RESEARCH ARTICLE

Relationship between the attitudes of biology education students towards statistics with knowledge of data analysis

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Abstract: Students' knowledge of data analysis determines the quality of the research they report but they tend to perceive courses on statistics or data analysis as challenging and unappealing. The present study aimed to investigate the correlation between biology education students' attitudes toward statistics and their proficiency in determining various data analytical techniques. This study involved biology education students from the Universitas Muhammadiyah Malang who had completed a course in statistics, research methods, and data analysis. The Survey of Attitudes Toward Statistics (SATS) and the Statistics Assessment of Graduate Students (SAGS) were used sequentially as instruments for collecting data on student attitudes toward statistics and data analysis competencies. The results revealed that while most students had positive attitudes toward statistics, they perceived the subject as challenging to learn. Additionally, the students demonstrated low levels of competency in data analysis. The aspects of cognitive competence and difficulty from SATS correlate significantly with their SAGS score. These results suggest that there is a need for a revision of the biology education curriculum to better equip students with the skills and knowledge to increase their data analysis competencies.

Keywords: attitude toward statistics; data analysis competency; educational statistics; research skills; statistics assessment

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Introduction

In higher education, the biology education curriculum includes mandatory courses on statistics or data analysis in which students gain knowledge of various measurement scales and the fundamental principles of analytical techniques in statistics. They also learn to identify and apply appropriate analytical techniques based on the nature of the data and the research design. Therefore, statistical and data analysis competencies are basic skills that students must acquire before conducting research (Fauzi & Fariantika, 2018). The competencies are not only important for their final research assignments but also for their future careers as educators as they will be expected to engage in ongoing research to enhance the effectiveness and quality of teaching (Ado, 2013; Tack & Vanderlinde, 2014).

Even though statistics is a compulsory course, many Biology education students tend to hold negative attitudes toward this course. Indeed, students from various academic programmes including Biology education have reported difficulty in mastering statistics (Deckard, 2017; Glancy et al., 2017; Leavy et al., 2013; Fauzi & Fariantika, 2018). Consequently, students' mastery of statistics-based concepts and competencies outside of the statistics and mathematics study programme has been reported to be

unsatisfactory (Burhan, 2013; Jatisunda et al., 2020). The formulas and calculations that must be learned, their anxiety (Macher et al., 2013), and their attitudes toward statistics (Mao et al., 2021; Sölpük, 2017) may contribute to their statistical competence.

In line with students' attitudes towards statistics, the data analysis competence of biology education students also tends to be low, which will affect the quality of research designed and implemented by Biology education students. This is because the better the knowledge of statistics and analysis, the better the quality of the data collection and selection of analytical methods when designing methods and reporting research results (Oster & Enders, 2018; Sendef & Robbins, 2019). Unfortunately, many research publications in the field of Biology education in Indonesia exhibit a poor selection of data analysis techniques (Susetyarini & Fauzi, 2020). These findings are consistent with previous studies that have also reported inaccuracies in the use of statistics in various research publications (Abah, 2018; Gogtay & Thatte, 2017; Wu et al., 2011). Inaccurate selection of data analysis techniques can lead to biased and invalid research conclusions (Ali & Bhaskar, 2016).

Despite the issue of statistical competence needing special attention, there is a lack of research on students' attitudes toward statistics in biology education. Studies on students' attitudes toward statistics have been conducted in various fields such as health (Ayebo et al., 2019; Hannigan et al., 2014; Zhang et al., 2012), engineering (Ghulami et al., 2015), business (Sharma & Srivastav, 2021; Wang et al., 2018), and psychology (Akour, 2022). Furthermore, previous research related to statistical knowledge also involved high school students, whereas research in tertiary institutions only involves subjects outside of biology education students, for example, mathematics education (Azis & Nurlita, 2018), public administration (Jatisunda et al., 2020), and GENERAL EDUCATION (Burhan, 2013). Additionally, these studies have not yet focused on measuring students' basic knowledge in applying statistics to research in biology education.

For these reasons, this study aimed to fill the gap in research on students' attitudes toward statistics and their related knowledge of data analysis in biology education. This research also reveals the relationship between aspects of attitudes towards their level of competence, providing an overview of knowledge related to data analysis techniques for biology education students. Furthermore, the effect of attitude on data analysis competencies can be confirmed through this study, and thus can be used as the basis for reformulating the design of statistics courses or even the biology education curriculum in tertiary institutions.

