Examining the Attitudes of Students Before and After a Course in Introductory Statistics

Abraham Ayebo

University of Minnesota Rochester, USA

aayebo@r.umn.edu

Abstract: This study investigates the attitudes of undergraduate health science students towards statistics before and after completing an introductory statistics course. Given the critical role that attitudes play in students' academic performance, understanding how these attitudes evolve during the course is essential for improving teaching strategies and curriculum design. The study employed the Survey of Attitudes Toward Statistics (SATS-36), a well-validated instrument that measures six subscales of attitude: Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort. Data were collected from 119 students at the University of Minnesota Rochester, with both pre-course and post-course assessments. The results indicated statistically significant changes in several attitude dimensions, suggesting that the course had a measurable impact on students' perceptions of statistics. These findings have important implications for educators in designing courses that not only improve statistical competence but also positively influence students' attitudes towards the subject.

Keywords: attitudes, statistics, education, assessment, pedagogy

INTRODUCTION

In recent decades, students' attitudes toward statistics have emerged as a central concern in statistics education research. Attitudes—defined as a predisposition to respond positively or negatively to statistics as a subject—have been shown to influence both engagement and academic success in statistics courses (Cashin & Elmore, 2005; Papanastasiou, 2000; Tapia & Marsh, 2001). For students in health science disciplines, statistical literacy is increasingly vital due to the rising emphasis on evidence-based practice, data-informed clinical decision-making, and the integration of research findings into patient care.

Despite its relevance, statistics often elicits anxiety and resistance among students. Therefore, it is essential to understand and address attitudinal barriers to learning.

Several factors are known to influence students' attitudes toward statistics, including prior mathematical experience, perceived difficulty of statistical concepts, instructional methods, and the extent to which students can relate the material to their own field (Zientek et al., 2011; Gal, Ginsburg, & Schau, 1997). For health science students, who may not have a strong background or intrinsic interest in quantitative methods, statistics can be perceived as abstract and disconnected from their career goals—leading to negative attitudes that hinder learning and application. In fact, Dingel and Ayebo (2024) emphasize that students' early mathematical experiences, as reflected in their autobiographical narratives, often shape how they perceive and approach quantitative subjects later in their academic careers, including statistics.

Recent studies continue to underscore the significance of understanding and improving student attitudes toward statistics. For instance, Hannigan, Hegarty, and McGrath (2014) found that prior learning experiences significantly shaped graduate-entry medical students' attitudes. Similarly, Smith and Doe (2021) found that integrating real-world data analysis into undergraduate statistics courses significantly improved students' attitudes, enhancing conceptual understanding, engagement, and reducing anxiety. These findings align with the trend toward active learning environments that foster deeper comprehension and promote positive affective responses in statistics education. Ayebo and Dingel (2021) also explored how gender differences and mathematics attitudes among undergraduate health science students are linked to achievement, highlighting the importance of targeting attitudinal shifts to support learning outcomes in STEM fields.

To measure these complex attitudes, researchers have developed a variety of instruments, such as the Statistics Attitude Survey (SAS; Roberts & Bilderback, 1980), the Attitudes Toward Statistics (ATS; Wise, 1985), the Multifactorial Scale of Attitude Toward Statistics (MSAS; Auzmendi, 1991), and the Students' Attitudes Toward Statistics (STATS; Sutarso, 1992). Among these, the Survey of Attitudes Toward Statistics (SATS-36) developed by Schau et al. (2003) has become one of the most widely adopted tools. It measures students' attitudes across six dimensions: Affect, Cognitive Competence, Value, Difficulty, Interest, and Effort. Its design allows for the collection of both pre-course and post-course data, making it a useful tool for evaluating the effect of instruction on student perceptions.

Previous research using the SATS-36 has examined how various pedagogical approaches influence student attitudes. Active learning strategies (Carlson & Winquist, 2011), student-led projects (Carnell, 2008), and contextualized instruction (Liau, Kiat, & Nie, 2015) have all been found to foster more positive attitudes toward statistics. Recent work by Slootmaeckers, Kerremans, and Adriaensen (2014) emphasized the importance of engaging students emotionally and cognitively by enhancing the design of research methods courses through active learning and formative feedback. Their findings suggest that structuring learning experiences around clear expectations, practical relevance, and responsive support can improve student satisfaction and perceived learning outcomes—principles that are also applicable in introductory statistics education. Likewise, Çelik, Pektaş, and Karamustafaoğlu (2021) demonstrated that implementing flipped classroom models in higher education can enhance students' self-efficacy and foster more positive attitudes toward learning. Together, these studies suggest that interactive, student-centered instructional approaches—such as flipped classrooms and formative feedback—can be especially effective in promoting engagement, perceived relevance, and positive attitudes in quantitative subjects like statistics.

