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Undergraduate sport sciences students' attitudes towards statistics: A gender perspective

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ABSTRACT

Statistics is involved in sport curricula, due to its importance in science in general and in sport sciences in particular (see for example the development of specific disciplines such as sabermetrics in baseball). The aim of this study is to investigate attitudes toward the first statistics course – the most relevant predictor for achievement – among sport sciences students of the University of Lausanne. Attitudes, measured by the instrument Survey of Attitudes Towards Statistics (SATS, Schau et al., 1995) were collected via a self-administered survey, that included known predictors of attitudes (Eichler & Zapata-Cardona, 2016) and a new one – interest in statistics in daily-life. Adopting a gender perspective, the results indicate that men have higher positive feelings toward statistics than women (Affect) and have higher confidence about their own capabilities than women (Competence). Gender and achievement in mathematics in secondary school are significant predictors of Affect and Competence, but there is an additional effect of age for the latter. Finally, there is no gender difference in achievement in the end of the semester. Gender differences in attitudes towards statistics are practically relevant for many reasons, such as women's experience during a course, the likelihood that they will take an additional optional statistical course, and in some cases, their achievement at the end of the course. It is important that the instructor is aware of them.

1. Introduction

Statistics are involved in most tertiary education curricula, reflecting the role of quantification in most scientific disciplines. Moreover, outside academia, the information society is a statistics-rich society (Crettaz von Roten & de Roten, 2013). A minimum of statistical literacy, which is "the ability to interpret, critically evaluate, and communicate about statistical information and messages" (Gal, 2002, p. 1), is essential for laypeople or citizen. Since universities develop their students to be future scientists and informed citizens, statistics need to be taught to prepare students.

However, teaching statistics is a delicate matter in social and human disciplines because many students perceive the subject as too remote from their centre of interest; statistics can also generate anxiety, as students may fear performing poorly in the course, which would affect their grades negatively (Chiesi & Primi, 2010; Zimprich, 2012).

Statistics education has become an increasingly developed field of research in the past three decades, with the particular aim of understanding differences in students' achievement (for a review of the field, see Eichler & Zapata-Cardona, 2016). Among the various

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predictors of achievement, many studies focused on learners' statistics-related attitudes. Precisely, these attitudes play a role in (1) the teaching and learning process, (2) students' statistical behaviour after they leave the classroom and therefore in their achievement, and (3) students' decision to enrol in a statistics course beyond the introductory course (Gal, Ginsburg, & Schau, 1997).

The study of students' attitudes uses mostly an instrument called Survey of Attitudes Towards Statistics (SATS) developed originally by Schau et al. (1995) with 28 items, then revised with 36 items (Schau, 2003). The instrument was validated in many languages. A meta-analysis found significant correlations between SATS subscales and achievement in statistics course (Emmioglu & Capa-Aydin, 2012).

Various predictors of these attitudes have been found based on course and student characteristics. Among the former, Eichler and Zapata-Cardona (2016) mentioned previous experience with statistics, whether taken online or in a traditional classroom, whether classical or project-based course. Statistics is "a branch of science rather than of mathematics" (Hand, 1998, p. 245), and its instruction must involve a minimal component of mathematics. Among students' characteristics, previous knowledge of mathematics is a relevant predictor of attitudes and achievement in statistics courses, confirmed in many studies (Chiesi & Primi, 2010; Cladera, Rejon-Guardia, Vich-i-Martorell, & Juaneda, 2019; Dempster & McCorry, 2009). However, the mathematical education literature indicates that women were significatively less self-confident in mathematics than men, even if the ability of men and women in that subject matter were equal in most countries (Else-Quest, Hyde, & Linn, 2010). In the same way, gender has been found related to attitudes towards statistics among students in psychology (Chiesi & Primi, 2015), management (Carillo, Galy, Guthrie, & Vanhems, 2016), tourism (Cladera et al., 2019), and information and communication technology (Noraidah, Hairulizza, Hazura, & Tengku, 2011); however, these differences were no significant among medical students (Hannigan, Hegarty, & McGrath, 2014; Milic et al., 2016).

