ATTITUDES TOWARD STATISTICS ARE BETTER IN TRADITIONAL COMPARED TO ONLINE COURSES, AT LEAST UNTIL COVID-19

HIROKI MATSUO
Baylor University
hiroki_matsuo1@baylor.edu

ALEISE L. NOONER
Arkansas State University
aleise.nooner@smail.astate.edu

AMY R. PEARCE
Arkansas State University
apearce@astate.edu

ABSTRACT

We examined students' initial and concluding attitudes toward statistics based on course delivery methods. Students enrolled in either traditional or online undergraduate statistics courses (N = 196) completed the Survey of Attitudes Toward Statistics-36. At the beginning of the semester, students in traditional courses felt better about the course and believed it would be easier, compared to students taking statistics online. Attitude differences, however, were mitigated as traditional courses were forced online by the pandemic, and distinct attitudinal differences were not observed at the semester's end. With limited offerings and restrictions on the delivery of traditional courses in the COVID-19 era, statistics educators should be cognizant of student attitudes, their potential for change, and how to best influence positive attitude shifts for different instructional formats.

Keywords: *Statistics education research; Survey of Attitudes Toward Statistics; College teaching; Undergraduate education; Course format; Pandemic*

1. INTRODUCTION

Introductory statistics is a required course within many undergraduate programs that emphasize the importance of and ability to conduct research and interpret data, yet students often reluctantly approach statistics, making them likely to face challenges that impact learning outcomes. Another important aspect of statistics education is the availability of online instruction. With the advancement and accessibility of technology, online courses are increasingly offered to students. Furthermore, during the COVID-19 pandemic, online courses may have been the only option for pursuing education. Instructional delivery methods continue to evolve and as educators and students adapt it is paramount to examine how attitudes toward courses taught online compare to equivalent in-person courses. This is particularly important in courses like statistics that tend to pose unique teaching challenges (Conners et al., 1998; Ruggeri et al., 2008).

Anecdotally, students' attitudes toward statistics are mostly adversarial, yet empirically, support for this hypothesis is mixed. For example, Schau and Emmioglu (2012) found that students entered their introductory statistics courses with neutral to very positive attitudes but by the end of the same course these attitudes either stayed the same or decreased. More recently, a study modeled on Schau and Emmioglu did not discover changes in attitudes toward statistics from the beginning to the end of the semester (Bateiha et al., 2020). Understanding the complex relationship between student attitudes and subsequent educational outcomes can aid instructors. Using the *Web Based Education Attitudes Scale* on graduate students in business, Erdogan and colleagues (2008) reported positive pairings of attitudes toward online education and academic achievement as measured by course grades.

1.1. COURSE FORMAT PREFERENCES

Research on students' preferences for course selection has proposed particular factors that impact choice of course format. Krug et al. (2016) examined undergraduate and graduate students' perceptions of online courses and compressed traditional eight-week semester courses. Survey results from a large sample revealed students overwhelmingly preferred to take upper-level courses in a traditional face-to-face environment as opposed to online. The researchers reasoned that upper-level courses were perceived as more complex and require more class time, and online course formats result in the absence of immediate feedback from the respective instructors (Krug et al., 2016). Weldy (2018) echoed these findings via a survey administered to university business students that measured their preference for traditional, online, or blended course formats, experiences in different course formats relevant to learning, study time, and perspectives on the effectiveness of web-based pedagogical tools. Results suggested students report more positive experiences toward traditionally formatted courses. Specifically, 76% of the sample stated a preference for the traditional format and claimed to spend more time studying in traditional courses. Weldy (2018) contended that student reports of spending more time studying in a traditional format led to higher grades and preferences for such courses.

