

A Systematic Review and Meta-analysis of the Relationships among Post-secondary Students' Attitudes Toward Statistics and Statistics Achievement: A Protocol

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ABSTRACT

Background: An understanding of statistics is essential in our data-driven world. Accordingly, successful completion of a statistics course is required for undergraduate and graduate students from many disciplines. Attitudes toward statistics is a multidimensional construct that expresses individuals' positive or negative dispositions to statistics. A wide body of research indicates that there are statistically significant relationships among attitudes toward statistics and statistics achievement. However, the reported magnitudes of these relationships differ across studies.

Methods/Design: This review will examine the relationships among post-secondary students' scores on the attitude components assessed by the Survey of Attitudes toward Statistics (SATS) and their statistics achievement assessed using a variety of measures. As the data allow, this review then will explore the impact of possible moderating research characteristics including, for example, those associated with research sources, institutions, courses, subjects, and the SATS and statistics achievement measures.

Discussion: In the resulting journal article, this section will focus on the results and the strengths and limitations of the synthesized literature. We expect that the study will contribute to the literature on the relationship between attitudes toward statistics and achievement by synthesizing the individual research results. The availability of the required information and the quality of primary studies will be potential limitations for the current study.

Keywords: *attitudes toward statistics, statistics achievement, post-secondary education, SATS, systematic literature review, meta-analysis*

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1. Background

Statistics is a discipline that developed from the need to solve everyday problems alongside societal problems such as social inequity and health. Statistics education should equip students with the tools necessary to deepen their understandings of issues of local and global importance. The study of statistics is becoming widespread, and statistics is a compulsory programme component for a significant number of non-statistics majors, leading to the identification of statistics as the one central science used in education and the social sciences (Ridgway et al., 2007). Attitudes toward statistics are related to achievement in statistics courses. It is not surprising that negative attitudes towards statistics likely impede statistics learning (Gal & Ginsburg, 1994; Lalonde & Gardner, 1993).

Although many psychological and educational theories support the importance of students' attitudes on achievement, perhaps the most comprehensive theory, and the one most often applied to statistics attitudes, is Eccles and colleagues' version of the Expectancy-Value Model of Achievement Motivation (e.g., Eccles & Wigfield, 2002). The survey instrument designed to assess students' attitudes that has been most widely administered is the *Survey of Attitudes Toward Statistics* (SATS; Schau, 1992, 2003) which draws on this theory. Studies using the SATS report results that support the multidimensionality, validity, and reliability of the constructs and scores (e.g., Chiesi & Primi, 2009, 2010; Coetzee & Van der Merwe, 2010; Tempelaar et al., 2007; Vanhoof et al., 2011). The SATS-28 was the original version of the instrument. It measured four attitude components: *Affect* ("students' feelings concerning statistics"), *Cognitive Competence* ("students' attitudes about their intellectual knowledge and skills when applied to statistics"), *Value* ("students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life") and *Difficulty* ("students' attitudes about the difficulty of statistics as a subject"). The revised SATS-36 incorporated two additional components: *Interest* ("students' level of individual interest in statistics") and *Effort* ("amount of work the student expends to learn statistics"). More information about the SATS is available at <https://www.evaluationandstatistics.com/>. Confirmatory factor analysis has provided evidence of the validity of the four-component structure of the SATS-28 (e.g., Dauphinee et al., 1997; Hilton et al., 2004) and the six-component structure of the SATS-36 (e.g., Emmioğlu & Capa-Aydin, 2012; Tempelaar et al., 2007). The use of a common measurement instrument such as the SATS supports comparisons of the attitudes of different student groups across various disciplinary, instructional, and geographical contexts.

The examination of students' attitudes towards statistics has received extensive consideration predominantly due to established theoretical and empirical links between attitudes and achievement in general. There is evidence to suggest that attitudes towards statistics and achievement in statistics are related (e.g., Chiesi & Primi, 2009, 2010; Dempster & McCorry, 2009; Emmioğlu & Capa-Aydin, 2012; Sizemore & Lewandowski, 2009; Sorge & Schau, 2002; Tempelaar et al., 2007; Zimprich, 2012). However, the strength of these relationships varies across studies, and the importance of potential moderator variables is unknown.