Eichler and Zapata-Cardona (2016, p. 23) deplores the lack of consideration of students' future profession: "why should psychology students value statistics in the same way as economic students do … ?" To our knowledge, there is no study about sport sciences students' attitudes towards statistics. This constitutes a very relevant case because statistics are intertwined in sports practice. Statistics can help to understand an athlete's performance or the management of a team (see for example the development of specific disciplines such as sabermetrics in baseball), to improve sports spectators' experience or recreational athlete's self-tracking with adapted smart devices. This proximity offers an avenue for a new predictor of attitudes for sport sciences students: that is interest in statistics in daily lives.

The aim of this research was to measure sport sciences students' attitudes toward statistics adopting a gender perspective, to examine the relevance of interest in statistics in students' daily lives to predict their attitudes and the achievement in the end of the course.

2. Material and methods

2.1. Participants

Bachelor sport sciences students at the University of Lausanne were recruited during their first statistics course in February 2022 to participate in this study. Participation was voluntary and anonymous. The course was conducted in the classroom. The instructor was a woman with a master's degrees in mathematics, a Ph.D. in statistics, and over 15 years of experience teaching introductory statistics courses. The instructor's teaching assistant was also a woman with a master's in mathematics, currently completing her Ph.D. in statistics.

2.2. Instrument

The SATS is the most widely used instrument (Whitaker, Unfried, & Bond, 2022) which has two versions with 28 or 36 items, where the later has two additional subscales. In confirmatory analyses of the SATS-36, researchers have found that some items should be deleted (Ncube & Moroke, 2015; Persson, Kraus, Hansson, & Wallentin, 2019; Vanhoof et al., 2011) and have not found the six subscales structure (Cladera et al., 2019; Hommik & Luik, 2017; Khavenson, Orel, & Tryakshina, 2012). For Whitaker et al. (2022), the two additional subscales should only be used in a descriptive manner. SATS-36 has been validated in French by Carillo et al. (2016), however their analysis found the superiority of a four subscales model without the two additional subscales – Interest and Effort. Cladera et al. (2019, p. 205) states that "SATS-28 seems to be the strongest of the available measures of attitudes". Therefore, we choose to use SATS-28 and to explore a new scale of Interest in statistics tailored for Sport students living in 2022 (see below the items of the scale).

The SATS consists of 28 items to evaluate on a 7-point Likert scale (rated 1 = strongly disagree to 7 = strongly agree). As indicated by Gal et al. (1997), negatively worded items had to be recoded before building the four subscales: Affect, Competence, Value, and Difficulty. A higher score indicates respectively more positive feelings towards statistics, precisely higher confidence in the student's ability to learn statistics, higher personal value of statistics, and lower difficulty of the subject matter. Whitaker et al. (2022) underlined the problematic interpretation of the subscale Difficulty: higher score indicates more positive attitude toward statistics therefore the subscale should have been called Facility of Easiness. Subscale means are positive if the mean is between 4.50 and 7.00, neutral if between 3.50 and 4.49, and negative if between 0 and 3.49. The SATS instrument was proven gender invariant (Hilton, Schau, & Olsen, 2004). The internal consistency of each of the SATS subscales, measured by Cronbach's alpha, indicates a "minimally acceptable" or "very good" scale (between $\alpha = .66$ and .89, Table 2, DeVellis (2003)).

The new interest instrument consists of four items to evaluate on a 4-point interest scale (from 1 = not at all interested to 4 = extremely interested) defined by a panel of experts. Two items are related to sport (students were asked to evaluate whether they were interested in statistics from sports performances or statistics gathered from a connected smartwatch or application for measuring physical activity) and two items are related to statistics in current events (students were asked to evaluate whether they were interested in statistics related to the COVID-19 pandemic or statistics on poll voting in the country) (see Supplementary material for exact wording). The internal consistency for the additive scale is "insufficient": $\alpha = .54$ (DeVellis, 2003).

Achievement in mathematics in secondary school is a self-reported item, varying from 1 as the lowest grade to 6 as the highest grade. A grade of 4 indicated a student had a sufficient grade in mathematics. One student indicated a grade of 0 (impossible in the Swiss system), which was subsequently turned into a missing value. This variable had a total of eight missing values (9%).

At the end of the semester, achievement in statistics was retrieved from the administrative file, which contained the achievement at the final exam and the gender of each student.

2.3. Procedure

Students were asked to fill in an online questionnaire created with the software Limesurvey. The questionnaire involved first sociodemographic variables such as gender and age, then the SATS instrument, the number of previous statistics courses, the instrument interest of statistics in daily life, and finally, the mathematics grade received in secondary school. The data collection was realised in 2022, during students' first statistics course.