1.2. INSTRUCTIONAL FORMAT TRANSITIONS DURING COVID-19

Not limited to statistics education, the demands and expectations of online teaching in higher education are rapidly growing, and at no time did such expansion occur more so than during the first half of 2020. Parker et al. (2021) studied perceptions of distance learning and found students thought remote coursework was challenging even though they recognized instructors' efforts to accommodate the transition. In one study, more than 70% of undergraduate students surveyed at a liberal arts college found adjusting to the online format either very or somewhat difficult (Roy & Covelli, 2021). In contrast, students from one dental college reported satisfaction with transitioning to online (Rad et al., 2021), and the percentage of first-year students strongly preferring to learn chemistry in a face-to-face environment declined between 2019 and 2020 (Miltiadous et al., 2020). Other studies, however, reported that more than half of chemistry students surveyed stated their study habits had worsened after the transition to online learning (Núñez & Leeuwner, 2020), and biology students preferred the earlier in-person learning, reporting difficulty maintaining a schedule following the forced pivot to online instruction as a consequence of the impact of the pandemic (Humphrey & Wiles, 2021).

Remote coursework during the pandemic was also considered less challenging and students and professors alike were perceived as less engaged in their courses (Parker et al., 2021). Additionally, several attitudinal studies concluded that transitioning from in-person to online instruction during the pandemic impacted students' learning behaviors and reduced motivation (e.g., Humphrey & Wiles, 2021; Núñez & Leeuwner, 2020; Roy & Covelli, 2021). Collectively, findings from these studies suggest there is much to learn about optimizing both educational strategies and their outcomes during times of rapid instructional transitions.

1.3. EXAMINING ATTITUDES BY COURSE FORMAT

Although much is known about the role attitudes play in educational outcomes, less is known about attitudes in relation to course format within a specific subject. Ours is likely one of the latest studies to capture pre-pandemic attitudes toward statistics. With the rise of online education and the uncertain future of traditional courses, we sought to compare attitudes toward statistics across course formats with the extensively used, *Survey of Attitudes Toward Statistics-36* (SATS-36; Schau, 2003a, 2003b). In doing so we focused on three primary research questions and preliminarily addressed a fourth:

1. What are the attitudes of students enrolled in traditional lecture-based statistics when they enter their courses?
2. What are the attitudes of students enrolled in online statistics when they enter their courses?
3. How do attitudes differ for students enrolled online compared to traditional lecture-based statistics at the beginning of their respective courses?

4. How did the transition from traditional to online courses amidst the onset of the COVID-19 pandemic impact end-of-semester attitudes toward statistics?

Therefore, the aims of this study were to examine students' attitudes toward statistics at the beginning and final stages of their respective courses and compare differences between traditional and online courses.

2. MATERIALS AND METHODS

2.1. SAMPLE SELECTION

Attitude responses were collected from students enrolled in either traditional or online undergraduate statistics courses at four four-year residential institutions. One university was in western Tennessee, and two universities were in the state of Arkansas, one of which included a campus in Mexico, which has US-based curricula taught exclusively in English. Each university offered online and traditional sections of undergraduate statistics courses. The statistics courses originated from academic programs in statistics, mathematics, sociology, and business, and each was considered an introduction to the field as the only pre-requisites were college algebra or a general education mathematics course. Comparison of course syllabi revealed comparable content for each course and section (e.g., measures of central tendency and dispersion, normal distributions, hypothesis testing, probability, correlation). We defined an online course as one in which all instruction and assignments were delivered asynchronously through learning management systems (e.g., Blackboard, Canvas) for the duration of the term, whereas traditional courses were characterized by the method of delivering all or most instruction in face-to-face lectures, or classroom-based settings, from the beginning of the term, then via web conferencing platforms (e.g., Zoom; Blackboard Collaborate) following onset of the pandemic. Five online and five traditional sections taught by seven different instructors were included in this study. Class sizes ranged from 17 to 48 students in the sections taught online and from 23 to 36 students in traditional courses.

Responses less than 50% complete were omitted from the dataset as they did not provide sufficient information for imputation of missing values. The pre-SATS sample (N = 199) consisted of 108 students enrolled in traditional statistics courses, 90 students enrolled in online statistics courses, plus 1 student who did not indicate course format, and whose responses were subsequently excluded from analysis. Response rates were 57.3% and 64.3% for online and traditional courses, respectively. Business majors comprised the majority of the sample, followed by pre-medicine and other. Most respondents were women (73%) and the average age was 24.4 years (SD = 7.84). The average age of students enrolled in a traditional course was 21.8 years (SD = 5.83), while the average age in online courses was 27.5 years (SD = 8.80). Approximately 93.5% of the participants indicated statistics was a course required for their program of study.