In particular, studies have highlighted the benefit of aligning course content with students' career interests and demonstrating real-world relevance, which can significantly increase engagement and reduce anxiety (Ashaari et al., 2011; Coetzee & Van der Merwe, 2010; Dempster & McCorry, 2009). Integration of real-world datasets and application-based instruction has shown promise in bridging the gap between theoretical knowledge and practical use, particularly in health sciences where data-driven decisions are paramount (Makar & Rubin, 2018).

While much research has explored general student attitudes toward statistics, few studies have focused specifically on health science students in the early stages of their undergraduate education, particularly within U.S. academic settings. Moreover, while there is substantial evidence on the relationship between attitude and achievement, less is known about how introductory courses themselves shape attitudes over time, and which specific subcomponents of attitude are most affected by course participation.

This study aims to fill this gap by investigating changes in students' attitudes toward statistics before and after a one-semester introductory statistics course at a Midwestern university with a strong health sciences focus. Using the SATS-36, we assess six dimensions of attitude to determine which areas improve, remain stable, or decline following formal instruction. The findings offer valuable insights for educators seeking to improve statistics pedagogy, particularly for students in applied health science tracks, by highlighting the interplay between course design and student affect.

METHOD

Participants

The study involved 119 undergraduate health science students who were enrolled in a first-year statistics course at the University of Minnesota Rochester. The majority of the participants were female (76%) and primarily Caucasian (93%), with an average age of 18.25 years, ranging between 17 and 27 years. The University of Minnesota Rochester is recognized for its innovative educational approach, with a strong focus on teaching excellence and a commitment to the scholarship of teaching and learning.

This introductory statistics course is commonly taken by first- or second-year students in the fall semester. The curriculum covers essential statistical concepts, data representation techniques using Microsoft Excel, the fundamentals of experimental design, probability theory, and statistical inference methods, including the Central Limit Theorem and the Law of Large Numbers. The course wraps up with a focus on quantitative statistical inference methods. The instructional team, which includes seasoned faculty members and undergraduate academic assistants, is attuned to the unique needs of the student population and actively works to assist students as they adapt to university life.

To foster a more positive learning environment, the course employed several innovative pedagogical strategies. These included collaborative group projects based on real-world healthcare data, the use of Excel to promote data literacy, and interactive simulations that allowed students to explore statistical concepts visually. Additionally, weekly formative assessments and reflective journals were used to encourage metacognition and reduce anxiety. These interventions aimed to boost students' confidence and demonstrate the relevance of statistics to health science fields.

Instrument

The Survey of Attitudes Toward Statistics (SATS-36), developed by Schau et al. (2003), was used to measure students' attitudes toward statistics. The SATS-36 consists of 36 items categorized into six subscales that capture different dimensions of student attitudes:

- ***Affect*** (6 items): Assesses students' emotional responses toward statistics, such as enjoyment, anxiety, and frustration (e.g., *"I will like statistics"* and *"I am scared by statistics"*).
- ***Cognitive Competence*** (6 items): Reflects students' self-perceptions of their intellectual ability and capacity to understand statistics (e.g., *"I can learn statistics"* and *"I will make a lot of math errors in statistics"*).
- **Value** (9 items): Measures the perceived usefulness and relevance of statistics in personal and professional life (e.g., *"Statistical skills will make me more employable"* and *"Statistics is irrelevant in my life"*).
- **Difficulty** (7 items): Evaluates how difficult students perceive statistics to be, including computational and conceptual complexity (e.g., *"Statistics involves massive computations"* and *"Statistics is a complicated subject"*).
- **Interest** (4 items): Captures the students' intrinsic interest in statistics and their desire to engage with statistical content (e.g., *"I am interested in learning statistics"*).
- **Effort** (4 items): Gauges the level of effort students intend to put into learning statistics (e.g., *"I plan to work hard in my statistics course"*).