The present study is a systematic review and meta-analysis of research examining the relationships among post-secondary students' attitudes toward statistics as assessed by the SATS-28 or the SATS-36 and their statistics achievement. Furthermore, it examines whether these relationships differ depending on possible moderator study characteristics such as those associated with students, institutions, courses, and instructors as well as those associated with research sources and the SATS and achievement measures.

The main research question explores how attitudes toward statistics as assessed by the SATS relate to statistics achievement for post-secondary students. Specifically,

- 1) How does post-secondary students' statistics achievement relate to their:

- Affect toward statistics?
- Cognitive Competence about learning statistics?
- dispositions about the Value of statistics?
- dispositions about the Difficulty of statistics?
- Interest in statistics?
- Effort applied to statistics?

In addition, as the data permit, the following questions will be investigated:

- 2) How do the relationships of attitudes toward statistics and statistics achievement differ for students who are
 - undergraduate or graduate level?
 - male or female?
 - from different continents?
 - enrolled in different disciplines?
 - enrolled in different types of post-secondary institutions?
 - enrolled in different types of courses?
 - enrolled in courses with different instructional characteristics?
 - taught by instructors with varying characteristics?
- 3) How do the relationships of post-secondary students' attitudes toward statistics and statistics achievement differ related to:
 - SATS characteristics and administration timing?
 - the statistics achievement measure's characteristics and administration timing?
 - the source of the research study?
 - the type of effect size information available?

2. Methods/Design

This study uses the PICo structure for review questions:

- P (population): post-secondary students
- I (the phenomenon of Interest): relationships among attitudes toward statistics and statistics achievement
- Co (Context): post-secondary statistics courses

2.1 Study eligibility criteria

This review will include quantitative studies that examine the relationships between attitudes toward statistics as assessed by the components of the Survey of Attitudes toward Statistics (SATS-28 with four components or SATS-36 with six) and achievement in statistics.

Selected studies must meet each of the following eight criteria. They must:

1. Include a quantitative research component.
2. Use at least one complete component of the SATS to measure attitudes toward statistics; components with items that have been eliminated or changed are excluded.
3. Include a measure of achievement-related outcomes administered at any time (e.g., pre, post, mid).
4. Report the quantitative relationships needed to calculate effect sizes among attitudes toward statistics and an achievement-related measure.

5. Have collected data from post-secondary students (undergraduates and/or graduate students).
6. Use component scores rather than one global SATS score.
7. Not be published in predatory journals (Please see <https://beallist.net/>).
8. Include the full text of the research document.

2.2 Information sources and search methods

The following databases will be searched:

- EBSCO
- PROQUEST
- Google Scholar
- Web of Science
- Web of Science also will be searched for the references cited in Schau et. al., 1995; Dauphinee et al., 1997; Hilton et al., 2004.
- Web of Science Proceedings Citation Index: CPCI-S and CPCI-SSH and Conference databases of CERME, ICOTS, and ISI Congress
- ProQuest dissertations and thesis global and PQDT OPEN

The following search structure will be used:

- “Attitudes toward statistics” OR “statistics attitudes” in Keywords and Title in EBSCO, PROQUEST, Web of Science,
- “Attitudes toward statistics” OR “statistics attitudes” anywhere in the article in Google Scholar,
- “Attitudes” in Titles for conferences

In addition to the database search, we will hand-search the Table of Contents of Journal of Statistics and Data Science Education, Statistics Education Research Journal, and Learning and Individual Differences for articles containing “attitudes” in their titles.

In addition to using “Attitudes toward statistics” OR “statistics attitudes” in Keywords and Title, the search structure for dissertations and theses will add AND "statistics achievement" AND "survey of attitudes toward statistics".