2.2. SURVEY OF ATTITUDES TOWARD STATISTICS-36

The SATS-36 (Schau, 2003a, 2003b), an instrument widely employed in peer-reviewed research (Bond et al., 2012; Coetzee & Merwe, 2010; Gundlach et al., 2015; Khavenson et al., 2012; Nolan et al., 2012; Sarikaya et al., 2018; Wang et al., 2018; Xu et al., 2020), was utilized to assess attitudes toward statistics at the beginning and at the end of the same statistics course. Briefly, the SATS-36 consists of 36 prompt items scored on a Likert scale from 1–7 (e.g., 1= strongly disagree to 7 = strongly agree), which assess six attitude components: *affect* (6 items), *cognitive competence* (6 items), *value* (9 items), *difficulty* (7 items), *interest* (4 items), and *effort* (4 items). To standardize numerical responses, responses to negatively worded items were reverse-scored meaning that for all items, therefore, a higher numerical response indicated a more positive attitude. Regarding the attitude component *difficulty*, higher scores indicate a perception that statistics is less difficult. Specifically, higher difficulty ratings mean students believe the course to be easier.

2.3. PROCEDURE

Responses were collected by contacting statistics instructors via email and requesting permission to survey students enrolled in their courses during Spring 2020. Sharable hyperlinks were sent for students to complete the pre-SATS and post-SATS via *Qualtrics*. Scores were not matched by respondent. Apart from one seven-week online statistics course taught January through February, in which responses were collected within the first week and final week, other responses to the pre- and post-SATS-36 were collected during the first and final two weeks of each 15-week course offered January through May. Participation was voluntary and anonymous, and all procedures were approved by the researchers' Institutional Review Board.

2.4. STATISTICAL APPROACH

A one-way multivariate analysis of covariance (MANCOVA) was performed with the instructional format (traditional versus online) being the grouping variable and the six attitude components the dependent variables. Within our descriptive statistics, and as reported elsewhere (Allen & Seaman, 2006; Johnson, 2019), there was a notable age difference between students enrolled in the two course formats, with online students being older. Heretick and Tanguma (2020) reported age-related differences in attitudes toward statistics, with older students expressing more positive attitudes; therefore, to control for its influence, student age was treated as a covariate. We used a Bonferroni adjusted alpha level of 0.0083. Preliminary assumption testing was conducted to check for normality, linearity, univariate and multivariate outliers, homogeneity of regression slopes and variance-covariances and normality of residuals. We conducted all analyses using *IBM SPSS* statistics software, Versions 24 and 27 for Windows.

3. RESULTS

3.1. ASSUMPTION TESTING & INTERNAL CONSISTENCY

A linear relationship existed between all attitude components for both course format groups, as determined by visual inspection of scatterplots. Homogeneity of regression slopes was observed, as assessed by the interaction term between age and course format, $F(6, 186) = 1.377$, $p = 0.226$. Although the assumption of homogeneity of variances and covariances was violated, indicated by Box's M test, $p < 0.001$, the sample was large and groups were of relatively equal size. Two univariate and multivariate outliers were detected, as assessed by standardized residuals and Mahalanobis distance values. Upon evaluation of each individual outlier, responses from two additional participants were removed before reporting results from the final dataset of $N = 196$, which had no missing data. Residuals were approximately normally distributed; the responses on the *effort* component, however, exhibited a ceiling effect. Considering a one-way MANCOVA can be a robust technique even with non-normality when the results are interpreted carefully, we deemed it appropriate for the analysis.

Cronbach's alphas were assessed for each dimension of the SATS-36 based on the lecture style and the time of survey administration. Using guidelines provided by DeVellis (2012), values above 0.70 were considered acceptable. All values showed adequate internal consistencies ranging from 0.70 to 0.94, except values of the *effort* component for online students, which were 0.46 and 0.59 at pre- and post-tests, respectively.

