



STATISTICAL LITERACY AND THE USE OF STATISTICAL TOOLS IN RESEARCH: A SYSTEMATIC REVIEW OF STUDENTS' STATISTICAL COMPETENCE IN NIGERIAN HIGHER EDUCATION

Offor, Moses¹, Mohammed Salihu Abubakar², Ameh Joseph Ojoniko³

Department of Educational Foundations, Prince Abubakar Audu University, Anyigba

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ABSTRACT

Statistical literacy has become an essential component of higher education and research competence because students increasingly encounter, analyse, interpret, and communicate quantitative information in academic, professional, and digital environments. This systematic review examines the literature on students' statistical literacy, with particular attention to their ability to understand statistical concepts, select appropriate statistical procedures, analyse data, interpret statistical outputs, critically evaluate evidence, and communicate research findings. The review synthesises evidence concerning statistical literacy, statistical reasoning, statistical thinking, statistical inference, statistical anxiety, attitudes toward statistics, statistical software, and contemporary approaches to statistics education. Existing research indicates that statistical literacy extends beyond computational proficiency and requires students to understand statistical concepts, recognise variability and uncertainty, select appropriate analytical procedures, interpret results within their substantive context, evaluate assumptions and limitations, and formulate defensible conclusions. Evidence also demonstrates persistent difficulties in understanding statistical inference, including p values, confidence intervals, sampling variability, statistical significance, effect sizes, and the distinction between association and causation. Meta-analytical evidence further indicates that statistics anxiety, self-efficacy, learning strategies, and attitudes can influence students' experiences with statistics, although affective outcomes should not be equated with demonstrated statistical competence. Recent research also highlights substantial diversity in the conceptualisation and measurement of statistical ability. This diversity creates challenges for cumulative evidence synthesis and demonstrates the need for multidimensional and authentic assessments. The review identifies important gaps concerning authentic research tasks, statistical-tool selection, software-supported reasoning, AI-supported statistics learning, longitudinal development, disciplinary differences, and evidence from African and Nigerian universities. The review concludes that statistics education should move beyond computational training toward integrated development of statistical knowledge, reasoning, interpretation, critical evaluation, and communication.

KEYWORDS: Statistical Literacy; Statistical Reasoning; Statistical Thinking; Statistical Tools; Statistical Inference; Statistics Education.

1. INTRODUCTION

The rapid expansion of quantitative information has transformed academic, professional, and social decision-making. Students routinely encounter percentages, averages, graphs, probability statements, correlations, regression coefficients, significance tests, confidence intervals, and other forms of statistical information in research articles, textbooks, institutional reports, news media, and digital platforms. Consequently, the ability to understand, interpret, and critically evaluate statistical information has become an important component of contemporary education. Statistical literacy extends beyond the ability to perform mathematical calculations. It involves understanding statistical information, interpreting data representations, recognising uncertainty, evaluating the credibility of quantitative claims, and communicating conclusions appropriately. Earlier scholarship emphasised that statistical literacy concerns the ability to interpret and critically evaluate statistical information encountered in everyday contexts rather than merely execute statistical algorithms (Sharma, 2017; Watson & Callingham, 2003). Sharma (2017), for example, demonstrated that

statistical literacy has been conceptualised through several models and that continued attention is required regarding its definition, development, teaching, and assessment.

The issue is particularly important in higher education because students are expected to read empirical research, conduct research projects, analyse data, and interpret research findings. Undergraduate and postgraduate students may therefore be required to use statistical procedures such as descriptive statistics, correlation, regression, t tests, analysis of variance (ANOVA), chi-square tests, and, in some disciplines, more advanced multivariate procedures. However, the ability to operate statistical software does not necessarily indicate that a student understands when a statistical procedure is appropriate or how its results should be interpreted. Research has repeatedly demonstrated difficulties in students' understanding of statistical inference. Castro Sotos et al. (2007), for instance, reviewed empirical evidence concerning students' misconceptions of statistical inference and demonstrated that students experience difficulties in understanding important aspects of inferential statistics.



Recent research has expanded the discussion from traditional statistical knowledge to broader concepts of statistical and data literacy. Systematic reviews have demonstrated considerable diversity in the conceptualisation, measurement, and instructional treatment of statistical and data literacy. This diversity creates a need for evidence synthesis because individual studies differ substantially in their definitions, samples, educational levels, instruments, instructional approaches, and outcome measures. Systematic reviews can organise this fragmented literature, identify common findings and inconsistencies, and reveal gaps requiring further empirical investigation.

The present review therefore examines literature concerning statistical literacy and students' ability to understand, analyse, and interpret statistical information. Particular attention is given to statistical reasoning, statistical thinking, statistical inference, statistics anxiety, attitudes toward statistics, statistical software, and research competence. The review also considers existing systematic reviews and meta-analyses to identify methodological, conceptual, geographical, and contextual gaps that can guide future research, particularly within Nigerian higher education.

2. LITERATURE REVIEW

2.1 Statistical Literacy

Statistical literacy is a multidimensional construct that cannot adequately be defined as the ability to calculate a mean, standard deviation, or correlation coefficient. Rather, it involves understanding statistical information and determining whether conclusions drawn from data are reasonable and adequately supported by evidence. Sharma (2017) noted that statistical literacy has received increasing attention within statistics education, although multiple definitions and models continue to exist. Watson and Callingham (2003) conceptualised statistical literacy as a hierarchical construct and identified levels ranging from informal and inconsistent understanding to more critical and mathematically sophisticated forms of statistical understanding. Their analysis of data involving more than 3,000 school students provided evidence that statistical literacy develops progressively rather than representing a single, uniform ability. Accordingly, statistical literacy requires students to ask questions such as:

- What does this statistical result mean?
- Is the statistical method appropriate?
- To which population can the result reasonably be generalised?
- How certain is the conclusion?
- Does correlation imply causation in this situation?
- What assumptions underlie the analysis?
- Are there alternative explanations?
- Is the graphical presentation potentially misleading?
- What practical conclusion can reasonably be drawn?

These questions demonstrate that statistical literacy is closely associated with critical thinking and evidence-based decision-making.