Method

Research design and participants

This correlational research was conducted at the Universitas Muhammadiyah Malang (UMM), Indonesia, in 2021 and involved biology education students who had taken data analysis courses, namely Statistics, Research methodology, and Computational data analysis. In the Statistics course, the students learned basic statistics including measurement scales, terminology, types of statistics, and how to process data manually. In Research methodology courses, students studied various research designs, sampling techniques, and various data analysis techniques. In the Computational data analysis course, students learned to use data analysis software for descriptive and inferential statistical analysis.

Instruments

The study examined students' attitudes toward statistics and their knowledge of data analysis techniques in quantitative research using the Survey of Attitudes Toward Statistics (SATS) instrument developed by Schau et al. (1995). This instrument consists of four dimensions, namely affect (6 items), cognitive competence (6 items), value (9 items), and difficulty (7 items). The students' responses were measured using a 7-point Likert scale from strongly disagree to strongly agree. The instrument is valid and consistent in multiple samples (Cladera et al., 2019; Emmioğlu & Capa-Aydin, 2012; Nolan et al., 2012; Sin & Rosli, 2020).

The student's knowledge of data analysis techniques was measured using a translated instrument from the Statistics Assessment of Graduate Students (SAGS) developed by Walpitage (2016). The SAGS instrument is intended to measure the ability to select appropriate statistical procedures to address certain research situations that are common in student research. The instrument is a multiple-choice test with 25 questions, each question asks to choose the most appropriate data analysis technique based on the given statistics problem. Several questions measured the accuracy of students selecting descriptive statistical analysis techniques, and several other questions measured the accuracy of selecting inferential statistical analysis techniques.

Scoring and data analysis

The scores were calculated after the students completed the SATS and SAGS instruments. On SATS,

a score of 7 was given for each positive statement if the student chose the "strongly agree" option, and a score of 1 was given if the student chose the "strongly disagree" option. On SAGS, a score of 1 was given for each correct answer, and a score of 0 for each incorrect answer. The final SAGS scores were then converted to a scale of 0 to 100. For all research samples, the average was used to describe the level of attitude (both the overall score of the 28 items and scores for each attitude dimension) and the level of competence in data analysis. The Pearson product-moment correlation was also used to examine the relationship between each attitude dimension and student competency. RStudio was used to analyse the collected data available from shorturl.at/fijLX.

Results and Discussion

In total, 141 biology education students participated in this study and completed questionnaires were obtained from 138 students (31 male students and 107 female students), thus, the response rate was 97.87%. This high response rate minimises the possibility of non-response errors (Dillman et al., 2014). Table 1 presents the average student attitudes toward statistics and the average scores of all SATS items, showing that many biology education students have a positive attitude toward statistics based on the average SATS score greater than the neutral score (a neutral score is 4, while the participants' average SATS is 4.5). Therefore, in general, the biology education students involved in this study did not have attitude problems, which is consistent with previous studies conducted on students in non-mathematics programmes such as business school students in India (Sharma & Srivastav, 2021) and health students in China (Zhang et al., 2012) and Serbia (Stanisavljevic et al., 2014).

Table 1. Attitude and knowledge score of Biology education students

Variables	Number of students (%)	Attitude		Knowledge	
		M	SD	M	SD
Male	31 (22.46)	4.4	0.5	22.5	10.0
Female	107 (77.54)	4.5	0.6	23.1	9.1
Total	138 (100)	4.5	0.6	22.9	9.3

Additionally, based on the average scores of each attitude dimension, the value dimension had the highest average score (M=5.4, SD=0.7) and the difficulty dimension had the lowest average score (M=3.1, SD=0.7) (Table 2). The difficulty dimension is the only dimension with an average score below the neutral score. This is consistent with research involving postgraduate students in England (Chowdhury, 2018), engineering students in Malaysia (Ghulami et al., 2015), students majoring in business in the Philippines (Melad, 2022), and industrial psychology students in South Africa (Coetzee & Van der Merwe, 2010). This dimension relates to students' perceptions of how difficult it is to learn statistics and the average score indicates that most Biology education students perceive statistics as a difficult subject to learn. This is in line with the opinion of both non-mathematics and mathematics students who feel statistics is one of the most difficult subjects to learn (Male & Lumbantoruan, 2021).

Table 2. Mean scores and standard deviations for each dimension of SATS

Dimension	M	SD
Affect	4.9	1.0
Cognitive Competence	4.5	0.8
Value	5.5	0.7
Difficulty	3.1	0.6
Total	4.5	0.6

The mean SAGS scores presented in Table 1 are unsatisfactory because many students did not correctly answer up to 50% of the questions raised (M = 22.9, SD = 9.3). These results align with previous studies that have also found low student proficiency in statistical tests in various academic programmes. Additionally, previous research also found low average scores for students in the Department of Education regarding their knowledge of data analysis similar to this study (Burhan, 2013). Several reasons may account for the inadequate understanding of data analysis techniques among Biology education students. Students' ability to master statistical knowledge can be significantly influenced by their mathematical competence (Lai et al., 2011; Yuniawatika, 2018) and many Biology education students choose this field of study despite not having a strong background or interest in mathematics, which may contribute to the problem.

