applying statistics in a discipline-specific context (e.g., using statistics to compute health disparities and population data in epidemiology and geography respectively).

Concerning using statistics to monitor academic performance at the class level, Student 20 stated that they could better understand the standard deviation and mean scores which were provided by their professor by applying measures of central tendency, stressing that "I was able to see how well I did compared to my classmates." Another student claimed that they would use standard deviations to see how much their "marks have fluctuated throughout the semester" and observe whether their marks have "stayed close… or were spread out throughout the semester" (Student 11). Students 96, 92, and a host of others made similar comments. Students also discussed using statistics in future to inform graduate school choices based on performance. This is demonstrated in the following example which was, in part, a response to a previous comment:

> I agree that using probabilities in terms of exam marks would be quite interesting. For myself I know that I have recently been looking a lot at grad (graduate) schools and the marks required to obtain admission to a variety of programs. It would be interesting to try to calculate the probability of getting the needed average to be admitted using expected and/or previously obtained marks. The more I think about it the more ways I can see how statistics will be incorporated into my future. (Student 49)

As a follow up to the above quote, Student 110, who also claimed they were considering graduate school suggested that they would use statistics to project which graduate level classes they would "likely succeed in" based the courses they best performed in during their undergraduate education.

Application of statistics to appraise everyday information A final subtheme in the discussion of critical life skill applications of statistics concerned students feeling more empowered to critically appraise everyday information (e.g., media and hearsay communication) and discern biases using their newly acquired statistical knowledge. Topics that were deemed relevant and useful in these discussions included Simpson's paradox, quantifying uncertainty, study design, sampling approaches and the topics of validity and generalizability.

Referring to the importance of statistical knowledge in deciphering the accuracy of information, one student, for instance, discussed using Simpson's paradox to uncover hidden "meanings in conversations with friends who may be speaking in statistical contexts" (Student 64). Discussing the importance of statistics in deciphering the accuracy of media reports, another student cautioned that most statistics quoted in the media are based on convenience and voluntary sampling; hence, the importance of learning "to figure out which studies and surveys you can trust and which to take with a grain of salt" (Student 95). Relatedly, a student cautioned about potential biases in opinion polls often reported in the media:

> I am a total policy wonk, and I'm constantly scanning newspapers like the Globe and Mail, NYTimes (New York Times) … One of my favorite quotes is: "there are three kinds of lies: lies, damned lies, and statistics." ……I had no idea how simple it was to change questions or create bias, which would skew the data through impartiality or the weakness of questions. But, in context of the kind of polls that come out, it makes sense. Think about it – how many different polls do we see every week? And some of them say completely different things. Even the same poll might come back week after week with varying results. Some potential insights: they might ask leading questions. They might not be accounting properly for updated demography or geography of certain areas (e.g. only talking to individuals from certain socio-economic backgrounds, racial backgrounds, or religious backgrounds, or they could be talking to urban or rural more than the other). (Student 85)

The quote above demonstrates the recognized importance of scrutinizing sampling and study design to help discern the accuracy of media-reported statistics. Students 13, 99, 113, and several others stressed the importance of paying attention to the potential manipulation of data or results when reading media reports that contain statistics.

A student who agreed with a previous statement concerning the importance of understanding how to quantify uncertainty stated that "I am going to be more skeptical when I am viewing statistics…I will question where the data is coming from and whether or not I think that there is information that was chosen not to be displayed…." (Student 60). The student further cautioned that being skeptical is especially key when viewing advertisements.

4.2. DISCIPLINE AND CAREER SPECIFIC APPLICATIONS OF STATISTICS

Within this second major area of responses, students identified statistical topics as potentially relevant to their future or ongoing disciplines and careers. These responses collectively demonstrate students' abilities to think beyond the course by establishing links between statistical topics and their respective disciplines and/or career aspirations. A shared value among students from different disciplines was the sense of empowerment with techniques to design and execute studies and/or experiments in their ongoing or aspiring fields of specialization. Students also felt equipped to critically assess the rigor of studies in their respective disciplines.