2.2 Statistical Literacy, Statistical Reasoning, and Statistical Thinking

Statistical literacy generally concerns the understanding and critical interpretation of statistical information. It has

become an increasingly important educational competency in contemporary society because individuals are routinely exposed to quantitative information through academic publications, government reports, news media, digital platforms, and social communication. In education, statistical literacy extends beyond the ability to calculate statistical quantities; it involves understanding, interpreting, evaluating, and communicating statistical information in meaningful contexts. Sharma (2017) conceptualised statistical literacy as a multidimensional construct involving the interpretation and critical evaluation of statistical information, while Watson and Callingham (2003) demonstrated that statistical literacy develops hierarchically, from basic understanding to more sophisticated forms of critical statistical reasoning. Thus, statistical literacy should be understood as the capacity to make informed judgments based on data rather than merely the ability to perform statistical calculations.

Recent scholarship reinforces the multidimensional nature of the construct. Komeijani et al. (2024), in a systematic review of statistical literacy, statistical reasoning, and statistical thinking, observed that these concepts are frequently discussed together but are not always clearly distinguished. Their review highlights a continuing tendency within statistics education to emphasise formulas and computational procedures while giving insufficient attention to critical thinking, interpretation, and problem-solving. This distinction is important because students may successfully calculate a statistical value without understanding what that value means or whether the procedure used was appropriate.

Contemporary systematic-review evidence further demonstrates the expanding scope of statistical literacy. Friedrich et al. (2024) reviewed statistical and data literacy research in K–12 STEM education and found considerable variation in the metrics used to assess literacy and in the instructional strategies adopted. Their findings indicate that statistical and data literacy research is developing rapidly but remains methodologically diverse. Similarly, Schreiter et al. (2024) reviewed 42 studies concerning statistical and data literacy among teachers and teacher education and reported that statistical literacy has become an increasingly important component of STEM education, although the empirical literature remains relatively recent and unevenly distributed across disciplines.

At the higher-education level, Habibie et al. (2025) specifically examined the challenge of developing statistical literacy among university students. Their systematic review noted that statistical literacy is increasingly necessary in an environment characterised by large quantities of quantitative and digital information. However, relatively limited attention has been given to clearly defining statistical literacy within higher education and identifying the challenges associated with its development. This finding is important because university students are expected to read research articles, conduct empirical studies, analyse datasets, and interpret statistical findings, yet these activities require considerably more than procedural knowledge.

Recent research also suggests that statistical literacy should be connected to authentic data and real-world contexts. Delport (2023) argued that analysing statistical information presented in media articles can provide meaningful opportunities for students to develop statistical literacy because



learners must evaluate claims, question evidence, and consider the context in which statistics are presented. This approach moves statistics education away from decontextualised calculations towards the interpretation of quantitative information as it occurs in real life. Similarly, recent work on statistical literacy among tertiary non-STEM students has identified difficulties involving anxiety, confidence, and the application of statistical concepts to real-world situations, reinforcing the importance of contextualised statistical learning.

The development of statistical literacy is also influenced by instructional approaches. Utari et al. (2025), in a systematic review of 18 studies concerning prospective teachers, found growing attention to pedagogical strategies for improving statistical literacy, while also identifying challenges in implementation and teacher preparation. A recent empirical comparison of pen-and-paper homework and project-based learning in an introductory statistics course found no statistically discernible difference between the two approaches in the particular setting examined. This finding illustrates that instructional effectiveness cannot simply be assumed from the label attached to a teaching method. Rather, the quality of implementation, nature of tasks, assessment methods, and learning context may be more important than the adoption of a particular instructional approach.

The relationship between statistical literacy and attitudes towards statistics is another important dimension. A recent meta-analysis by Rodliyah et al. (2025) synthesised 29 primary studies involving university students and examined changes in attitudes following basic statistics training. The study considered factors including geographical region, discipline, educational level, learning methodology, and the use of RStudio. The findings demonstrate that students' responses to statistics education are not uniform and that contextual and instructional factors may influence outcomes. Importantly, however, attitudes towards statistics should not be equated with statistical literacy itself. A student can have a positive attitude towards statistics without possessing adequate ability to interpret statistical evidence, while another student may experience anxiety but nevertheless demonstrate strong statistical reasoning.

Another important issue is the measurement of statistical literacy. Oh et al. (2026), in a systematic review of statistical ability measures, identified 51 papers containing 25 unique measures. Approximately 60% of the measures focused on knowledge-based competencies. The diversity of measures raises questions about the extent to which findings from different studies can legitimately be compared or synthesised. This measurement diversity is particularly important for systematic reviews and meta-analyses because statistical pooling assumes sufficient conceptual and methodological comparability among outcomes.

Recent bibliometric and systematic evidence provides further confirmation that statistical literacy is an expanding research area. Rodliyah et al. (2025/2026) analysed 89 articles published between 2002 and 2025 and found increasing research activity, particularly after 2017. The review identified statistical literacy, statistics education, and data literacy as major themes and reported growing attention to digital learning, real-world data, interdisciplinary approaches, and the relationship between statistical thinking, statistical reasoning,

and statistical literacy. However, the review also identified an imbalance in research distribution, with higher education receiving disproportionate attention relative to some other educational contexts.

Although recent studies and systematic reviews have established the importance of statistical literacy, substantial gaps remain in the conceptualisation and measurement of the construct, particularly regarding students' ability to move beyond computational knowledge to the selection, interpretation, critical evaluation, and communication of statistical evidence. Existing literature also provides limited evidence from Nigerian higher education and limited assessment of statistical literacy through authentic research tasks. Consequently, there is a need for empirical research that examines statistical literacy as an integrated research competency rather than as a narrow ability to perform statistical calculations through statistical reasoning.

Statistical reasoning has become an increasingly important component of students' quantitative and research competence because contemporary academic, professional, and social environments require individuals to make informed decisions based on data. Students are expected not only to calculate statistical values but also to understand variation, evaluate evidence, interpret data representations, recognise uncertainty, and draw conclusions that are appropriate to the available evidence. Consequently, contemporary statistics education has increasingly shifted from an exclusive emphasis on procedural calculation towards developing students' capacity to reason with data and statistical information (Fielding et al., 2025).

Statistical reasoning refers to the process through which individuals use statistical concepts and principles to make sense of data, identify patterns, account for variability, interpret statistical information, and draw conclusions that are consistent with available evidence. It therefore differs from simply knowing statistical formulas or operating statistical software. A student may correctly calculate a mean, standard deviation, correlation coefficient, or regression coefficient but still demonstrate weak statistical reasoning if the student cannot explain what the statistic means, determine whether the statistical procedure was appropriate, or recognise the limitations of the resulting conclusion. Recent research has reinforced this distinction, with Sabbag et al. (2025) examining whether statistical literacy and statistical reasoning can be empirically distinguished. Their work highlights the importance of understanding statistical reasoning as a distinct but related dimension of statistical competence.