3.2. INITIAL ATTITUDES

Attitude ratings on the pre-SATS are presented in Table 1. Attitudes from the traditional group showed a general trend, in which the mean scores were higher compared to the online group except on the *effort* component. Notably, *effort* ratings were at the high end of the scale for both groups. *Difficulty* rated below the neutral point of 4 for students enrolled in either lecture style, suggesting that traditional and online students believed the course would be challenging. *Affect* was also below neutral for students in online courses. Means and adjusted means generated by the MANCOVA were comparable. After

controlling for age, there was a difference between course formats on the combined dependent variables, $F(6, 187) = 3.138$, $p = 0.006$, Wilks' $\Lambda = 0.909$, partial $\eta^2 = 0.091$. Follow up univariate one-way ANCOVAs revealed differences in adjusted means for *affect* [$F(1, 192) = 11.545$, $p = 0.001$, partial $\eta^2 = 0.057$)], *difficulty* [$F(1, 192) = 13.315$, $p < 0.001$, partial $\eta^2 = 0.065$)], and *cognitive competence* [$F(1, 192) = 4.566$, $p = 0.034$, partial $\eta^2 = 0.023$)]. One-way ANCOVAs were followed with pairwise comparisons.

Table 1. Means (M), adjusted means (M_{adj}), standard deviations (SD), standard errors (SE), and pairwise contrasts for adjusted means with confidence intervals (CI) for the six attitude components for each lecture group at pre-test.

	Attitude Components					
	Affect		Cognitive Competence		Value	
Lecture Style	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*
Traditional	4.45 (1.26)	4.35 (0.12)	5.14 (1.06)	5.11 (0.12)	4.88 (1.14)	4.87 (0.12)
Online	3.60 (1.23)	3.72 (0.13)	4.69 (1.24)	4.73 (0.13)	4.58 (1.18)	4.60 (0.13)
Pairwise contrasts	0.64 [*CI* (0.27, 1.00)]		0.38 [*CI* (0.03, 0.72)]		0.27 [*CI* (-0.09, 0.62)]	
	Difficulty		Interest		Effort	
	M(SD)	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*
Traditional	3.67 (0.89)	3.57 (0.08)	4.90 (1.50)	4.91 (0.16)	6.52 (0.73)	6.55 (0.06)
Online	2.99 (0.86)	3.11 (0.09)	4.55 (1.59)	4.54 (0.17)	6.68 (0.43)	6.65 (0.07)
Pairwise contrasts	0.47 [*CI* (0.21, 0.72)]		0.37 [*CI* (-0.10, 0.84)]		-0.10 [*CI* (-0.28, 0.09)]	

Note. $p < 0.01$, $p < 0.05$ after Bonferroni adjustment; 95% confidence interval (*CI*) is simultaneous confidence interval based on Bonferroni adjustment

3.3. CONCLUDING ATTITUDES

Among students who began the semester in a traditional course but transitioned online, their attitudes mirrored those of students who began and ended the semester in an online course (Table 2). *Effort* ratings remained at the high end of the scale for both groups. MANCOVA results indicated there were no differences between students in transitional versus online courses on the combined dependent variables after controlling for age, $F(6, 169) = 1.847$, $p = 0.093$, Wilks' $\Lambda = 0.938$, partial $\eta^2 = 0.062$. Upon closer examination of the univariate one-way ANCOVAs and adjusted means, a negligible difference in *interest* was detected, [$F(1, 174) = 3.949$, $p = 0.048$, partial $\eta^2 = 0.022$].

Table 2. Means (M), adjusted means (M_{adj}), standard deviations (SD), standard errors (SE), and pairwise contrasts for adjusted means with confidence intervals (CI) for the six attitude components for each lecture style group at post-test.