Applying statistics in study design and execution Based on knowledge acquired in the introductory statistics course, students from diverse disciplines and those aspiring to specialize in specific disciplines (e.g., chemistry, nutrition, health studies, kinesiology and psychology) felt they grasped the skills necessary to design and conduct discipline-specific studies from the ground up. A procedure which was almost unanimously acknowledged as useful and relevant irrespective of disciplinary context was study design. Other topics that emerged in this context included producing experimental data, regression analysis, data visualization, probability and sampling. In general, individual students often acknowledged multiple topics as useful. For example, the importance of understanding study design was discussed by a student who also acknowledged that they were aspiring to pursue medicine in the future and to conduct health-related research:

> In my opinion the most important/useful topic that I have learnt in statistics thus far is study design. Considering I hope to do research in my time as an undergraduate student and possibly in my post-graduate studies, I believe knowing how to perform different types of experiments would be most beneficial for my future.… if a doctor wanted to run an experiment to test a new drug or track an illness among patients, they may use an experimental study like the ones we learnt in study design. As well, over the past summer I assisted an allergist in his study of a hive that arises from contact with the skin, known as dermographism, or dermatographic urticaria. If I had learnt study design before compiling research and patients with this form of hives, I could have more easily grouped the patients into study groups based on how the experiment was planned on being run. (Student 13)

Similar to the above example, students occasionally recalled past research experiences and explained how the topics covered in the introductory statistics course would have been beneficial if acquired earlier. As noted earlier, the quote above came from a student who was aiming to pursue medicine in future. It is also noteworthy that students often discussed discipline- and career-based applications of statistics in tandem.

In response to a psychology student who was speculating about the potential usefulness of study design in future, an upper year psychology student provided insights on the importance of study design and other statistical topics as follows:

> Are you considering doing a thesis in 4th year, because as a psychology student, if you opt to, you will get to use your new knowledge in a very important way. In psychology a lot of research is retrospective or prospective in nature and involves surveys often times using recognized scales to evaluate whatever variable you desire e.g., EDS-21 for Exercise Dependence. An important analysis apart from comparing statistical significance with T-TESTS, is Correlations especially when dealing with surveys designed to evaluate the relationship between two things. What do you think? are you considering a thesis? (Student 55)

Sampling was another topic which was discussed as relevant for designing and running discipline-specific studies within the discussion forum. One student who claimed they were interested in pursuing physiotherapy, for instance, explained different types of sampling methods while claiming that in assessing patients, they would likely "use a simple random sample to ensure that every patient has the same chance of being selected and their data being taken into consideration" (Student 21). A fourth-year chemistry student also drew links between the importance of sampling as studied in the course and their ongoing research experiences as follows:

> The group I have been involved with over the past year performed many of their simulations using a class of algorithms known as Monte Carlo methods. These methods make use of random sampling techniques to pick out various molecular states that are then used to calculate a certain parameter. Learning about the different variations of taking a random sample in this course has allowed me to better understand this statistical method. (Student 111)

As in the quote above, students with research experiences often acknowledged gaining new insights from introductory statistics. Discussing the likelihood of studying "female athletes that have had reconstruction on their Anterior Cruciate Ligament (commonly known as ACL)" Student 101 acknowledged the importance of sampling. More generally, Student 96 and a host of others acknowledged the importance sampling will likely have in their future Masters and Ph.D. research as well as their aspiring careers.