Statistical reasoning encompasses several interconnected abilities, including understanding statistical concepts, recognising variability, interpreting data representations, understanding sampling, reasoning about distributions, connecting samples with populations, understanding statistical inference, selecting appropriate statistical procedures, interpreting statistical outputs, and communicating evidence-based conclusions. Thus, statistical reasoning goes beyond answering the computational question, "*What is the mean?*", to addressing the more important question, "*What does the mean tell us about the data, and what conclusions can reasonably be drawn from it?*" Similarly, obtaining a correlation coefficient of $r = .45$ is a computational outcome, whereas statistical reasoning requires students to



understand that the coefficient represents an association, evaluate its magnitude in context, consider uncertainty, and avoid interpreting the association as evidence of causation (Sabbag et al., 2025).

An important component of statistical reasoning is the ability to recognise and interpret variability. Statistical data rarely produce identical observations, and understanding why observations differ is fundamental to statistical thinking and inference. Students may know how to calculate a standard deviation but fail to understand what the value represents or how variability affects the interpretation of statistical findings. Huynh et al. (2024), in a study of university students, found that a research-informed statistics course improved students' statistical reasoning, with notable improvement in their reasoning about variability. This finding suggests that appropriately designed instruction can improve students' conceptual understanding rather than merely their ability to perform statistical calculations.

Sampling and statistical inference also constitute important dimensions of statistical reasoning. Because researchers generally use samples to make inferences about populations, students need to understand the relationships among sample characteristics, population parameters, sampling variability, and uncertainty. Gok and Goldstone (2024), in their integrative review of students' reasoning about statistical sampling with computer simulations, reported continuing difficulties involving sampling distributions, the law of large numbers, statistical inference, and the transfer of statistical reasoning across contexts. These difficulties suggest that students may acquire procedural knowledge without developing a sufficiently deep understanding of the conceptual foundations of statistical inference.

Statistical reasoning is also demonstrated through the ability to interpret data and statistical representations. Students should be able to examine graphs, tables, distributions, and statistical outputs and explain what they mean within a particular research context. Fielding et al. (2025) emphasised the importance of developing students' reasoning with data through practices that involve engaging with, interrogating, and making sense of data. This perspective is particularly relevant in contemporary higher education, where students increasingly encounter complex datasets, digital visualisations, statistical dashboards, and computer-generated analytical outputs.

Another important aspect of statistical reasoning is statistical problem-solving. Students should be able to move from a research question to an appropriate statistical procedure rather than simply applying a formula provided by an instructor. Makwakwa et al. (2024) examined first-year undergraduate students' statistical problem-solving skills and demonstrated the importance of coordinating several statistical concepts when addressing problems involving probability, distributions, regression, and hypothesis testing. This suggests that assessments based exclusively on routine computational exercises may provide an incomplete picture of students' statistical reasoning abilities. Authentic assessment should instead require students to identify the appropriate procedure, justify their choice, analyse the data, interpret the output, and formulate a defensible conclusion.

Research-informed and active approaches to statistics education have also demonstrated potential for strengthening statistical reasoning. Huynh et al. (2024) reported

improvements in students' reasoning following a research-informed statistics course, while Alvarado Martínez et al. (2026) examined active methodologies for strengthening statistical reasoning among engineering students. Their findings suggest that research-oriented activities can encourage students to formulate questions, engage with data, and construct arguments based on statistical evidence. These approaches are important because statistical reasoning develops through opportunities to investigate authentic problems rather than through the memorisation of statistical rules alone.

Statistical reasoning is closely related to argumentation and justification. A student who states that "there is a significant difference" has provided a statistical statement, but a student demonstrating stronger reasoning should be able to explain the evidence supporting that conclusion, identify relevant assumptions, acknowledge uncertainty, and clarify what the evidence does and does not establish. Fielding (2025) highlighted the role of argumentation in statistical investigations and showed how students' engagement with data can contribute to a deeper understanding of statistical concepts, processes, and representations. Statistical reasoning therefore involves not only arriving at an answer but also providing a logical justification for that answer.

The emergence of artificial intelligence (AI) has introduced a new dimension to statistical reasoning. AI systems can now generate statistical code, recommend statistical procedures, interpret outputs, and produce research explanations. Wahba et al. (2024) reported that ChatGPT-supported statistics learning improved undergraduate students' statistical reasoning and attitudes towards statistics. However, the use of AI also raises concerns about whether students are developing independent reasoning or simply accepting machine-generated answers. DeLuca et al. (2025) argued for the importance of writing as a means of developing statistical reasoning in data science education, particularly in an environment where large language models can perform aspects of students' analytical work. Consequently, future statistics education should emphasise students' ability to verify, critique, and justify AI-generated statistical analyses rather than simply accepting them.

The literature also reveals that statistical reasoning is not necessarily equivalent to statistical literacy. Statistical literacy generally focuses on understanding and critically evaluating statistical information, whereas statistical reasoning concerns the use of statistical concepts to reason about data and statistical evidence. Sabbag et al. (2025) specifically investigated this distinction, demonstrating the importance of conceptual clarity when assessing students' statistical competencies. Treating statistical literacy, statistical reasoning, statistical thinking, and statistical competence as interchangeable may contribute to inconsistencies in research findings and measurement.

Several important research gaps emerge from the literature. First, there is a conceptual gap concerning the boundaries between statistical reasoning, statistical literacy, statistical thinking, and statistical competence. Although recent scholarship has begun examining these distinctions, greater theoretical integration is required (Sabbag et al., 2025). Second, a measurement gap remains because researchers use different instruments and tasks to assess statistical reasoning. The development of situated assessments, such as the instrument proposed by Gaviria-Bedoya et al. (2025) for postgraduate



health-sciences students, represents progress; however, comparable measures across disciplines and educational levels remain limited.

Third, there is an authentic-context gap. Many studies assess statistical reasoning using abstract statistical questions rather than authentic research problems. Consequently, more research is needed to determine whether students can transfer statistical reasoning from statistics courses to actual research projects, dissertations, and professional situations. Fourth, a software-versus-reasoning gap exists. The increasing use of SPSS, R, Stata, and other statistical packages makes computation easier, but software proficiency does not necessarily demonstrate an understanding of statistical assumptions, methodological appropriateness, or interpretation.