	Attitude Components					
	Affect		Cognitive Competence		Value	
Lecture Style	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*
Traditional	4.44 (1.24)	4.32 (0.16)	5.06 (1.11)	5.00 (0.13)	4.79 (1.08)	4.74 (0.14)
Online	4.18 (1.63)	4.32 (0.16)	5.06 (1.20)	5.13 (0.13)	4.52 (1.41)	4.57 (0.14)
Pairwise contrasts	0.004 [*CI* (-0.46, 0.47)]		-0.136 [*CI* (-0.51, 0.24)]		0.176 [*CI* (-0.24, 0.59)]	
	Difficulty		Interest		Effort	
	M(SD)	M_{adj}*(SE)*	*M(SD)*	M_{adj}*(SE)*	*M(SD)*	M_{adj} *(SE)*
Traditional	3.92 (0.92)	3.75 (0.11)	4.64 (1.52)	4.65 (0.18)	6.10 (0.93)	6.15 (0.09)
Online	3.47 (1.24)	3.66 (0.12)	4.12 (1.74)	4.11 (0.19)	6.23 (0.84)	6.33 (0.10)
Pairwise contrasts	0.085 [*CI* (-0.25, 0.42)]		0.541 [*CI* (0.00, 1.08)]		-0.183 [*CI* (-0.45, 0.09)]	

Note. $p < 0.05$ after Bonferroni adjustment; 95% confidence interval (*CI*) is simultaneous confidence interval based on Bonferroni adjustment.

4. DISCUSSION

Statistics education has been described as a challenging but important endeavor for instructors where empirical research focused on improving both teaching and learning of statistics is continually warranted (for review see Zieffler et al., 2008). Many academic professionals have searched for ways to improve attitudes toward the mathematical discipline as one's understanding of statistics is likely the product of both knowledge and dispositional elements (Gal, 2002). Our attitudinal study contributes insights into non-academic outcomes of statistics education for different delivery methods captured at the onset of the COVID-19 era.

4.1. INITIAL AND CONCLUDING ATTITUDES

Our study focused on detecting attitude differences between course formats at the early and late phases of a semester. Overall, results suggested students enrolled in traditional and online statistics entered their respective courses with different attitudes. As reported in similar studies comparing students' attitudes based on course formats (DeVaney, 2010; Gundlach et al., 2015), the initial attitudes of students in traditional courses were higher for *affect* and *difficulty*, both of which had medium effect sizes as measured by partial η^2. In other words, compared to students enrolled online, students in traditional classes felt better about their statistics course and believed it would be easier. We also detected a slight difference in *cognitive competence*, which was also higher for students in traditional courses. In contrast, using the SATS-28, Suanpang et al. (2004) reported more positive attitudes from undergraduate students taking business statistics courses online compared to traditional courses (Suanpang et al., 2004). It is highly likely further underlying factors influence students' attitudes, such as their majors, previous experiences in online courses, and characteristics of the instructor (Xu et al., 2020).

Interestingly, our findings did not detect striking group differences in students' attitudes toward statistics nearing the end of the semester. Though students enrolled in the transitional courses showed higher *interest*, the overall size of this effect was small. Rather, the two groups became more homogeneous as students completed statistics classes—whether enrolled initially in a traditional or

online format. That traditional courses transitioned to online, thus neutralizing the impact of the grouping variable, is the most obvious explanation. Similar course formats equated to similar results; more stringent experimental designs will help to explore contributing factors.

4.2. THE CONCEPTUAL MODEL OF STUDENTS' ATTITUDES TOWARD STATISTICS AND *EFFORT*

Exploration of each attitude dimension more closely and development of curriculum plans to improve students' attitudes may be of interest to statistics instructors. To the researchers' knowledge, little is known about the factors that influence a specific attitude component. Particularly, observations of *effort* ratings at both testing timepoints warrant further consideration. Coinciding studies (e.g., Schau & Emmioğlu, 2012; Tempelaar et al., 2007) also report students scoring high on the *effort* component. However, in our study, unlike the other scales, internal reliability ratings on *effort* were unacceptably low. Further, the score distributions exhibited ceiling effects for both lecture formats at both testing timepoints (not shown).

An aspect of the conceptual model of Students' Attitudes Toward Statistics (SATS-M; Ramirez et al., 2012), indicated that within the construct of students' statistics attitudes, *effort* is a product of other attitude components of the SATS-36. In spite of this, the SATS-36 does not differentiate the *effort* domain from the other five attitudes in terms of scoring and interpretations. Additionally, items on the SATS-36 for the *effort* domain are worded toward students gauging their performance in the actual course in which they are enrolled and not strictly about the field. In contrast, other items on the SATS-36 target the larger subject matter of statistics and students' self-perceptions of the discipline. This leads us to an interpretation that *effort* is a unique construct of SATS-36 that intends to measure students' attitudes toward their introductory statistics work expenditure rather than the conceptual perception of statistics. Moreover, students initially expected to work hard in their introductory statistics course and believed they did work hard upon completion of their respective courses. Yet how students feel about the *effort* they put into the course and whether *effort* positively correlates with educational outcomes are unknown.