2.4. Statistical analysis

After establishing descriptive statistics, a series of *t*-test for independent samples were performed to study gender differences. If homogeneity of variances was violated, a Welch test was used, and when all assumptions of the *t*-test were violated, a Mann-Whitney test was performed. The effect size of the *t*-test was measured by Cohen's *d*, with its 95% confidence interval.

Pearson correlations were calculated between the SATS subscales and other quantitative variables. To explain the SATS subscales, a series of hierarchical regressions were performed. Hierarchical regression is a type of regression model in which independent variables are entered in steps: each step groups together independent variables of the same sort. At step one, sociodemographic variables were entered; at step two, achievement in mathematics and previous statistics courses were introduced; finally interest in statistics in daily life was introduced at step three.

To further examine the gender effect, a second model was completed with a moderation in the third step of the previous model: an interaction between gender and achievement in mathematics was introduced at step three to examine if men and women differ only in terms of origins or also on the slopes of the independent variable mathematical achievement.

To perform a multiple regression analysis with five independent variables, a power of .80, a type I error rate of .05, and a medium effect size, a sample of 92 subject is needed (Cohen, 1992). With a sample size of 85 subjects, this study is slightly smaller.

The level of statistical significance was set at .05. All analyses were performed using SPSS (version 25).

3. Results

3.1. Sample characterization

Demographics of the sample are presented in Table 1. Among the respondents to this study, 74% were male. The ages ranged between 19 and 35 years old, with a mean age of 23 (SD = 3.2). Before this course, 31% had completed at least one semester of statistics.

3.2. Gender differences in attitudes toward statistics

Table 2 indicates a neutral mean for Affect (M = 4.29, SD = 1.21), a positive mean for Competence and Value (resp. M = 4.65, SD = 1.19 and M = 4.71, SD = 0.99), but a negative mean for Difficulty (M = 3.36, SD = 0.76), which denotes that, on average, sport sciences students fear the difficulty of the course. The SATS subscales are significantly positively correlated, except between the

Table 1
Demographic and educational characteristic of the sample (n = 85), n (%) for qualitative or M (SD) for quantitative variable.

Variable	Total	Men	Women	p
Gender	–	63 (74.1%)	22 (25.9%)	–
Age	23.18 (3.15)	23.22 (2.97)	23.05 (3.71)	.822 [b]
Previous statistics course				.222 [a]
No	59 (69.4%)	46 (73.0%)	13 (59.1%)	
Yes	26 (30.6%)	17 (27.0%)	9 (40.9%)	
Achievement in mathematics	4.64 (0.84)	4.68 (0.86)	4.55 (0.79)	.545 [b]

— Not applicable; Achievement in math = Achievement in mathematic in secondary.
*$p < .05$.
[a] Chi-square test.
[b] t-test for independent samples.

Table 2
Descriptive statistics and internal consistency of subscales, total and among gender (*n* = 85).

Variable	Cronbach	Total	Men	Women	p	d [95% CI]
	alpha	M (SD)	M (SD)	M (SD)		
Affect	.81	4.29 (1.21)	4.47 (1.10)	3.79 (1.39)	.022*	0.58 [0.08; 1.07]
Competence	.84	4.65 (1.19)	4.85 (1.04)	4.08 (1.41)	.046*	0.67 [0.17; 1.16]
Value	.89	4.71 (0.99)	4.76 (1.02)	4.60 (0.92)	.417	0.16 [-0.33; 0.65]
Difficulty	.66	3.36 (0.76)	3.41 (0.75)	3.22 (0.81)	.308	0.25 [-0.23; 0.74]

Note. *p < .05.

subscales Value and Difficulty (between .38 and .80, see Supplemental material).

There was a significant difference among gender for two subscales: Affect, where men have higher positive feelings toward statistics than women ($p = .022$, $M_m = 4.47$, $SD_m = 1.10$, $M_w = 3.79$, $SD_m = 1.39$), and Competence, where men have higher confidence about their capabilities than women ($p = .046$, $M_m = 4.85$, i.e., a positive attitude, $SD_m = 1.04$, $M_w = 4.08$, i.e., a neutral attitude, $SD_w = 1.41$). However, there was no gender gap in mathematical achievement in secondary school ($p = .545$, Table 1). See other analyses of gender differences in Supplemental material.