Fifth, an AI-versus-independent-reasoning gap is emerging. Although Wahba et al. (2024) demonstrated positive effects of ChatGPT-supported learning, limited evidence currently exists concerning whether AI-supported statistics education produces durable, independent statistical reasoning or merely improves students' ability to obtain correct statistical answers. Sixth, a sampling and inference gap remains because students continue to experience difficulties understanding sampling distributions, variability, and statistical inference even when simulation technologies are available (Gok & Goldstone, 2024).

Seventh, a longitudinal gap exists because many studies measure statistical reasoning at one point in time or immediately before and after an instructional intervention. There is insufficient evidence concerning whether improvements are retained and transferred to later research activities. Eighth, a geographical gap is evident. Although recent studies have examined statistical reasoning in several international contexts, evidence concerning university students in Nigeria remains limited. This creates an important opportunity to examine statistical reasoning among Nigerian university students, particularly those in education, social sciences, psychology, health sciences, and other disciplines that require quantitative research.

Finally, there is a disciplinary gap. Statistical reasoning may manifest differently depending on the context in which statistical information is used. For example, education students may reason about achievement data, psychology students about behavioural measures, health-science students about clinical evidence, and engineering students about production or quality data. Gaviria-Bedoya et al. (2025) demonstrated the value of situated assessment in postgraduate health sciences, suggesting that disciplinary context should receive greater attention in future research.

Overall, statistical reasoning should be understood as a higher-order research competency involving the ability to understand statistical concepts, recognise variability and uncertainty, interpret data, select appropriate statistical procedures, evaluate statistical evidence, justify conclusions, and communicate findings appropriately. Recent evidence indicates that statistical reasoning can be strengthened through research-informed instruction, active learning, authentic data, argumentation, simulation, and technology-supported learning (Huynh et al., 2024; Gok & Goldstone, 2024; Alvarado Martínez et al., 2026). Nevertheless, important gaps remain concerning measurement, authentic assessment, software use, AI-supported learning, longitudinal development, disciplinary

differences, and evidence from Nigerian universities. Addressing these gaps would strengthen understanding of how students develop the capacity not merely to calculate statistics but also to reason meaningfully and critically with statistical evidence.

Statistical thinking extends further to understanding variation, data-generation processes, and the broader investigative cycle. Statistical thinking refers to the ability to understand and apply statistical ideas throughout the research process rather than merely performing statistical calculations (Gao et al., 2025). It involves formulating statistical questions, identifying appropriate data, recognising variation and uncertainty, selecting suitable analytical methods, interpreting statistical results, and making evidence-based conclusions. Recent research shows that statistical thinking is increasingly linked to statistical literacy, statistical reasoning, data literacy, and statistical modelling, although these concepts are not always clearly distinguished (Friedrich et al., 2024; Oh et al., 2026).

Evidence suggests that students develop stronger statistical thinking when they engage with real-world data, statistical modelling, active learning, and authentic investigations rather than relying solely on formula-based instruction (Hasim et al., 2024). Real-world datasets expose students to variability, uncertainty, missing information, and unexpected patterns, requiring them to make genuine statistical decisions. Similarly, student-generated explanations can improve conceptual and procedural understanding by requiring learners to explain what statistical results mean rather than simply produce numerical answers (Gao et al., 2025).

However, important gaps remain. Existing research frequently measures students' statistical knowledge and procedural skills rather than their ability to apply statistical thinking to authentic research problems. There is also considerable overlap among statistical thinking, statistical reasoning, and statistical literacy, while available assessment instruments vary considerably (Friedrich et al., 2024; Oh et al., 2026). Furthermore, limited evidence exists on whether students can transfer statistical thinking learned in statistics courses to independent research activities. Evidence from Nigerian and other African higher-education contexts is also comparatively limited.

Therefore, future research should focus on authentic assessment of statistical thinking, examining whether students can formulate research questions, recognise variation, select appropriate statistical tools, interpret statistical outputs, and critically evaluate research conclusions. Such studies would help determine whether students merely know statistical procedures or can genuinely think statistically when conducting and interpreting research.

Despite growing evidence on statistical-thinking instruction, insufficient research has examined university students' ability to transfer statistical thinking from classroom statistics to authentic research contexts, particularly their ability to select appropriate statistical methods, interpret outputs, and critically evaluate evidence. This gap is especially evident in Nigerian higher education.

2.3. Statistical Tools and Research Competence

Statistical tools are procedures used to summarise, compare, model, and interpret quantitative data. Common



statistical tools used in educational and social-science research include:

- frequency distributions;
- percentages;
- means and standard deviations;
- correlation;
- regression;
- *t* tests;
- ANOVA;
- chi-square tests;
- non-parametric tests;
- effect-size measures;
- confidence intervals; and
- multivariate procedures.

The purpose of statistical literacy is not to encourage students to use more statistical procedures. Instead, students need to understand which procedure is appropriate for a particular research question and dataset. The statistical decision-making process can therefore be represented as:

Research question → Variables → Measurement → Assumptions → Statistical procedure → Statistical output → Interpretation → Conclusion

Failure at any stage can produce misleading research conclusions. A statistically literate researcher should therefore understand not only how to execute a statistical procedure but also why the procedure is appropriate, what assumptions it requires, how its results should be interpreted, and what conclusions can reasonably be drawn.

2. 4. Statistical Literacy in Understanding Research Reports

Statistical literacy is increasingly recognised as an essential component of students' ability to understand, evaluate, and communicate research findings. Within higher education, students regularly encounter research reports containing percentages, means, standard deviations, correlation coefficients, regression coefficients, *p*-values, confidence intervals, graphs, tables, and other statistical representations. Understanding such information requires more than computational proficiency; students must be able to interpret statistical results within their research context, evaluate the credibility of claims, recognise limitations, and determine whether conclusions are supported by the evidence. Gal (2002) conceptualised statistical literacy as the ability to interpret, critically evaluate, and communicate statistical information, emphasising that this competence draws on statistical, mathematical, contextual, literacy, and critical knowledge.

A review of the literature indicates that statistical literacy is particularly important for reading and interpreting research reports. A literature review by Gal and colleagues' scholarship, as synthesised in later reviews, shows that statistically literate individuals should be able to move beyond merely recognising statistical terminology to questioning how data were collected, what the statistics represent, and whether conclusions are justified. In the context of research reports, this means that students should be able to identify the research population and sample, understand how variables were measured, interpret statistical summaries, and evaluate whether the statistical evidence adequately supports the researchers' claims.