Probability was another topic which was acknowledged as having discipline-specific relevance. In the words of a chemistry student, “many of the equations we use in my chemistry courses deal with probabilities. One of the most important equations would be Schrodinger’s equation, which is an unsolvable function used to describe the probability of an electron being at a given point in space….” (Student 31). In response to previous comments on the importance of probability, a kinesiology student discussed their appreciation of the topic and its likely usefulness in future:

> I agree with a lot of you that the probability aspect of this course was the most useful. More specifically being able to understand a written problem and being able the apply the right probability rule to it. This was what I found to be the hardest aspect of the course and therefore, when I started to get the hang of it I found it to be the most useful. So far I haven't had to apply anything I have learned in this course to other classes I am taking (I am in Kinesiology as well) However, I am positive the information I have learned will be useful in my 3rd and 4th year …. This is backed up by the great examples the rest of you have been giving on all the ways you have already applied the information you have learned. (Student 14)

Relative to the aforementioned topics, fewer students acknowledged that learning about data visualization and regression analysis would be relevant to research in their future disciplines. Student 76, a second-year chemistry student, for instance discussed regression analysis as a “critical” topic for students in the sciences, acknowledging that “...many aspects of linear regression from module 5, and one variable descriptive statistics from module 4 have been applied in another course I am enrolled in.” The following quote demonstrates a physics student’s experience-based appreciation of the importance of data visualization for research in their discipline:

> A topic that has been extremely useful for me that we learned in the course has been the use of residual plots. While here we mostly used residual plots with the least squares regression line, the residual plot can be used with any regression fit. This allows patterns in the data to be viewed with any type of fit, and the multiple types of fits, whether they are linear, polynomial, or exponential can be compared side by side. This has been specifically useful to me as I have been able to apply this to my senior thesis in the Physics 4999E course. In simplistic terms my thesis is on a mathematical model of cancer growth. After using the residual plot for my thesis, I think it is clear that it can be an extremely useful tool. In the future I am sure there will be other opportunities in data analysis for me to use the residual plot to help visualize data. (Student 69)

As demonstrated in the above quote and several others, some upper year students connected various statistics topics to their ongoing or past research experiences when discussing useful and relevant topics.

Using statistical knowledge to understand and assess discipline-specific studies In addition to recognizing statistics as useful for discipline-based research, some students felt empowered by the topics covered in the course to better understand and assess the rigor of studies in their respective disciplines. The dominant topics that emerged in this context included study design, sampling, confounding, descriptive statistics and validity. Overall, students deemed these topics as foundational, best expressed in the words Student 95 who asserted that “differentiating what separates good research vs. bad research is a main hallmark of university educated critical thinker.” As such, some students were even critical of peer reviewed research, claiming that they could have flaws. This occurrence is best captured in the following quote which also highlights a majority of topics which were acknowledged within this category of responses:

> As a third year Kinesiology student, I am enrolled in a required course in which lab reports compose the majority of academic assessments. Study designs, variables, avoiding confounding, sample sizes, statistical analysis play very important roles in validity of experimental studies. Statistical Analysis has been by far the concept of statistics that has intrigued me the most. The importance of being able to quantify certainty and uncertainty, is invaluable to the literature that has been published in academic journals. Just because two test conditions appear different DOES NOT mean they are actually statistically different!!! This is absolutely intriguing. Most people would agree that if two numbers are different….eg: A study has been conducted to evaluate the effectiveness of Goat Manure on Apple production. The study has found that the control group yielded an average of 28 apples per tree, and the manure group yielded 32 apples per tree on average. Most people would agree that the above example shows two different values for apples produced per tree, which would likely lead one to believe that the Manure Condition leads to increased yield (32 vs 28) BUUUUUUUT

> depending on statistical analysis, we might conclude that the yield is actually statistically similar between the two trees (due to the sample characteristics and standard deviation and other factors). (Student 55)

Similar to the above example, Student 95 identified the need for "extensive meta-analysis" to understand academic studies beyond face value, claiming that "there is so much pseudoscience being spread around these days and people accept the findings as the absolute truth, just based on the fact the authors managed to find some mediocre research journal to publish it."