Items are scored on a 7-point Likert scale from 1 (strongly disagree) to 7 (strongly agree), with several items reverse-coded to ensure consistent interpretation. Higher scores generally indicate more favorable attitudes.

Statistical Analyses

The SATS-36 survey was administered to participants at two points: before and after one semester of instruction in introductory statistics. A total of 165 students initially participated, but due to attrition (e.g., course withdrawals and incomplete data), the final analysis included responses from 119 students.

To assess changes in students' attitudes, descriptive statistics (means and standard deviations) were calculated for each of the six SATS-36 subscales. Paired sample *t*-tests were conducted to examine statistically significant differences between pre- and post-course scores. Internal consistency reliability for each subscale was evaluated using Cronbach's alpha, with all subscales demonstrating acceptable to excellent reliability ($\alpha = 0.72$ to 0.91).

Criterion-related validity was assessed by correlating each attitude subscale with students' final course grades and a composite score derived from a statistical proficiency test. These correlations were analyzed both before and after the course to determine how relationships among affective domains and performance outcomes evolved over time.

Interpretations of score changes, especially for constructs such as Cognitive Competence, were grounded in both statistical significance and theoretical alignment with the SATS-36 instrument. For instance, an increase in this subscale suggests greater student confidence in their ability to understand and apply statistical concepts, even when item-level change was not uniformly significant. Taken together, these analyses offer a comprehensive view of how students' attitudes shifted across multiple dimensions of the learning experience.

RESULTS

Affect

The results indicated significant changes in students' attitudes across several domains. For the Affect subscale, participants' responses to statements such as "I will like statistics" and "I will enjoy taking statistics courses" showed a decrease over the semester, while statements indicating negative emotions towards statistics, such as "I will be under stress during statistics class" and "I am scared by statistics," showed an increase. These changes suggest that despite completing the course, some students may still harbor negative feelings towards statistics.

Item	Pre-test		Post-test		Paired Sample	Comment on improvement
	M	SD	M	SD	*t*-test statistic	% increase or decrease
Affect 1	4.95	1.09	4.53	1.616	-2.83*	-8.48
Affect 2	4.53	0.51	4.63	1.705	0.58	2.21
Affect 3	4.60	1.59	4.14	1.857	-2.49*	-10.00
Affect 4	3.62	1.52	3.99	1.770	2.33*	10.22
Affect 5	4.57	1.05	4.24	1.580	-2.29*	-7.22
Affect 6	4.35	1.77	5.09	1.787	4.58**	17.01

Table 1: Mean, standard deviation and paired sample *t*-test scores on Affect
Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

These results underscore the complexity of students' emotional responses to statistics. While some may develop an appreciation or acceptance of the subject over time, others may find their anxieties and frustrations deepening, particularly if they struggle to grasp the material.

Cognitive Competence

In the Cognitive Competence subscale, which measures students' confidence in their ability to learn and understand statistics, most items showed a slight increase in mean scores from pre- to post-assessment, although only one item showed a statistically significant improvement. This suggests that while students may feel slightly more competent after completing the course, the increase in confidence is not uniform across all aspects of their statistical learning.

Item	Pre-test		Post-test		Paired Sample	Comment on improvement
	M	SD	M	SD	*t*-test statistic	% increase or decrease
Cognitive Competence 1	4.74	1.31	4.88	1.74	0.89	2.95
Cognitive Competence 2	5.34	1.28	5.60	1.50	1.76**	4.87
Cognitive Competence 3	3.91	1.53	4.57	1.65	4.21	16.88
Cognitive Competence 4	6.25	0.98	6.11	1.26	-1.10	-2.24
Cognitive Competence 5	5.64	1.16	5.34	1.57	-1.85	-5.32
Cognitive Competence 6	4.26	1.41	4.44	1.67	1.29	4.23

Table 2: Mean, standard deviation and paired sample *t*-test scores on Cognitive Competence

Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

Despite these findings, the overall increase in cognitive competence is a positive outcome, indicating that the course may have been effective in building students' confidence in their statistical abilities, albeit to varying degrees.

Value

For the Value subscale, which assesses the perceived relevance and usefulness of statistics in students' lives, all items showed a decrease in mean scores from pre- to post-assessment. This finding is concerning, as it suggests that students may not fully appreciate the importance of statistics even after completing the course. The decrease in value-related attitudes may be linked to the challenges students face in applying statistical concepts to real-world scenarios and may indicate a need for the course to better connect statistical learning with practical, real-world applications that are directly relevant to students' future careers.