3.3. Predictors of attitudes towards statistics

To look more closely at the difference in effects of groups of predictors on the two subscales with gender differences, the findings of hierarchical regressions are presented in three separate steps (Table 3).

For the subscale Affect, the first step indicates a significant effect of gender ($p = .027$) but not of age ($p = .215$). The next step, introducing the educational predictors, showed a significant change in R^2 (the increase of R^2 .25, $p = .000$). Among the additional predictors, only achievement in mathematics is significant ($b = 0.68$, $p = .000$: an increase of achievement in mathematics in secondary school is associated with more positive feelings towards statistics), but not a previous statistics course ($p = .190$). Gender remains significant once the other predictors are incorporated into the model in step two ($p = .026$). The last step, introducing the new predictor interest, showed no significant change in R^2 (the increase of R^2 .000, $p = .989$); therefore, the predictor interest in daily life is not relevant to explain Affect once the other variables are in the model. The model in step two explains 33% of the variance of Affect.

For the subscale Competence, the first step indicates a significant effect of gender ($p = .010$), but not of age ($p = .056$). The next step introducing the educational predictors showed a significant change in R^2 (the increase of R^2 .20, $p = .000$). Among the additional predictors, only achievement in mathematics is significant ($b = 0.62$, $p = .000$: an increase of achievement in mathematics is associated with more confidence about capabilities in statistics), but not a previous statistics course ($p = .666$). Gender remains significant once the other predictors are incorporated into the model in step two ($p = .012$) along with age ($b = -0.09$, $p = .012$: an increase of age is associated with less confidence about their capabilities in statistics). The last step, introducing the new predictor interest, showed no significant change in R^2 (the increase of R^2 .00, $p = .974$); therefore, the predictor interest in daily life is not relevant to explain Competence. The model in step two explains 32% of the variance of Competence.

Finally, a new model was performed for the two subscales – Affect and Competence– with an interaction between gender and achievement in mathematics as an independent variable in step three and found a nonsignificant interaction ($p = .367$ and .069, respectively).

Table 3
Hierarchical regression results for Affect and Competence.

Predictor	Affect					Competence				
	B	SE	β	R^2	ΔR^2	B	SE	β	R^2	ΔR^2
Step 1				.08	.08				.10	.10**
Constant	5.72	1.08				6.70	0.96			
Gender	−0.69	0.31	−.25*			−0.78	0.29	−.29**		
Age	−0.05	0.04	−.14			−0.08	0.04	−.21		
Step 2				.33	.25***				.32	.20***
Constant	3.38	1.19				4.27	1.11			
Gender	−0.61	0.27	−.22*			−0.70	0.26	−.26***		
Age	−0.07	0.04	−.19			−0.09	0.04	−.25**		
Previous statistics course	−0.32	0.24	−.13			−0.10	0.24	−.04		
Achievement in mathematics	0.68	0.14	.47***			0.62	0.14	.44***		
Step 3				.33	.00				.32	.00
Constant	3.36	1.37				4.29	1.30			
Gender	−0.61	0.27	−.22*			−0.70	0.26	−.26**		
Age	−0.07	0.04	−.19			−0.9	0.04	−.25*		
Previous statistics course	−0.32	0.24	−.13			−0.10	0.24	−.04		
Achievement in mathematics	0.68	0.14	.47***			0.62	0.14	.44***		
Interest in statistics	0.00	0.21	.001			−0.01	0.21	−.001		

Note. *p < .05, **p < .01, ***p < .001.

3.4. Students' achievement in statistics

At the end of the semester, the mean of achievement in statistics was 4.37, i.e. higher than 4 the sufficiency criteria (Med = 4.5, SD = 0.87). There was no significant difference in the achievement by gender ($t\ (81) = -1.39$, $p = .167$, $M_m = 4.27$, $SD_m = 0.88$, $M_w = 4.57$, $SD_w = 0.83$).

4. Discussion

The purpose of this study was to examine the first course of statistics of sport sciences, adopting a gender perspective. We analysed students' attitudes towards statistics, interest in statistics in their daily live and achievement in statistics in the end of the semester.

4.1. Discussion of results

The results indicate that the instructor of an introductory statistics course can expect sport science students to have more positive than negative attitudes – i.e. *students feel competent* and *students value the subject matter* – at the same time to have a genuine fear of course difficulty. Researchers have found a similar pattern of attitudes in most previous studies (e.g., in psychology, Hood, Creed, & Neumann, 2012; in medicine, Hannigan et al., 2014; in management, Carillo et al., 2016).