Systematic-review evidence demonstrates that this ability remains problematic among students. Castro Sotos et al. (2007), in a systematic review of empirical research on university students' misconceptions of statistical inference, found substantial evidence of difficulties in interpreting inferential statistical results. Their review identified 21 publications representing 17 studies that met their inclusion criteria. Importantly, the reviewed evidence showed that students could sometimes manipulate statistical information and perform calculations while simultaneously holding serious misconceptions about the interpretation of inferential results. This distinction is highly relevant to research-report comprehension because the ability to obtain a statistical result does not necessarily mean that a student understands what the result indicates.

The interpretation of statistical significance represents one important challenge. Students reading research reports need to understand what a *p*-value indicates and, equally importantly, what it does not indicate. Statistical literacy requires students to avoid interpreting statistical significance as proof that a research hypothesis is true or that an observed relationship is necessarily important in practical terms. Instead, students should consider the statistical result alongside the research design, sample, effect size, uncertainty, and substantive context. The systematic review by Castro Sotos et al. (2007) demonstrates that misconceptions surrounding statistical inference can substantially interfere with students' ability to interpret research findings accurately.

A second major component is the interpretation of graphs and tables. Research reports frequently communicate findings through bar charts, histograms, scatterplots, frequency distributions, tables, and other statistical representations. These representations require students to understand patterns, distributions, centre, variability, and relationships among variables. A systematic review of 86 publications on histogram interpretation found that students, teachers, and researchers frequently experience conceptual difficulties when interpreting graphical representations. The review identified recurring problems involving data characteristics and the interpretation of distributions, particularly shape, centre, and variability.

Statistical literacy also requires attention to sampling and representativeness when interpreting research reports. Research findings are often based on samples rather than entire populations. Therefore, students must understand that conclusions drawn from a sample may be affected by sampling variability, sampling error, and the characteristics of the sample. When reading a research report, a statistically literate student should therefore ask whether the sample is appropriate for the research question, whether it adequately represents the target population, and whether the researchers have made claims that extend beyond what the design and sample can reasonably support. Gal's conceptualisation of statistical literacy explicitly incorporates contextual and critical knowledge, which supports this evaluative dimension of research-report interpretation.

Another important dimension is the ability to connect statistical findings with research context. Statistical values have limited meaning when interpreted in isolation. For example, a correlation coefficient must be interpreted in relation to the variables examined, the direction and strength of the association, the research design, and the limitations of the



evidence. Similarly, a mean difference should be considered alongside the measurement scale, variability, sample characteristics, and substantive importance of the difference. Statistical literacy therefore involves integrating statistical information with contextual knowledge rather than treating statistical outputs as self-explanatory numbers.

Recent systematic scholarship further supports this multidimensional interpretation of statistical literacy. Komeijani et al. (2024), in their systematic review of statistical literacy, statistical reasoning, and statistical thinking, noted that these constructs are frequently discussed together but are not always clearly differentiated. The review highlights a continuing tendency to emphasise formulas and calculations at the expense of critical thinking and problem-solving. For students interpreting research reports, this distinction is particularly important because understanding a statistical procedure is not equivalent to understanding the evidence produced by that procedure. Similarly, Friedrich et al. (2024), in a systematic review of statistical and data literacy research in K–12 STEM education, reported considerable variation in how statistical and data literacy are conceptualised and measured. Many studies used related concepts such as statistical reasoning, statistical thinking, data exploration, statistical modelling, understanding variation, and informal inference. This conceptual diversity suggests that research on students' ability to understand research reports should clearly specify which aspects of statistical literacy are being assessed.

The literature further suggests that critical evaluation is central to statistical literacy. Understanding a research report does not simply involve reading the results section and repeating the reported findings. Students should be able to question the quality of the evidence, consider whether the statistical method is appropriate, identify possible sources of bias, distinguish association from causation, and assess whether the conclusions are consistent with the data. Koga (2024), in a review of trends and issues in statistical literacy research, similarly highlighted the importance of interpreting and evaluating statistical information and identified approaches involving media reports, questioning statistical information, discussion, multiple forms of knowledge, and activities designed to develop appropriate interpretation skills.

Research-report comprehension also depends on students' broader ability to understand scientific and academic texts. A systematic review and meta-analysis of reading comprehension in higher education found that university students generally performed better at literal comprehension than at inferential, critical, and organisational levels. The authors reported substantially lower proportions of students demonstrating optimal performance at the inferential and critical levels. Although this review was not specifically about statistical literacy, its findings are relevant because interpreting research reports requires students to integrate textual information with statistical evidence and make critical judgments about what the findings mean.

Overall, the systematic-review literature suggests that statistical literacy in understanding research reports is a multidimensional competence. It involves the ability to understand statistical terminology, interpret tables and graphs, understand descriptive and inferential statistics, evaluate sampling and uncertainty, distinguish statistical association from causation, integrate statistical findings with research

context, recognise limitations, and critically evaluate researchers' conclusions. The literature consistently indicates that computational competence alone is insufficient. Students may be able to calculate or identify statistical values while still experiencing substantial difficulties in interpreting what those values mean and determining whether conclusions are justified.

2.5. Systematic Review Evidence on Statistical Literacy

Recent systematic reviews demonstrate substantial growth in scholarly interest in statistical literacy. Rodliyah et al. (2025/2026) conducted a hybrid systematic literature review and bibliometric analysis of 89 articles published between 2002 and 2025. The review identified increasing research activity, particularly after 2017, and highlighted statistical literacy, statistics education, and data literacy as major themes. The review also identified increasing attention to digital learning, real-world data, interdisciplinary approaches, and the relationship among statistical thinking, statistical reasoning, and statistical literacy. These findings reinforce the argument that statistical literacy has developed into a multidisciplinary field. However, the diversity of definitions and measurement approaches continues to present a challenge for cumulative research. Oh et al. (2026) conducted a systematic review of statistical ability measures and identified 51 papers containing 25 unique measures. Approximately 60% of the measures assessed knowledge-based competencies. The review also examined reliability, validity, and relationships between statistical ability and cognitive and non-cognitive variables.

The diversity of measurement approaches has direct implications for systematic reviews. Statistical knowledge, statistical reasoning, statistical literacy, statistics attitudes, statistics anxiety, software competence, and research competence are related constructs, but they are not interchangeable. Consequently, future meta-analyses should synthesise conceptually comparable outcomes separately or employ multivariate or multilevel approaches where the available data and research questions justify such methods.