Relatedly, some student accounts suggest that they were benefiting from the topics covered by being able to better understand studies in their respective disciplines. This is exemplified in the following quote from a student who found they possessed more statistical knowledge than their colleagues within their discipline (nutrition):

> As a nutrition student, my program doesn't require me to take a statistics course until second year, but I am so glad I took statistics this year. In my FN 1030 class, we just recently completed a big group research project. This project involved analyzing a number of scientific studies, which made use of statistics in both study design (e.g. single blind vs. double blind, randomized or not, control groups, blocking, etc.) and in the way results were interpreted (measures of center, sampling distributions). I often found myself explaining these terms to others in my group, and I think taking these two courses concurrently enhanced my understanding of both. (Student 107)

Student 42 similarly claimed that they were already applying insights from one of the topics covered (i.e., quantifying uncertainty) in "topics in biology as well such as population genetics and evolution," whereas Student 103 acknowledged descriptive statistics and correlations as useful in helping them analyze data "and writing a research paper" in their elective psychology course. Students also mentioned that some topics covered better equipped them in their class engagement. For instance, Student 37 who was specialising in psychology felt better equipped to identify bias in statistics when presented with studies during lectures. Students also felt better positioned to understand visual statistical data in their respective disciplines.

Future application of statistics in career-based contexts Students' discussions also revealed that they considered various statistics topics as having potential relevance to future careers. As evident in the previous subsections, career-related discussion often came up when students discussed discipline-based relevance and usefulness of various topics. Students rarely discussed the career-related relevance or usefulness of statistics discussed in isolation. In cases where they did, the key topics discussed were measures of central tendency, probability and standard deviations. For example, Student 24, who could see themselves working in finance in future, suggested that "applying standard deviations to a company's past sales growth measures will allow me to see how volatile changes in sales are occurring and how stable their revenue streams actually are…"; consequently, revealing potential future growth trends.

Acknowledging the potential career relevance of probability, Student 24 who could see themselves owning a car rental business in future claimed that "if I own 20 rental cars, the chance that any one car will break down on a day is about 1 in 10. I might want to know the chance on a particular day (tomorrow) that 5 of them will be out of action… module 6 will come in practically useful for myself in the future." Finally, in response to a colleague's comment about applying statistics in studying children, a student who had experiences working with children who were getting diagnosed with autism stated that, for a specific child, they "had to use different statistics to learn what programs to use with this child, and how to deal with the situation in the best manner" (Student 110). They therefore acknowledged that understanding different statistical methods could be useful in such work-based contexts.

4.3. OTHER APPLICATIONS OF STATISTICS

The 'other' category captured all applications of statistics which were not discussed in the context of students' everyday lives, future careers, or disciplines of specialization. Athough most of these responses are similar in nature to the discipline- and career-specific discussions in the previous sections, they were not connected to students' personal lives. Hence, we only highlight statistical applications which were unique to this category of responses. The major topics which came up within these responses included Simpson's paradox, statistical inference, confidence intervals, sampling techniques, probability and normal distributions. The main statistical application which was unique to the other category came from student 101, who in response to a previous comment on sampling, stressed that a critical understanding of sampling "would be more suited for people that want to work for very large organization or even something such as stats Canada that deals with national statistics."

5. DISCUSSION

The current study sought to understand students' interest in statistics and perceptions of the future usefulness of statistics after completion of a general introductory statistics course offered online. To allow students to express themselves subjectively and personally, we utilized a qualitative approach. The goal was not to generalize to all students who take introductory statistics online or otherwise; but rather to delve deeper into students' perceptions after taking this course to gain some insight into the nature of their perceived relevance and usefulness of statistics. Despite variations in responses, students' perspectives of the potential usefulness of statistics in future fell under three broad thematic areas: (1) practical life skill applications, referring to the use of statistics in everyday life events and activities; (2) career specific applications, referring to the potential use of statistics in students' future jobs, and (3) discipline specific applications, referring to the application of statistics in students' current or aspiring academic disciplines of specialization. A few others identified potential future statistical applications not linked to these categories. Overall, the study helps demonstrate the value of qualitative methods in statistics education research.