Additionally, Table 3 summarises the results of the correlation analysis of SATS and SAGS scores, showing that the SATS score has a significant correlation with SAGS ($r = 0.199$, $p = 0.019$). These results confirm that students' attitudes towards statistics can be a factor related to students' statistical knowledge regarding the use of various data analysis techniques and is consistent with a study

involving health students in Serbia (Stanisavljevic et al., 2014) and China (Zhang et al., 2012) who reported a significant correlation between attitudes toward statistics and student achievement. Additionally, these findings also support the correlation between attitudes and student academic achievement in subjects other than statistics, such as in Science (Mao et al., 2021; Narmadha & Chamundeswari, 2013), English (Lukman et al., 2022), as well as Mathematics (Musa et al., 2022).

Table 3. The correlation coefficient of each SATS domain and the SAGS score

	Difficulty	Value	Cognitive Competence	Affect
Value	0.074			
Cognitive Competence	0.364**	0.375**		
Affect	0.333**	0.424**	0.704**	
SAGS	0.168*	0.063	0.205*	0.155

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

Regarding the correlation analysis of the dimensions of attitude and SAGS, only the dimensions of cognitive competence ($r = 0.205$, $p = 0.016$) and difficulty ($r = 0.168$, $p = 0.048$) are significantly correlated with SAGS. The strong correlation between the difficulty dimension and SAGS score can be explained by the fact that students who find statistics hard will have lower academic achievements. Research involving health students in Serbia also reports that cognitive competence is strongly correlated with statistical achievement (Stanisavljevic et al., 2014) as well as research in the Philippines (Melad, 2022). Concerning the items stated in this dimension, the study findings imply that students who feel competent in statistics will have better achievements (Stanisavljevic et al., 2014; Zhang et al., 2012). The lack of correlation between the dimensions of values and student competence is also supported by previous studies whose samples were students taking introductory statistics courses at Spanish universities (Carmona et al., 2005).

The present study indicates that efforts to improve biology education students' attitudes toward statistics may have a positive impact on their data analysis competence. Therefore, it is recommended that instructors should devise lectures and learning environments that can decrease students' fear and anxiety while studying statistics. Moreover, to improve students' knowledge of data analysis techniques, lectures should expose students to processing actual research data. In addition, the application of flipped classes was also reported to have a positive impact on student attitudes (Wilson, 2013). In this form of lecture, the lecture and homework structure is “reversed” with the aim of most of the acquired basic knowledge moving out of the classroom.

Furthermore, students' anxiety about statistics can also be reduced if lecturers facilitate students studying statistics through the use of data processing software (Park et al., 2022), as it has been reported that several attitude dimensions are higher in students who used statistical analysis software (Hasabo et al., 2022). The use of data processing software will also help students learn statistics and improve their critical thinking skills about data analysis (Counsell & Cribbie, 2019). However, the use of software in statistics courses needs to be carefully designed as it can reduce student statistical achievements (Jatnika & Rahardyan, 2015). The selection of data processing software also needs to be considered because some data processing software is not suitable for use in statistics courses outside the mathematics department.

While this study presents valuable research findings, it also has some limitations that should be acknowledged. The biology education students were only from one university, therefore, for a more comprehensive understanding of the attitudes and competency level of the students, research should be conducted involving biology education students from various institutions. The data analysis competence measured was limited to students' critical thinking skills in identifying data analysis techniques. To address these limitations, further research that also assesses biology education students' abilities in data processing should be conducted and attitudes and data analysis competency instruments should be developed or validated to provide valid and reliable measures of the biology education students in Indonesia.

Conclusion

The attitude of biology education students towards statistics tends to be positive but their competencies fall short of expectations. Their overall attitude significantly correlated with competency but when sorted in each dimension, only cognitive competence and difficulty were significantly correlated with student competency. It is recommended that educators design curricula and learning environments that optimise biology students’ competencies in determining data analysis techniques and help students to overcome their negative attitudes toward statistics.

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Conflicts of Interest

The authors declare that there is no conflict of interest regarding this paper.

Author Contributions

A. Fauzi: Data collection; Data analysis; Writing – original draft**. D. Fatmawati:** Writing – original draft. **A. U. Hali:** Writing – review and editing.

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