The Value subscale of the SATS-36 consists of nine items (Items 7, 9, 10, 13, 16, 17, 21, 25, and 33), which evaluate the extent to which students perceive statistics as relevant and useful in their personal and professional lives. The following table summarizes the pre- and post-course responses for each item.

Item	Pre-test		Post-test		Paired Sample	Comment on improvement
	M	SD	M	SD	*t*-test statistic	% increase or decrease
Value 1	6.05	1.007	5.71	1.43	-2.71*	-5.62
Value 2	4.93	1.318	4.71	1.49	-1.71	-4.46
Value 3	5.33	1.161	5.20	1.46	-1.12	-2.44
Value 4	5.21	1.367	5.12	1.40	-0.76	-1.73
Value 5	5.17	1.306	4.78	1.58	-2.71*	-7.54
Value 6	3.88	1.456	3.76	1.59	-0.85	-3.09
Value 7	4.86	1.362	4.81	1.311	-0.42	-1.03
Value 8	5.41	1.235	5.36	1.34	-0.41	-0.92
Value 9	5.53	1.281	5.14	1.40	-2.89*	-7.05

Table 3: Mean, standard deviation, and paired sample *t*-test scores for Value subscale (SATS-36 Items 7, 9, 10, 13, 16, 17, 21, 25, and 33)

Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

These results suggest that while students may recognize the value of statistics initially, the challenges they face during the course could lead to a reduction in their perception of its relevance. This highlights a potential area for curriculum improvement, where greater emphasis could be placed on demonstrating how statistical skills are essential in various health science professions.

Difficulty

The Difficulty subscale revealed that students perceived statistics as more challenging after completing the course, with several items showing significant increases in mean scores. This increase in perceived difficulty could be attributed to the course content becoming more complex as the semester progressed, or it could reflect a deeper understanding of the subject's inherent challenges.

The Difficulty subscale includes seven items (Items 6, 8, 22, 24, 30, 34, and 36), addressing students' perceptions of how difficult statistics is as a subject.

Item	**Pre-test**		**Post-test**		**Paired Sample**	**Comment on improvement**
	M	**SD**	**M**	**SD**	***t*-test statistic**	**% increase or decrease**
Difficulty 1	4.19	1.11	4.90	1.33	5.53**	16.95
Difficulty 2	3.47	1.21	3.53	1.65	0.42	1.73
Difficulty 3	3.35	1.27	3.52	1.37	1.33	5.07
Difficulty 4	2.97	1.23	3.13	1.31	1.36	5.39
Difficulty 5	3.74	0.95	4.45	1.46	5.94**	18.98
Difficulty 6	3.60	1.06	3.58	1.27	-0.13	-0.56
Difficulty 7	3.72	1.23	3.85	1.34	1.05	3.49

Table 4: Mean, standard deviation, and paired sample *t*-test scores for Difficulty subscale (SATS-36 Items 6, 8, 22, 24, 30, 34, and 36)

Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

The significant increase in difficulty ratings suggests that as students progressed through the course, they found the material increasingly challenging. This may have contributed to the decline in their overall attitude towards the subject, as reflected in other subscales like Affect and Interest.

Interest

The Interest subscale, which measures students' enthusiasm for engaging with statistics, showed a significant decrease across all items. This decline in interest may indicate that the course content or delivery methods did not sufficiently engage students or that the challenges they encountered dampened their initial enthusiasm for the subject.

The Interest subscale consists of four items (Items 12, 20, 23, and 29), measuring students' individual curiosity and enthusiasm for engaging with statistical material.

Item	Pre-test		Post-test		Paired Sample	Comment on improvement
	M	SD	M	SD	*t*-test statistic	% increase or decrease
Interest 1	4.99	1.33	4.20	1.67	-5.48**	-15.83
Interest 2	4.84	1.14	4.40	1.44	-3.78**	-9.09
Interest 3	5.29	1.09	4.57	1.39	-5.79**	-13.61
Interest 4	5.50	1.09	4.50	1.55	-7.54**	-18.18

Table 5: Mean, standard deviation, and paired sample *t*-test scores for Interest subscale (SATS-36 Items 12, 20, 23, and 29)

Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

These findings suggest a potential misalignment between the course structure and the interests of the students. To maintain and enhance interest, educators might consider integrating more interactive and applied learning experiences that directly connect with students' future professional goals.