Further, according to the SATS-M (Ramirez et al., 2012), student attitudes are influenced by two primary constructs: 1) student characteristics such as gender, age, and race, and 2) previous achievement-related experiences such as overall GPA and grades from their previous mathematics courses. Recently, Xu and Schau (2020) reported student characteristics like fields of study as influential factors that contribute to diverse attitudes toward their statistics education. Differences in primary constructs and fields of study were not examined directly in this study but may help to explain student selection of one lecture style over the other. For example, one student may choose to take an introductory statistics course in person, anticipating expeditious instructor feedback compared to an equivalent online course; other factors including work schedule, cost of course, or family situation also influence students' choices of one lecture format over another (Zare-ee & Shekarey, 2010). Thus, pre-course attitudes are largely distinct for students who select traditional versus online courses. We contend the SATS-M helps to explain initial differences in attitudes between students enrolled in the two course formats, yet it is possible that once students become immersed within their introductory statistics courses and are exposed to similar content over several weeks, the initial attitude differences begin to diminish and become more homogeneous.

4.3. LIMITATIONS

Many statistics courses that began in the traditional format transitioned to online delivery in response to the global pandemic. Therefore, the post-SATS results are presented as exploratory and interpreted with caution. Findings potentially indicate an effect of course format, certain content-specific factors, extenuating circumstances presented to instructional delivery by the pandemic, or some combination. Nonetheless, the post-test results still showed means and adjusted means were comparable, and both transitional and online groups displayed little to no difference in their attitude scores at the semester's end.

Only one of the four institutions included more than one instructor. Due to the limited number of instructors at each location, we determined an appropriate analysis for potential instructor effects required a different approach, such as a nested design with multiple instructors at each location. Plus, we did not explicitly explore the effect of location. Although the current study focused on the differences between course format alone, future larger-scale studies should examine potential interaction effects between course format, institution, and instructor.

Another limitation of the current study is that pre- and post-SATS-36 scores were not matched by respondent, preventing more powerful within-subjects analyses such as a two-way multivariate analysis of variance or linear mixed-effects models. This design decision was made in consideration of practical constraints of conducting a multi-institutional survey study. Further, all of the pre-SATS responses were collected prior to COVID-19 disrupting education systems worldwide. Yet, with the exception of one online course, post-SATS responses were received approximately two months into a nation-wide lockdown.

5. CONCLUSION

We cautiously propose differences exist in students' initial attitudes toward statistics between traditional and online courses and that attitudes change over time. Statistics educators should be cognizant of student attitudes, their potential for change, and how to best influence positive shifts within either instructional format, or emerging hybrid courses. In times when in-person instruction is compromised, such as the COVID-19 era, online teaching plays an even more important role in higher education. We recommend educators become aware of students' perceptions of online classes and explore potential solutions to improve students' attitudes toward statistics overall. Along with intriguing curriculum development, future studies are warranted that explore factors to improve students' feelings toward statistics and to better understand how students assess their personal effort in such courses.

ACKNOWLEDGEMENTS

We thank Dr. C. Schau for giving permission to use the SATS-36**,** the university's Research & Technology Transfer for an Undergraduate Research Award to support this project, plus Haley Peoples and Eleanor Pulliam Allen for their assistance with data collection. We also extend thanks to the statistics instructors at the external institutions for facilitating this study and to their students for contributing data.

REFERENCES

Allen, E., & Seaman, J. (2006). *Making the grade: Online education in the United States*. Sloan-C.