2.6. Nigerian Research Gap

The literature indicates that statistical literacy is an important component of research competence among university students because contemporary research requires students to understand, analyse, interpret, and communicate quantitative evidence. However, evidence from Nigeria suggests that important gaps remain in students' ability to move beyond the mechanical use of statistical procedures towards meaningful interpretation and critical evaluation of statistical information. Nigerian scholarship has identified weaknesses in statistical education, practical training, access to statistical software, and students' ability to apply statistical knowledge to authentic research problems.

One major gap concerns the limited practical orientation of statistical education in Nigerian higher institutions. Adelodun and Awe (2013) reported that statistics education in Nigeria continued to experience a substantial gap compared with more developed contexts. Their study highlighted problems in the development and appreciation of statistics education and called for greater attention to its role within Nigerian universities. More recent work similarly indicates that statistical education has often been dominated by theoretical or textbook-based instruction rather than authentic applications. A



chapter examining teaching and learning statistics in Nigeria reports that traditional approaches have contributed to weak practical engagement and argues for greater use of statistical computing and real-world datasets.

A related gap concerns students' ability to use statistical tools appropriately in research. Statistical literacy should not be equated with knowing how to operate software such as SPSS, R, or other statistical packages. Rather, students need to understand why a particular statistical procedure is appropriate, identify the assumptions underlying the procedure, correctly interpret the resulting output, and relate the findings to the research question. Evidence from the University of Ibadan's experience with interdisciplinary statistical training indicates that students have required additional practical exposure to statistical tools, statistical consulting, statistical communication, and software such as R beyond formal classroom instruction.

The Nigerian literature also reveals a conceptual and interpretive gap in students' understanding of statistical inference. Particularly important is the interpretation of p -values and statistical significance. Agbaegbu's study involving research students in tertiary institutions in Akwa Ibom State developed and validated an instrument for assessing students' reasoning about p -values and statistical significance. The study reported differences in performance among students with different levels of statistical competence and recommended greater emphasis on statistical literacy in introductory courses. This evidence suggests that students' ability to interpret inferential statistics cannot be assumed merely because they have been taught the relevant statistical procedures.

Another important gap is the measurement of statistical literacy itself. Ofem et al. (2022) developed, validated, and standardised instruments for measuring statistical literacy, statistical reasoning, and statistical anxiety among university undergraduates in Cross River State. Their study involved 753 students and demonstrated that statistical literacy was related to statistical reasoning but distinct from statistical anxiety. The development of such instruments represents progress; however, it also demonstrates that statistical literacy requires direct and multidimensional assessment rather than being inferred solely from students' examination scores or their ability to perform statistical calculations.

Recent Nigerian evidence further points to weaknesses in higher-order statistical skills. Ojini and Egbai (2026), in a study of postgraduate students at the University of Calabar, found that although many students understood basic statistical concepts such as the mean and median, a substantial number experienced difficulties with hypothesis testing, statistical software, and data interpretation. The authors identified inadequate teaching methods, limited practical exposure, and infrastructural challenges as important barriers. These findings are particularly relevant because postgraduate students are expected to use statistical tools independently in research rather than simply reproduce procedures learned in statistics courses.

There is also a research-application gap. Students may possess knowledge of individual statistical techniques without being able to select and apply the appropriate procedure to an actual research problem. Evidence from Nigerian statistical training initiatives suggests that students benefit from hands-on experiences involving statistical consulting, real datasets, statistical communication, and collaboration. The University of

Ibadan Laboratory for Interdisciplinary Statistical Analysis (UI-LISA), for example, was established partly to provide practical statistical experience that was not sufficiently available through conventional training. Its programmes include hands-on training, statistical consulting, statistical collaboration, and statistical communication.

The literature further indicates an infrastructure and technological gap. Access to computers, statistical software, reliable electricity, and internet facilities can influence students' opportunities to develop practical statistical competence. Okewole (2018), in discussing statistical education in Nigerian private universities, identified insufficient teaching aids, including computers, statistical software, electricity, electronic boards, and internet facilities, as challenges to statistical education. Such constraints may limit students' opportunities to practise analysing authentic datasets and interpreting computer-generated statistical outputs.

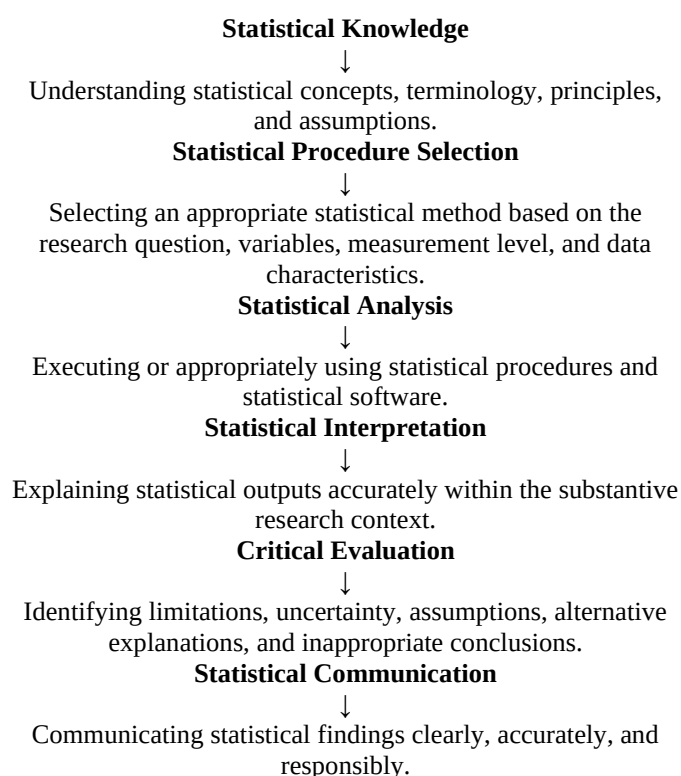
Another gap concerns the disconnect between statistical computation and statistical interpretation. Research statistics in Nigerian universities may still be approached as a set of procedures to be demonstrated in research-methodology courses. Abdurrazaq's discussion of research statistics in the Nigerian university system identifies challenges involving manual and electronic statistical demonstrations, data collection, empirical research, and the application of research statistics. This suggests that students may encounter statistics primarily as a technical requirement for completing research projects rather than as a means of reasoning about evidence.