Duplication from search results will be identified and removed.

2.3 Data management and analysis

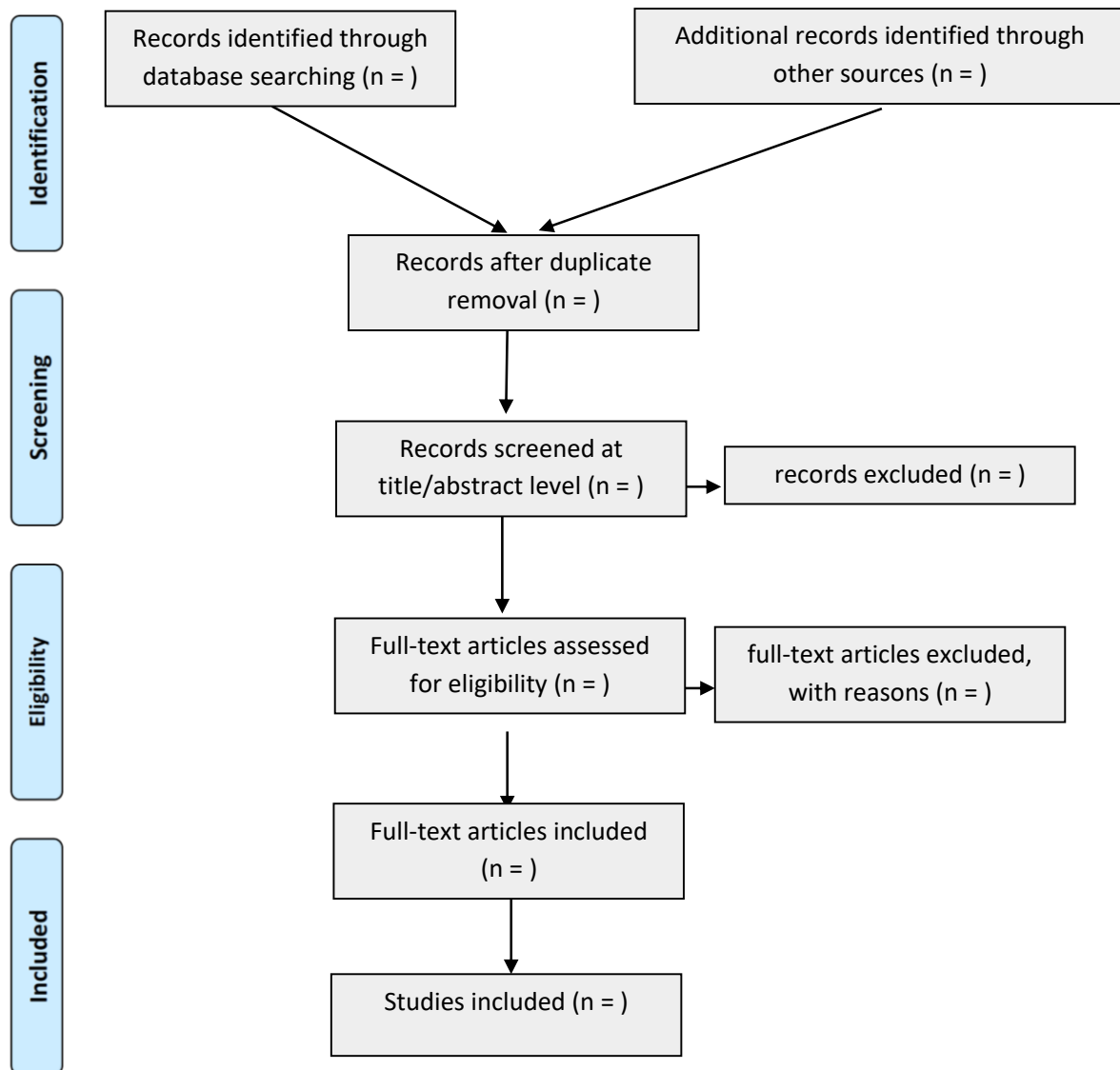
CADIMA software (<https://www.cadima.info/index.php>, Kohl et. al, 2018) will be used for documenting the literature search, study screening, and data extraction. JASP (JASP Team, 2021) and/or CMA (Borenstein et al., 2005) will be used for data synthesis and analysis.