Bateiha, S., Marchionda, H., & Autin, M. (2020). Teaching style and attitudes: A comparison of two collegiate introductory statistics classes. *Journal of Statistics Education*, *28*(2), 154–164. https://doi.org/10.1080/10691898.2020.1765710

Bond, M., Perkins., S., & Ramirez, C. (2012). Students' perceptions of statistics: An exploration of attitudes, conceptualizations, and content knowledge of statistics. *Statistics Education Research Journal*, *11*(2), 6–25. https://doi.org/10.52041/serj.v11i2.325

Coetzee, S., & Van der Merwe, P. (2010). Industrial psychology students' attitudes towards statistics. *SA Journal of Industrial Psychology/SA Tydskrif vir Bedryfsielkunde*, *36*(1), 1–8. https://doi.org/10.4102/sajip.v36i1.843

Conners, F. A., McCown, S. M., & Roskos-Ewoldsen, B. (1998). Unique challenges in teaching undergraduate statistics. *Teaching of Psychology*, *25*(1), 40–42. https://doi.org/10.1207/s15328023top2501_12

DeVaney, T. A. (2010). Anxiety and attitude of graduate students in on-campus vs. online statistics courses. *Journal of Statistics Education, 18*(1). https://doi.org/10.1080/10691898.2010.11889472

DeVellis, R. F. (2012). *Scale development: Theory and application* (3rd ed.). SAGE Publications.

Erdogan, Y., Bayram, S., & Deniz, L. (2008). Factors that influence academic achievement and attitudes in web based education. *International Journal of Instruction*, *1*(1), 32–47.

Gal, I. (2002). Adults' statistical literacy: Meanings, components, responsibilities. *International Statistical Review, 70*(1), 1–25.
Gundlach, E., Richards, K., Nelson, D., & Levesque-Bristol, C. (2015). A comparison of student attitudes, statistical reasoning, performance, and perceptions for web-augmented traditional, fully online, and flipped sections of a statistical literacy class. *Journal of Statistics Education*, *23*(1), 1–33. https://doi.org/10.1080/10691898.2015.11889723
Heretick, D. M. L., & Tanguma, J. (2020). Anxiety and attitudes toward statistics and research among younger and older nontraditional adult learners. *The Journal of Continuing Higher Education*. https://doi.org/10.1080/07377363.2020.1784690
Humphrey, E. A., & Wiles, J. R. (2021). Lessons learned through listening to biology students during a transition to online learning in the wake of the COVID-19 pandemic. *Ecology and Evolution*, *11*(8), 3450–3458. https://doi.org/10.1002/ece3.7303
Johnson, G. M. (2019). On-campus and fully-online university students: Comparing demographics, digital technology use and learning characteristics. *Journal of University Teaching & Learning Practice*, *12*(1), 1–13. http://ro.uow.edu.au/jutlp/vol12/iss1/4
Khavenson, T., Orel, E., & Tryakshina, M. (2012). Adaptation of Survey of Attitudes Towards Statistics (SATS 36) for Russian sample. *Procedia Social and Behavioral Sciences*, *46*, 2126–2129. http://dx.doi.org/10.1016/j.sbspro.2012.05.440
Krug, K. S., Dickson, K. W., Lessit, J. A., & Vassar, J. S. (2016). Student preference rates for predominantly online, compressed, or traditionally taught university courses. *Innovative Higher Education*, *41*, 255–267. http://dx.doi.org/10.1007/s10755-015-9349-0
Miltiadous, A., Callahan. D. L., & Schultz, M. (2020). Exploring engagement as a predictor of success in the transition to online learning in first year chemistry. *Journal of Chemical Education, 97*(9), 2494–2501. https://doi.org/10.1021/acs.jchemed.0c00794
Nolan, M. M., Beran, T., & Hecker, K. G. (2012). Surveys assessing students' attitudes toward statistics: A systematic review of validity and reliability. *Statistics Education Research Journal*, *11*(2), 103–123. https://doi.org/10.52041/serj.v11i2.333
Núñez, J. R., & Leeuwner, J. (2020). Changing courses in midstream: COVID-19 and the transition to online delivery in two undergraduate chemistry courses. *Journal of Chemical Education, 97*(9), 2819–2824. https://doi.org/10.1021/acs.jchemed.0c00781
Parker, S. W., Hansen, M. A., & Bernadowski, C. (2021). COVID-19 campus closures in the United States: American student perceptions of forced transition to remote learning. *Social Sciences*, *10*(2), 1–18. https://doi.org/10.3390/socsci10020062
Rad, F. A., Otaki F., Baqain Z., Zary, N., & Al-Halabi, M. (2021). Rapid transition to distance learning due to COVID-19: Perceptions of postgraduate dental learners and instructors. *PLoS ONE, 16*(2). https://doi.org/10.1371/journal.pone.0246584
Ramirez, C., Schau, C., & Emmioğlu, E. (2012). The importance of attitudes in statistics education. *Statistics Education Research Journal, 11(*2), 57–71. https://doi.org/10.52041/serj.v11i2.329
Roy, S., & Covelli, B. (2021). COVID-19 induced transition from classroom to online mid semester: Case study on faculty and students' preferences and opinions. *Higher Learning Research Communications*, *11*(0), 10–32. https://doi.org/10.18870/hlrc.v11i0.1197
Ruggeri, K., Dempster, M., Hanna, D., & Cleary, C. (2008). Experiences and expectations: The real reason nobody likes stats. *Psychology Teaching Review*, *14*(2), 75–83.
Sarikaya, E., Ok, A., Aydin, Y., & Schau, C. (2018). Turkish version of the survey of attitudes toward statistics: Factorial structure invariance by gender. *International Journal of Higher Education*, *7*(2), 121–127. https://doi.org/10.5430/ijhe.v7n2p121
Schau, C. (2003a). Survey of Attitudes Toward Statistics (SATS-36). http://evaluationandstatistics.com
Schau, C. (2003b). Students' attitudes: The "other" important outcome in statistics education. In *Proceedings of the 2003 Joint Statistical Meetings, San Francisco* (pp. 3673–3683). http://statlit.org/pdf/2003SchauASA.pdf
Schau, C., & Emmioğlu, E. (2012). Do introductory statistics courses in the United States improve students' attitudes? *Statistics Education Research Journal, 11*(2), 86–94. https://doi.org/10.52041/serj.v11i2.331
Suanpang, P., Petocz, P., & Kalceff, W. (2004). Student attitudes to learning business statistics: Comparison of online and traditional methods. *Educational Technology and Society*, *7*(3), 9–20.