Within the current study context, students managed to provide insights on how statistics could be useful in future, though to varying degrees of depth (i.e., mentions versus in-depth discussions). In general, this finding reinforces several studies that emphasize that online statistics courses are as effective as face-to-face courses (see Björnsdóttir, Garfield, & Everson, 2015 for a list of these studies). Although the current study does not focus on this comparison, it suggests the overall effectiveness of online statistics courses in developing students who understand that statistics holds value beyond the classroom environment. As Gal, Ginsburg, & Schau (1997) noted, students' beliefs impact their ability to develop statistical thinking skills and/or apply statistics beyond the classroom. Insofar as we see in the current study outcomes, students left the course empowered with varying levels of positive beliefs and statistical thinking skills, evident in their ability to connect the topics covered to different aspects of their future lives. Thus, we can verify that students gained some statistical thinking skills, which remains a primary goal of statistics education (Rahman, 2016).

In the words of Zieffler, Garfield, delMas, & Reading (2008, p. 40) "drawing inferences from data is part of everyday life." Among statistics educators, there exists consensus about the importance of increasing students awareness of the existence of data in everyday life (Rumsey, 2002). Within the current study, the most commonly discussed potential future application of statistics was in the area of practical life skills (i.e., everyday life). Specific themes of focus within students' discussions included the application of statistics in games, personal finances, monitoring personal progress, discerning the accuracy of media and hearsay information, and making health-based decisions. These themes align with the key themes around which statistics educators are building pedagogy to ensure students find statistics more relevant, useful, and practical (e.g., Baglin & Huynh, 2015; Hourigan & Leavy, 2016 and others identified in the introduction). Practical life skill discussions also contained more in-depth reflections than mentions, suggesting that students strongly grasped the potential future utility of statistics for their everyday lives.

Though relevant, the ability of students to recognize the usefulness of statistics in everyday life seems at best a first step towards developing statistical thinking skills. Although students were able to, in several cases, provide in-depth explanations about applying statistics in practical contexts (e.g., comparing hockey goalkeepers, choosing a surgery, discerning media biases, etc.), it is difficult to imagine them engaging in such deep statistical analyses while watching sports, reading newspapers or even visiting physicians. Thus, practical life skill applications pertain more to thinking statistically on a daily basis rather than applying statistics to the full extent possible (e.g., working through calculations). As mentioned in the introduction, statistics education scholarship suggests that students' ability to apply statistics in the real world helps minimize statistics anxiety (Wilson, 1999). Whereas practical life skill applications may represent a first step towards statistics literacy, the ability of students to identify and demonstrate the real-life relevance of statistics in the current study suggests that the course may have minimized their experiences of statistics anxiety. Hence, it is important that statistics pedagogy continues to maintain a focus on empowering students to understand the everyday importance of statistics.

Discipline-specific applications were the second most prominent group of potential future statistical applications that were discussed by students. This is encouraging because students generally felt better equipped to understand statistics and conduct research involving statistics in their aspiring disciplines and careers. Of note is the fact that the frequency of mentions were almost two times greater than in-depth discussions. In most cases students therefore failed to provide detailed explanations of how they could utilize statistics in their future carriers or academic disciplines of specialization. As Gal and Ginsburg (1994) and several others have noted, students' first statistics courses should prepare them for academic and/or professional careers. A major challenge faced by instructors of general introductory statistics courses such as the one offered in the current study is the fact that students have a broad range of career and academic interests. This makes it challenging to use context-specific situations that help students develop statistical thinking skills relevant to their disciplines and career aspirations, which remains a core goal of statistics education (e.g., Snee, 1993). For example, an instructor may be confronted with the question of providing a context-specific example pertaining to a topic (e.g., probability, study designs, Simpson's paradox) that holds relevance for students aspiring to be psychologists, kinesiologists, economists, biologists, chemists, and physicists.