2.4 Study selection for inclusion in the coding pool

The searches described above will yield a pool of potential studies. They will be examined to determine which ones should be included in the pool to be coded. Three authors will screen the title and abstract for each study. If two of these authors agree that the study should be excluded because it does not meet the eight inclusion criteria described above, it will be eliminated from further consideration. If two agree that the study should be included provisionally, it will join the pool of studies for the full-text inclusion/exclusion review. The full-text review is necessary because the title and abstract may not include enough information to determine if that study should be included in the coding pool.

Two authors will complete the full-text inclusion/exclusion screening for each study in the provisional pool. If there is disagreement on including or excluding the study for full study coding, one author again will read the study to see if the disagreement can be resolved. If not, a third author will read the study and decide on inclusion/exclusion. Each study must have 100% agreement from at least two authors on the inclusion/exclusion decision. See Figure 1 for the resulting PRISMA flowchart:

Figure 1. PRISMA flowchart.



2.5 Data coding

Each study will be coded independently by two authors. If there is 100% consensus on the coding for a study, the coding of that study will be finalized. If not, a third team member will code the study. Discrepancies then will be discussed until complete consensus is achieved.

The codebook will include codes related to reporting characteristics (e.g., year of publication, type of publication), setting characteristics (e.g., country, language, design), sample characteristics (e.g., gender, age, education level), institutional characteristics, course characteristics, SATS' characteristics, the statistics achievement measure's characteristics, and

effect size information. When additional study information is needed for coding, the authors of the studies will be contacted through e-mail.

2.6 Assessment of study quality

The risk of bias will be examined by coding the methodological characteristics of each included study. The categories for methodological characteristics (design, sampling, measurements, missing data, statistical analysis) will be developed using the MMAT tool (Hong et al., 2018).

2.7 Meta-biases

No study design or language limits are imposed on the search. Studies in languages other than English will be translated by team members or by using Google translate when team members do not read that language. Both published and unpublished studies (e.g., conference presentations, dissertations) are included in the review.

2.8 Data synthesis

We first will present a narrative systematic literature review based on the included studies. We then will conduct a meta-analysis. If the data permit, we will consider subgroup and/or moderator analyses using the following:

- Study characteristics
- Course characteristics
- Sample characteristics
- SATS characteristics
- Statistics achievement characteristics

The unit of analysis of this meta-analysis will be each primary study. If a primary study reports more than one effect size value regarding the same research question, we will calculate the weighted average of these values to include in the analysis. The common effect size metric will be Pearson's correlation coefficient (r). If any other effect size measure is reported in a primary study, it will be converted into r , whenever possible, using an appropriate conversion method. We will use the random-effects model to combine the effect size values across primary studies. We will also create a forest plot to visualize the distribution of observed effects with their confidence intervals based on a random-effects model.

We will use several methods to detect any publication bias and to estimate an adjusted mean effect size if the bias is not negligible. We will calculate Orwin's fail-safe N to quantify how robust the results of the meta-analysis are to publication bias. We will utilize funnel plots to visualize small study effects. We will also conduct Egger's regression test to examine if the publication bias is statistically significant. Finally, we will use the Trim and Fill method and Robust Bayesian Meta-analysis to estimate an adjusted mean effect size, which is the estimate of the effect size if there were no publication bias.

Regarding the heterogeneity of the data, we will use a Q -statistic to quantify the variation in observed effects and perform the corresponding χ^2 test to check if the heterogeneity of true effects is statistically significant. We will calculate the I^2 statistic to find the ratio of true variance to the total variance. Finally, we will explore the degree to which the distribution of true effects is heterogeneous using the variance of true effects (tau squared) and the corresponding prediction interval for the mean effect size.