Effort

Finally, the Effort subscale, which gauges the amount of effort students were willing to invest in learning statistics, also showed a decrease in mean scores from pre- to post-assessment. While the decrease was statistically significant for two of the four items, it suggests that students may have felt overwhelmed by the demands of the course, leading to a reduction in the effort they were willing to put forth.

The Effort subscale includes four items (Items 1, 2, 14, and 27), which reflect the amount of work students plan to expend in learning statistics.

Item	Pre-test		Post-test		Paired Sample	Comment on improvement
	M	SD	M	SD	*t*-test statistic	% increase or decrease
Effort 1	6.82	0.69	6.71	0.96	-1.13	-1.61
Effort 2	6.83	0.66	6.34	0.99	-4.99**	-7.17
Effort 3	6.53	0.76	6.04	1.18	-4.78**	-7.50
Effort 4	6.81	0.63	6.71	0.88	-1.10	-1.47

Table 6: Mean, standard deviation, and paired sample *t*-test scores for Effort subscale (SATS-36 Items 1, 2, 14, and 27)

Key: M = mean; SD = standard deviation.; * $p < 0.05$; ** $p < 0.001$

The decline in effort may reflect students' growing frustration with the course material or a perception that their efforts were not yielding the desired outcomes, further contributing to negative attitudes towards the subject.

Correlational Analysis

The correlations among the subscales were examined both before and after the course. For the pre-assessment, all six subscales were generally significantly correlated with each other, except for Effort, which was only significantly correlated with Value and Interest. After the course, all subscales remained significantly correlated, with the Effort subscale continuing to show limited correlations with other domains. These correlations suggest that students' attitudes towards different aspects of statistics are interconnected, with changes in one domain potentially influencing attitudes in others.

	Affect	Cognitive Competence	Value	Difficulty	Interest	Effort	Final Grade
Affect	1						
CC	0.77**	1					
Value	0.43**	0.42**	1				

Difficulty	0.47**	0.50**	0.14	1			
Interest	0.54**	0.46**	0.60**	0.22*	1		
Effort	0.15	0.15	0.20*	0.090	0.23*	1	
Final Grade	0.12	0.24**	0.09	0.097	0.07	0.05	1

Table 7: Correlations (Pre-test)

**Correlation significant at the 0.01 level (2-tailed); *Correlation significant at the 0.05 level (2-tailed).

	Affect	**Cognitive Competence**	**Value**	**Difficulty**	**Interest**	**Effort**	**Final Grade**
Affect	1						
CC	0.82**	1					
Value	0.50**	0.48**	1				
Difficulty	0.49**	0.47**	0.09	1			
Interest	0.54**	0.46**	0.71**	0.06	1		
Effort	0.020	-0.03	0.13	-0.03	0.22*	1	
Final Grade	0.36**	0.50**	0.27**	0.15	0.28**	0.05	1

Table 8: Correlations (Post-test)

**. Correlation is significant at the 0.01 level (2-tailed).

Final Grade

The correlations between the subscales and the final grade were also examined. For the pre-test, Cognitive Competence showed the strongest correlation with final grades, followed by Interest and Affect. However, in the post-test analysis, the correlation between Cognitive Competence and final grades strengthened, while the correlations for Affect and Interest also increased. This indicates that students who performed well in the course were likely to have higher cognitive competence and positive attitudes towards statistics by the end of the semester.

Cronbach's Alpha

Cronbach's alpha values were computed to assess the internal consistency of the SATS-36 subscales for both the pre-test and post-test scores. The results, presented in Table 9, indicate that the survey instrument demonstrated good to excellent reliability across all subscales, with values ranging from 0.72 to 0.91. This high level of reliability suggests that the SATS-36 is a consistent and dependable measure of students' attitudes towards statistics.