The general lack of depth in the discussion of discipline and career related applications of statistics may speak to context and pedagogy in general introductory statistics courses. Specifically, there is a need for instructors to find ways of incorporating discipline and career-based perspectives within such courses despite variations in students' aspirations or backgrounds. How can this be achieved? A partial remedy to this challenge emerges from the current study itself. It has been argued that online discussions are a benefit of teaching online (Everson & Garfield, 2008; Groth, 2008), because they enable students gain a variety of perspectives from their peers (Kear, 2004). As evident in the current study results, upper year students often responded to the speculations and uncertainties of lower year students concerning the discipline-specific relevance of statistics. For example, they would often provide tangible examples of how they were using the topics studied in their projects and, in some cases, upper year thesis research. Online introductory statistics courses could consider setting up forums that group students based on their discipline- and career-based interests with the goal of discussing the relevance of statistical topics. These groupings would also be possible in a classroom environment, or as a supplement to the classroom environment. Teachers of general introductory statistics courses could also consider choosing statistically proficient Teaching Assistants from different disciplines to provide discipline-specific mentoring for students and help them grasp the relevance of statistics within their disciplines of interest. Resources such as videos which speak more directly to the usefulness of introductory statistics in certain careers could also be made available to students via online course management systems. Introductory statistics instructors may also consider assessments that require students to find studies in their discipline of interest or talk to experts in their aspiring careers and reflect on how specific topics studied in the course may be useful in future. Such an exercise could trigger interest and increase the likelihood of students staying motivated and interested in statistics or even pursuing more advanced statistics in future. Statistics anxiety, which stems from the idea that statistics is abstract, may also be minimized through these pedagogical initiatives.

Finally, a major strength we see in the current study lies in the fact that the potential future relevance of statistics for students was elicited via open-ended questions. The responses therefore represent students' subjective perceptions of what makes statistics relevant. Student-centered teaching, which has been found to improve student learning (Laursen, 2013), requires instructors to respond to and focus on the 'needs' of students (Lin, Chuang, & Hsu, 2014). Its effectiveness therefore requires detailed knowledge of student interests and needs, which can be best defined by students themselves. The contexts within which students discussed statistics as relevant in the current study therefore has implications for statistics pedagogy. For example, some of the context-specific issues which were discussed (e.g., games and sports) have been found to motivate student learning or minimize statistics anxiety when incorporated in statistics courses (see Sanchez, Minosa, Cook, & Masegela, 2013). The context-specific themes which students considered as relevant in the current study, falling within the categories of their practical lives, career goals, and academic pursuits, could prove to be relevant if incorporated more directly into statistics pedagogy. Instructors of general introductory statistics courses such as that of the current study could also consider conducting precourse evaluations to assess students' needs and interests.

6. STUDY LIMITATIONS AND IMPLICATIONS FOR FUTURE RESEARCH

The current study is not without its limitations, some of which chart a path forward for future research. Firstly, although we acknowledge some benefits of using online group discussions to elicit student perspectives, similar studies could benefit from face-to-face interviews (e.g., in-depth interviews and/or focus group discussions). Using a face-to-face interview format would enable researchers probe students' responses for more depth on the potential future usefulness of statistics. Future studies could therefore consider utilizing these alternative qualitative approaches.

The discussion groups for the current study were formed randomly. However, as we reflect on our results, the lack of depth in discipline-based discussions could result from students avoiding discussions which may not be relevant to their fellow group members (e.g., a student interested in psychology feeling concerned about boring their fellow group members interested in kinesiology and biology if they discuss discipline-specific insights in detail). It may also just be that many of these students are too junior to have a firm grasp on research and research methods in their disciplines. Future studies of this sort will likely benefit from purposefully forming groups that consist of students with similar career or discipline-specific interest. Such groupings will likely motivate more in-depth discussions about the discipline-specific relevance of the topics studied in the course. Because the current study was conducted in the context of an online course, future studies of this sort could consider using mixed methods and comparing student perceptions of statistics with online learning to a group that studies statistics in class.

The current study involved a one-time data collection process at the end of the semester. Hence, we are unable to directly speak to the transformation of students' perceptions (e.g., any change to statistics anxiety) over the course. As we acknowledge in previous sections, existing research leads us to believe that students grasping the practical usefulness of statistics motivates interest and, in some cases,, may help lessen statistics anxiety. To explicitly address these issues, future studies should consider examining students' notions about statistics before and after the course. This will help provide deeper insights on the extent to which students have been transformed by the course.

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