We will conduct moderator analyses to explain any heterogeneity in true effects. We are planning to conduct simple and multiple meta-regression to check if the variables coded as possible moderators will explain a significant amount of this heterogeneity.

3. Discussion

There is continuing interest in the relationships among students' attitudes toward statistics and their statistics achievement. This study will add significantly to this discussion by synthesizing the body of individual research studies that address this issue. This study also benefits from the inclusion of researchers from six different countries including the U.S., Ireland, Italy, Spain, Australia, and Turkey. Potential limitations relate to the information that is available in the primary research studies and from their authors as well as to the research quality of these studies. Individual studies may use different measures to assess statistics achievement (e.g., statistical reasoning, statistical literacy, statistics course achievement). Different types of achievement measures may moderate results. Possible heterogeneity across primary studies will be explored using sensitivity analysis and moderator analysis, but again that is dependent on having the required information. The Meta-Analysis Reporting Standards (MARS; Appelbaum et al., 2018) will be used for the evaluation of the present study.

Declarations

Authors' Contributions: Five of the authors have developed the search strategy. All authors contributed to the development of the selection criteria for the studies, the risk of bias assessment criteria, and the data extraction criteria. All authors will work on the development of the coding sheet, study coding, and the final protocol manuscript. One author will work as a meta-analysis expert.

Ethics approval: This study was approved by the XX University Social and Human Sciences Research Ethics Committee (date: October 08, 2021, approval number: 83436).

Competing interests: None

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References

- APA Publications and Communications Board Working Group on Journal Article Reporting Standards. (2008). Reporting standards for research in psychology: Why do we need them? What might they be? *American Psychologist*, *63*(9), 839–851. <https://doi.org/10.1037/0003-066X.63.9.839>
- Appelbaum, M., Cooper, H., Kline, R. B., Mayo-Wilson, E., Nezu, A. M., & Rao, S. M. (2018). Journal article reporting standards for quantitative research in psychology: The APA Publications and Communications Board task force report. *American Psychologist*, *73*(1), 3-25. <https://www.apa.org/pubs/journals/releases/amp-amp0000191.pdf>
- Borenstein, M., Hedges, L., Higgins, J., & Rothstein, H. (2005). *Comprehensive meta-analysis* (Version 2) [Computer Software]. Biostat. <https://www.meta-analysis.com/>
- Chiesi, F., & Primi, C. (2009). Assessing statistics attitudes among college students: Psychometric properties of the Italian version of the Survey of Attitudes Toward Statistics (SATS). *Learning and Individual Differences*, *19*(2), 309–313. <https://doi.org/10.1016/j.lindif.2008.10.008>
- Social Science Protocols*, April 2022, 1-9. <http://dx.doi.org/10.7565/ssp.v5.6949>