A particularly important gap for the present systematic-review perspective is the limited evidence connecting statistical literacy directly to students' comprehension of complete research reports. Existing Nigerian studies tend to examine individual components, such as statistical skills, statistical anxiety, statistical significance, software use, or statistical education. There is comparatively less evidence examining whether students can read an entire empirical research report and integrate its statistical components—from the research question and sampling procedure to tables, graphs, inferential statistics, discussion, and conclusions. This distinction is important because understanding a research report requires students to connect statistical information with research design and context rather than interpret isolated numerical outputs.

There is also a contextual and geographical gap. Although Nigerian studies have examined statistical education and statistical literacy in particular institutions and states, the available evidence remains fragmented across different populations, disciplines, educational levels, and measures. For example, evidence is available from Cross River State, Akwa Ibom State, the University of Ibadan, and other institutional contexts, but these studies do not provide a comprehensive national picture of students' ability to understand, analyse, and interpret statistical information.

Conceptual Framework

Based on the reviewed literature, statistical literacy can be conceptualised as a multidimensional research competency comprising six interrelated components:



The framework can therefore be expressed as:

Statistical Knowledge → Method Selection → Analysis → Interpretation → Critical Evaluation → Communication

The development of these competencies may be influenced by contextual factors such as statistics anxiety, self-efficacy, previous mathematical experience, instructional approaches, academic discipline, educational level, access to statistical software, exposure to authentic data, and previous research experience. This framework distinguishes doing statistics from understanding statistics, which is essential when statistical literacy is examined as a component of research competence.

3. METHODOLOGY

3.1 Research Design

This study adopted a systematic literature review design to synthesise existing empirical and review evidence on statistical literacy and the use of statistical tools in research, with particular emphasis on students' ability to understand, analyse, interpret, evaluate, and communicate statistical information. A systematic review was considered appropriate because the literature on statistical literacy is conceptually diverse and includes studies examining statistical knowledge, statistical reasoning, statistical thinking, statistical anxiety, attitudes toward statistics, software use, and research competence. The review was structured to identify relevant studies systematically, assess their methodological characteristics, and synthesise their major findings. Rather than generating new primary data, the study relied exclusively on previously published scholarly evidence.

3.2 Review Questions

The systematic review was guided by the following questions:

1. How has statistical literacy been conceptualised in the existing literature?

2. What statistical competencies are most frequently examined among students?
3. What difficulties do students experience in understanding, analysing, and interpreting statistical information?
4. What statistical tools and procedures are most commonly addressed in statistics education and research training?
5. What instructional and technological approaches have been associated with improved statistical reasoning and statistical literacy?
6. What roles do statistics anxiety, attitudes, self-efficacy, and other affective factors play in students' statistical learning?
7. What measurement approaches have been used to assess statistical literacy and statistical ability?
8. What gaps remain in the literature, particularly concerning university students in Nigerian higher education?

3.3 Search Strategy

A systematic search of the scholarly literature was conducted using major academic databases and scholarly search platforms. The search focused on publications addressing statistical literacy, statistical reasoning, statistical thinking, statistics education, statistical ability, statistical interpretation, statistical anxiety, statistical software, and students' use of statistical information. The search terms were combined using Boolean operators. Examples included:

"statistical literacy" AND students
"statistical reasoning" AND university students
"statistical thinking" AND higher education
"statistical ability" AND students
"statistics education" AND interpretation
"statistical literacy" AND statistical software
"statistics anxiety" AND university students
"statistical tools" AND research competence
"statistical interpretation" AND students

Additional studies were identified by examining the reference lists of relevant systematic reviews. Particular attention was given to recent systematic reviews studies because they provide synthesised evidence across multiple primary studies.

3.4 Eligibility Criteria

Studies were considered eligible when they met the following criteria:

- examined statistical literacy, statistical reasoning, statistical thinking, statistical ability, or closely related statistical competencies;
- focused on students, learners, university students, prospective teachers, or other educational populations relevant to statistics learning;
- examined students' understanding, analysis, interpretation, evaluation, or application of statistical information;
- addressed statistics education, statistical tools, statistical software, statistical inference, or related competencies;
- were published as peer-reviewed scholarly articles or systematic reviews/meta-analyses;



- provided sufficient information concerning the purpose, population, methods, or findings of the study; and
- were available in a form that permitted examination of the relevant findings.

Studies were excluded when they were unrelated to statistical literacy or statistical competence, focused exclusively on professional statisticians without an educational component, consisted only of opinion or non-scholarly commentary, or did not provide sufficient information relevant to the review questions.

3.5 Study Selection

The identified records were screened in stages. First, titles and abstracts were examined to determine their relevance to the review objectives. Potentially relevant studies were subsequently examined in greater detail against the eligibility criteria. Studies that did not address the central concepts of statistical literacy, statistical reasoning, statistical thinking, statistical ability, statistics education, or students' interpretation of statistical information were excluded. Particular care was taken to avoid treating related but conceptually different constructs as identical. Studies examining statistics anxiety, attitudes toward statistics, software competence, and statistical achievement were therefore considered as related evidence rather than automatically classified as direct measures of statistical literacy.

3.6 Data Extraction

Information extracted from the eligible literature included:

- author(s) and publication year;
- educational context;
- geographical location;
- participant characteristics;
- sample size where reported;
- conceptualisation of statistical literacy or related competence;
- statistical competencies assessed;
- statistical tools or procedures examined;
- measurement instruments;
- instructional approaches;
- use of statistical software or technology;
- statistics anxiety and attitudinal factors;
- principal findings; and
- limitations and research gaps identified by the authors.

The extracted information was organised thematically to facilitate comparison across studies.

3.7 Quality and Methodological Considerations

The methodological quality of the reviewed evidence was considered in relation to the design, sample, measurement procedures, analytical approach, and clarity of reporting. Greater interpretive weight was given to systematic reviews and empirical studies with clearly described methods and validated or adequately documented measurement procedures. The review also considered methodological heterogeneity. This was particularly important because the literature uses different definitions and instruments to measure statistical literacy, statistical reasoning, statistical thinking, statistical knowledge, and statistical ability. Consequently, findings were not treated

as directly comparable when the underlying constructs or outcome measures differed substantially.