There were substantial gender differences in term of attitudes, which highlight the importance of the gender perspective. Men had more positive feelings and more confidence in their competence than women. This result is consistent with the literature. For example, in management, the same two differences as in this study were found plus one additional (women perceived more difficulty in the course (Carillo et al., 2016) whereas in information and communication technology, only one difference was found (affect: women have more positive feelings than men; Noraidah et al., 2011). Studying psychology in Italy, Chiesi and Primi (2015) reported a difference in affect, competence and difficulty whereas in the same context in Switzerland, Zimprich (2012) found a difference only in difficulty. However, in both psychology studies, women perceived statistics as more difficult than men did.

At the end of the semester, we observed no significant gender difference in statistical achievement, in line with Chiesi and Primi (2015) and Zimprich (2012). Since Emmioglu and Capa-Aydin (2012) highlighted the correlation between attitudes and achievement in statistics, how can one explain that there are gender differences in attitudes but not in achievement? Various explanations may be formulated in connection with the literature. Schram's meta-analysis revealed that gender difference in achievement is sensitive to aspects of the course (type of course, type of grade determination), and no gender differences were found for courses that include a final exam (Schram, 1996). Moreover, Haley, Johnson, and Kuennen (2007) found that "gender alone is not a significant contributor to student performance in introductory business statistics" (p. 12), but there is an interaction between student and professor gender: "Students taught by a professor of the opposite gender fare significantly worse than students taught by a professor of the same gender" (p. 14). Finally, Brooks (1985) explained women's achievement in statistics with the fact that women are more conscientious and seek help more often.

In this study, the results can be explained by an effect of the teaching methodology that moves away from formulas and demonstrations to opt for a more problem-driven approach (i.e., learning from the data), an effect of the final examination or of the professor's and teaching assistant's genders. This study did not allow us to differentiate between these possible effects, so we call for more research on this issue.

5. Practical implications

Because the attitude towards statistics with the highest mean is value, instructors should place the value of statistics centre stage and build a problem-driven approach to teaching for sport sciences students based on actual sport data. For example, an instructor could draw inspiration from Spiegelhalter's book (2019), which focuses more on conceptual issues than on technicalities, and foster critical thinking regarding statistics used in communication.

In a gender perspective, when considering the minimal component of mathematics to introduce in the statistics course, an instructor should consider it not a direct effect – the results showed no gender gap in mathematical achievement in secondary school – but an indirect effect – mathematical background had a strong association with the affective and competence attitudes toward statistics (in line with Cladera et al., 2019; Chiesi & Primi, 2015; Hannigan et al., 2014), attitudes that influence course achievement (Chiesi & Primi, 2010; Dempster & McCorry, 2009).

In general, an instructor has to handle multiple heterogeneities in a class (different educational backgrounds, sociocultural environments and learning strategies and styles). Gender differences in attitudes add up in the context of statistics. Sadly, the gender difference in cognitive competence may overshadow women in the classroom, who may be more reluctant to ask questions or intervene in practical work due to their lack of confidence. It is up to the instructor to involve women students more to enhance the classroom dynamic, especially when, as in this study, women are in the minority.

5.1. Limitations and future research

The present study has some limitations that readers should consider when interpreting the results. The present study is on only one course in one sports science university in Switzerland. It is difficult to say how valid the results are for sport students in the whole country or in an international context. Moreover, this study was somewhat underpowered (achieved power = .76) and must be replicated with a larger cohort of students. The internal consistency of the exploratory interest instrument is insufficient. Therefore, future researchers should try to define and validate an improved version of this scale.

6. Conclusion

This study represents the first attempt to date to examine sport sciences students' attitudes towards statistics before the first course. Adopting a gender perspective, the study highlights substantial gender differences in attitudes towards statistics that are important because they influence women's experience during a course (process consideration) and the likelihood of them taking an (additional) optional statistical course (access consideration; Gal et al., 1997). Finally, these differences in attitudes are important because they may lead to differences in achievement depending on the instructor's choice of teaching style.

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FCvR: Study conceptualization, methodology, statistical analyses, writing of original draft, writing of manuscript revisions.
YdR: Writing of original draft, writing of manuscript revisions.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jhlste.2023.100452.

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