- Chiesi, F., & Primi, C. (2010). Cognitive and non-cognitive factors related to students' statistics achievement. *Statistics Education Research Journal*, 9(1), 6–26. <https://doi.org/10.52041/serj.v9i1.385>
- Coetzee, S., & van der Merwe, P. (2010). Industrial psychology students' attitudes toward statistics. *South African Journal of Industrial Psychology*, 36(1), 1–8. <https://doi.org/10.4102/sajip.v36i1.843>
- Dempster, M., & McCorry, N. K. (2009). The role of previous experience and attitudes toward statistics in statistics assessment outcomes among undergraduate psychology students. *Journal of Statistics Education*, 17(2). <https://doi.org/10.1080/10691898.2009.11889515>
- Dauphinee, T. L., Schau, C., & Stevens, J. J. (1997). Survey of Attitude Toward Statistics: Factor structure and factorial invariance for female and males. *Structural Equation Modeling*, 4, 129–141. <https://doi.org/10.1080/10705519709540066>
- Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology* 53(1), 109-132. <https://doi.org/10.1146/annurev.psych.53.100901.135153>
- Emmioğlu, E., & Capa-Aydin, Y. (2012). Attitudes and achievement in statistics: A meta-analysis study. *Statistics Education Research Journal*, 11(2), 95-102. <https://doi.org/10.52041/serj.v11i2.332>
- Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Towards an assessment framework. *Journal of Statistics Education*, 2(2), 1–16. <https://doi.org/10.1080/10691898.1994.11910471>
- Hilton, S. C., Schau, C., & Olsen, J. A. (2004). Survey of Attitudes Toward Statistics: Factor structure invariance by gender and by administration time. *Structural Equation Modeling*, 11(1), 92–109. https://doi.org/10.1207/S15328007SEM1101_7
- Hong, Q. N., Fàbregues, S., Bartlett, G., Boardman, F., Cargo, M., Dagenais, P., Gagnon, M., Griffiths, F., Nicolau, B., O’Cathain, A., Rousseau, M., Vedel, I., & Pluye, P. (2018). The Mixed Methods Appraisal Tool (MMAT) version 2018 for information professionals and researchers. *Education for Information*, 34(4), 285-291. <https://doi.org/10.3233/EFI-180221>
- JASP Team (2021). *JASP* (Version 0.16). [Computer Software]. <https://jasp-stats.org/>
- Kohl, C., McIntosh, E. J., Unger, S., Haddaway, N. R., Kecke, S., Schiemann, J., & Wilhelm, R. (2018). Online tools supporting the conduct and reporting of systematic reviews and systematic maps: a case study on CADIMA and review of existing tools. *Environmental Evidence*, 7(1), 1-17. <https://doi.org/10.1186/s13750-018-0115-5>
- Lalonde, R. N., & Gardner, R. C. (1993). Statistics as a second language: Predicting performance of psychology students. *Canadian Journal of Behavioral Science*, 25, 108-125. <https://doi.org/10.1037/h0078792>
- Ridgway, J., Nicholson, J., & McCusker, S. (2007). *Teaching statistics—Despite its applications*. *Teaching Statistics*, 29(2), 44-48. <https://doi.org/10.1111/j.1467-9639.2007.00276.x>
- Schau, C. (1992). Survey of Attitudes Toward Statistics (SATS-28). <http://evaluationandstatistics.com/>
- Schau, C. (2003). Survey of Attitudes Toward Statistics (SATS-36). <http://evaluationandstatistics.com/>
- Schau, C., Stevens, J. J., Dauphine, T. L., & Del Vecchio, A. (1995). The development and validation of the Survey of Attitudes Toward Statistics. *Educational and Psychological Measurement*, 55, 868–875. <https://doi.org/10.1177/0013164495055005022>
- Sizemore, O. J., & Lewandowski, G. (2009). Learning might not equal liking: Research methods course changes knowledge but not attitudes. *Teaching of Psychology*, 36(2), 90–95. <https://doi.org/10.1080/00986280902739727>

- Sorge, C., & Schau, C. (2002, April). *Impact of engineering students' attitudes on achievement in statistics: A structural model*. [Paper presentation] The annual meeting of the American Educational Research Association, New Orleans, USA.
- Tempelaar, D. T., Gijsselaers, W. J., Schim van der Loeff, S., & Nijhuis, J. F. H. (2007). A structural equation model analyzing the relationship of student achievement motivations and personality factors in a range of academic subject-matter areas. *Contemporary Educational Psychology*, 32(1), 105–131. <https://doi.org/10.1016/j.cedpsych.2006.10.004>
- Vanhoof, S., Kuppens, S., Sotos, A. E. C., Verschaffel, L., & Onghena, P. (2011). Measuring statistics attitudes: Structure of the Survey of Attitudes Toward Statistics (SATS-36). *Statistics Education Research Journal*, 10(1), 35–51. <https://doi.org/10.52041/serj.v10i1.354>
- Zimprich, D. (2012). Attitudes toward statistics among Swiss psychology students. *Swiss Journal of Psychology*, 71(3), 149–155. <https://doi.org/10.1024/1421-0185/a000082>