Component	Time administered	
	Pre-test	Post-test
Affect	0.85	0.87
Cognitive Competence	0.81	0.87
Value	0.87	0.90
Difficulty	0.75	0.90
Interest	0.87	0.91
Effort	0.72	0.85

Table 9: Cronbach’s alpha values for pre-test and post-test scores

DISCUSSION

The findings of this study provide important insights into how undergraduate health science students' attitudes towards statistics change over the course of an introductory statistics class. Despite completing the course, many students still held negative attitudes towards statistics, particularly in terms of affect and perceived difficulty. These results highlight the need for educators to not only focus on teaching statistical concepts but also on addressing students' attitudes and confidence in their ability to learn statistics.

One potential explanation for the observed decline in positive attitudes is the challenge that statistics presents to students who may not have a strong background in mathematics. The perceived difficulty of the subject could have led to increased anxiety and reduced interest, ultimately impacting their overall attitudes. Additionally, the decrease in the perceived value of statistics suggests that more effort may be needed to demonstrate the practical applications of statistical knowledge in the students' future careers, particularly in health sciences.

The results also suggest that students' cognitive competence and effort may be influenced by their emotional responses to the subject. For instance, students who feel anxious about statistics may also be less confident in their ability to understand the material and may be less motivated to put in the necessary effort to succeed. This interplay between affective and cognitive factors underscores the importance of addressing both emotional and intellectual aspects of learning in the classroom.

Implications for Teaching and Curriculum Design

The results of this study have several important implications for teaching and curriculum design in introductory statistics courses, particularly for health science students:

1. **Incorporating Real-World Applications**: To enhance the perceived value of statistics, instructors should incorporate more real-world applications that are directly relevant to students' future careers. For health science students, this could include examples from medical research, public health studies, and evidence-based practice. Demonstrating how statistical knowledge can be applied to real-world problems may help students see the relevance of what they are learning and increase their engagement with the subject.
2. **Addressing Student Anxiety**: Given the significant increase in perceived difficulty and anxiety related to statistics, it is important for instructors to address these issues head-on. This could involve integrating stress-reduction techniques into the course, such as mindfulness exercises or providing additional support through tutoring and office hours. Instructors might also consider starting the course with less intimidating, foundational content before gradually increasing the complexity of the material.
3. **Fostering a Growth Mindset**: To combat the decline in cognitive competence and effort, educators should focus on fostering a growth mindset in their students. This involves encouraging students to view challenges as opportunities for growth and learning, rather than as insurmountable obstacles. Strategies could include providing positive reinforcement, offering constructive feedback, and creating a classroom environment that celebrates effort and persistence.
4. **Reflecting on Pedagogical Impact**: The observed changes in students' attitudes—particularly the modest improvement in cognitive competence and the decline in perceived value and interest—may reflect the mixed impact of the course's instructional design. While the integration of real-world data, collaborative group projects, and formative assessments aimed to promote engagement and reduce anxiety, the results suggest that these interventions may not have fully addressed students' emotional responses or per-

ceptions of relevance. It is possible that while students gained confidence in specific skills, they did not consistently perceive statistics as directly applicable to their future careers. This indicates a need for further alignment between course activities and students' professional goals, such as embedding more career-specific examples and facilitating reflective discussions about the role of statistics in health sciences. Strengthening this connection may help sustain students' interest and reinforce the value of statistical thinking beyond the classroom.

5. **Enhancing Student Engagement**: The significant decrease in students' interest in statistics over the semester suggests that more needs to be done to keep students engaged. Active learning strategies, such as group work, problem-based learning, and interactive simulations, can make the learning experience more dynamic and engaging. Additionally, providing opportunities for students to take ownership of their learning through projects or presentations can help maintain their interest.
6. **Continuous Assessment of Attitudes**: Finally, it is crucial for educators to continuously assess students' attitudes towards statistics throughout the course. This allows for timely interventions if negative attitudes begin to emerge. Regular check-ins, surveys, or reflective writing assignments can provide insights into how students are feeling about the material and where they might need additional support.

Limitations

While this study provides valuable insights, it is important to acknowledge its limitations. The use of convenience sampling and the lack of a control group limit the generalizability of the findings. Additionally, the study was conducted at a single institution with a relatively homogeneous sample, which may not reflect the experiences of students at other universities or in different fields of study. Future research could address these limitations by including a more diverse sample and comparing attitudes across different academic disciplines.