Tempelaar, D., & Schim van der Loeff, S. (2007). A structural equation model analyzing the relationship of students' attitudes toward statistics, prior reasoning abilities, and course performance. *Statistics Education Research Journal*, *6*(2), 78–102. https://doi.org/10.52041/serj.v6i2.486

Wang, P., Palocsay, S. W., Shi, J., & White, M. M. (2018). Examining undergraduate students' attitudes toward business statistics in the United States and China. *Innovative Higher Education*, *16*(3), 197–216. https://doi.org/10.1111/dsji.12159

Weldy, T. (2018). Traditional, blended, or online: Business student preferences and experience with different course formats. *e-Journal of Business Education and Scholarship of Teaching*, *12*(2), 55–62.

Xu, C., & Schau, C. (2020). Measuring statistics attitudes at the student and instructor levels: A multilevel construct validity study of the Survey of Attitudes Toward Statistics. *Journal of Psychoeducational Assessment*, *39*(3), 315–331. https://doi.org/10.1177%2F0734282920971389

Xu, C., Peters, M., & Brown, S. (2020). Instructor and instructional effects on students' statistics attitudes. *Statistics Education Research Journal*, *19*(2), 7–26. https://doi.org/10.52041/serj.v19i2.107

Zare-ee, A., & Shekarey, A. (2010). The effects of social, familial, and personal factors on students' course selection in Iranian technical schools. *Procedia Social and Behavioral Sciences*, *9*, 295–298. https://doi.org/10.1016/j.sbspro.2010.12.153

Zieffler, A., Garfield, J., Alt, S., Dupuis, D., Holleque, K., & Chang, B. (2008). What does research suggest about the teaching and learning of introductory statistics at the college level? A review of the literature. *Journal of Statistics Education [Online]*, *16*(2). http://dx.doi.org/10.1080/10691898.2008.11889566

HIROKI MATSUO
Baylor School of Education
Department of Educational Psychology
Baylor University
One Bear Place #97304
Waco, TX 76798-7304