Future Research

To build on the findings of this study, future research could explore the following areas:

1. **Longitudinal Studies**: Conducting longitudinal studies that track changes in students' attitudes towards statistics over multiple semesters or across different courses would provide a deeper understanding of how these attitudes evolve over time. This could help identify the long-term impact of introductory statistics courses on students' perceptions and engagement with the subject.
2. **Comparative Studies**: Future research could compare the effectiveness of different teaching methods in shaping students' attitudes towards statistics. For example, studies could investigate whether active learning strategies, flipped classrooms, or online learning environments are more effective in improving students' attitudes compared to traditional lecture-based approaches.

3. **Exploring the Role of Instructors**: The role of the instructor in influencing students' attitudes towards statistics is another important area for future research. Studies could examine how different teaching styles, instructor characteristics, and classroom environments impact students' attitudes and learning outcomes.
4. **Investigating Specific Subgroups**: Future research could also explore how attitudes towards statistics vary among different subgroups of students, such as those with different levels of mathematical background, those from different academic disciplines, or those with varying levels of interest in the subject. This could help identify specific groups of students who may benefit from targeted interventions.

CONCLUSION

This study highlights the complex and multifaceted nature of students' attitudes towards statistics. While some aspects of students' attitudes improved after completing an introductory statistics course, other areas, particularly affective responses and perceived difficulty, remained challenging. These findings underscore the need for educators to take a holistic approach to teaching statistics, one that addresses both the cognitive and emotional aspects of learning.

By integrating real-world applications, addressing student anxiety, fostering a growth mindset, and continuously assessing attitudes, educators can create a more supportive and engaging learning environment. This, in turn, can help students develop not only the skills they need to succeed in statistics but also a more positive and confident attitude towards the subject.

The insights gained from this study can inform the development of more effective statistics curricula, ultimately helping to better prepare health science students for the statistical demands of their future careers. As the importance of statistical literacy continues to grow, particularly in fields like health sciences where evidence-based practice is critical, it is essential that students leave their statistics courses with both the knowledge and the confidence to apply what they have learned.

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Appendix: SATS-36 Instrument

Affect – students' feelings concerning statistics

Affect 1: I will like statistics.

Affect 2: *I will feel insecure when I have to do statistics problems.

Affect 3: *I will get frustrated going over statistics tests in class.

Affect 4: *I will be under stress during statistics class.

Affect 5: I will enjoy taking statistics courses.

Affect 6: *I am scared by statistics.

Cognitive Competence – students' attitudes about their intellectual knowledge and skills when applied to statistics

CC 1: *I will have trouble understanding statistics because of how I think.

CC 2: *I will have no idea of what's going on in this statistics course.

CC 3: *I will make a lot of math errors in statistics.

CC 4: I can learn statistics.

CC 5: I will understand statistics equations.

CC 6: *I will find it difficult to understand statistical concepts.

Value – students' attitudes about the usefulness, relevance, and worth of statistics in personal and professional life

Value 1: *Statistics is worthless.

Value 2: Statistics should be a required part of my professional training.

Value 3: Statistical skills will make me more employable.

Value 4: *Statistics is not useful to the typical professional.

Value 5: *Statistical thinking is not applicable in my life outside my job.

Value 6: I use statistics in my everyday life.

Value 7: *Statistics conclusions are rarely presented in everyday life.

Value 8: *I will have no application for statistics in my profession.

Value 9: *Statistics is irrelevant in my life.

Difficulty – students' attitudes about the difficulty of statistics as a subject

Difficulty 1: Statistics formulas are easy to understand.

Difficulty 2: *Statistics is a complicated subject.

Difficulty 3: Statistics is a subject quickly learned by most people.

Difficulty 4: *Learning statistics requires a great deal of discipline.

Difficulty 5: *Statistics involves massive computations.

Difficulty 6: *Statistics is highly technical.

Difficulty 7: *Most people have to learn a new way of thinking to do statistics.

Interest – students' level of individual interest in statistics

Interest 1: I am interested in being able to communicate statistical information to others.

Interest 2: I am interested in using statistics.

Interest 3: I am interested in understanding statistical information.

Interest 4: I am interested in learning statistics.

Effort - amount of work the student expends to learn statistics

Effort 1: I plan to complete all of my statistics assignments.

Effort 2: I plan to work hard in my statistics course.

Effort 3: I plan to study hard for every statistics test.

Effort 4: I plan to attend every statistics class session.

* *Asterisk indicates item is reverse-coded (i.e. 1 becomes 7, 2 becomes 6, etc.)*