3.8 Synthesis Approach

Because the reviewed literature was conceptually and methodologically heterogeneous, the principal synthesis approach was narrative and thematic synthesis. Evidence was organised around the major dimensions emerging from the literature:

1. conceptualisation of statistical literacy;
2. statistical knowledge and reasoning;
3. statistical thinking;
4. selection and use of statistical tools;
5. interpretation of statistical outputs;
6. statistical inference and misconceptions;
7. statistical anxiety and attitudes;
8. statistical software and technology;
9. measurement of statistical ability;
10. instructional approaches; and
11. geographical and contextual research gaps.

Existing meta-analyses were incorporated as secondary quantitative evidence rather than re-analysed as though they represented new primary datasets.

4. RESULTS OF THE SYSTEMATIC REVIEW

4.1 Overview of the Reviewed Evidence

The synthesis of the reviewed literature indicates that statistical literacy has developed into a multidimensional area of research encompassing statistical knowledge, statistical reasoning, statistical thinking, statistical interpretation, statistical problem-solving, statistical software competence, and affective factors associated with statistics learning. The evidence consistently indicates that statistical literacy extends beyond the ability to perform calculations and includes students' capacity to understand statistical concepts, select appropriate analytical procedures, interpret statistical outputs, evaluate evidence, and communicate conclusions appropriately.

The reviewed studies also demonstrate substantial variation in how statistical literacy and related competencies are conceptualised and measured. Komeijani et al. (2024) noted that statistical literacy, statistical reasoning, and statistical thinking are frequently discussed together despite important conceptual differences. Similarly, Friedrich et al. (2024) identified considerable variation in the metrics and instructional approaches used to examine statistical and data literacy. This methodological and conceptual diversity limits direct comparison across studies and indicates that statistical literacy should not be treated as a single, uniformly measured construct.

4.2 Students' Understanding of Statistical Information

The reviewed evidence suggests that students generally demonstrate stronger performance in basic statistical knowledge and computational procedures than in higher-order interpretation and evaluation. Students may understand basic statistical concepts and calculate statistical quantities but still experience difficulties explaining the meaning of statistical results within a research context. This pattern is particularly evident in inferential statistics. Castro Sotos et al. (2007), in their systematic review of university students' misconceptions



of statistical inference, identified 21 publications representing 17 studies and found substantial evidence of students' difficulties in understanding inferential statistical results. Importantly, students could sometimes manipulate statistical information and perform calculations while simultaneously holding misconceptions about what those calculations meant.

The evidence therefore suggests a distinction between procedural understanding and conceptual understanding. Knowing how to calculate a statistical value does not necessarily demonstrate an understanding of the statistical concept underlying the calculation. This finding is consistent with the broader systematic-review evidence showing that statistics education has often emphasised formulas and computational procedures at the expense of interpretation, critical thinking, and problem-solving.

4.3 Students' Ability to Analyse Statistical Information

The review indicates that students' ability to analyse statistical information involves more than operating statistical software or applying statistical formulas. Statistical analysis requires students to connect the research question with the variables, measurement characteristics, assumptions, statistical procedure, statistical output, and eventual conclusion. The review therefore conceptualises the analytical process as:

Research question → Variables → Measurement → Assumptions → Statistical procedure → Statistical output → Interpretation → Conclusion.

Evidence from the reviewed literature indicates that students may possess knowledge of individual statistical techniques without being able to determine which technique is appropriate for a particular research problem. Makwakwa et al. (2024), for example, demonstrated the importance of coordinating several statistical concepts when students address problems involving probability, distributions, regression, and hypothesis testing. This finding suggests that routine computational exercises may provide an incomplete assessment of students' actual statistical-analysis competence.

The Nigerian evidence reinforces this finding. Ojini and Egbai (2026) reported that although many postgraduate students understood basic concepts such as the mean and median, substantial difficulties remained in hypothesis testing, statistical software, and data interpretation. The difficulties were associated with inadequate teaching approaches, limited practical exposure, and infrastructural constraints.

4.4 Students' Ability to Interpret Statistical Outputs

Interpretation emerged as one of the most important weaknesses identified across the reviewed evidence. Students may successfully obtain statistical outputs but experience difficulty explaining their meaning in relation to the research problem. The difficulty is particularly evident when students interpret inferential statistics. The literature indicates persistent misconceptions concerning *p*-values, statistical significance, confidence intervals, and hypothesis testing. Students may interpret statistical significance as proof that a hypothesis is true or assume that a statistically significant result necessarily represents an important practical effect. The review therefore indicates that statistical literacy requires students to interpret statistical findings alongside the research design, sample, effect size, uncertainty, and substantive context.

The same problem occurs in interpreting relationships between variables. A statistically literate student should understand that a correlation coefficient represents an association and should consider its direction, strength, context, and research design. Statistical literacy also requires students to avoid drawing causal conclusions from correlational evidence when the research design does not support such conclusions.

4.5 Interpretation of Tables, Graphs, and Other Statistical Representations

The review identified the interpretation of tables and graphical representations as another important component of statistical literacy. Research reports frequently communicate findings through tables, bar charts, histograms, scatterplots, distributions, and other visual representations. Understanding these representations requires students to recognise patterns, centre, variability, distribution, and relationships among variables. The evidence reviewed indicates that difficulties in graphical interpretation are not restricted to students. A systematic review of 86 publications concerning histogram interpretation found recurring conceptual difficulties involving data characteristics and the interpretation of distributions, particularly shape, centre, and variability.

These findings suggest that statistics instruction should assess whether students can **extract** meaning from statistical representations, rather than merely reproduce or construct graphs. In the context of research reports, students need to connect information presented in tables and figures with the accompanying methodological and textual explanations.

4.6 Statistical Inference, Uncertainty, and Critical Evaluation

The review identified statistical inference as a major area of difficulty. Students need to understand sampling, variability, uncertainty, statistical significance, and the limitations associated with drawing conclusions from samples. However, evidence indicates continuing difficulties in understanding sampling distributions, the law of large numbers, variability, and statistical inference. Gok and Goldstone (2024) reported such difficulties even in contexts where computer simulations were available. Critical evaluation represents a further level of statistical literacy. Students should not simply accept the statistical conclusions presented in research reports. They should examine whether the statistical method was appropriate, consider possible sources of bias, evaluate the adequacy of the sample, identify assumptions and limitations, distinguish association from causation, and determine whether the conclusions are consistent with the available evidence. Koga (2024) similarly emphasised interpretation and evaluation as central components of statistical literacy.

4.7 Use of Statistical Tools and Software

The reviewed evidence demonstrates that statistical tools constitute an important part of students' research competence. Commonly addressed procedures include frequencies and percentages, means and standard deviations, correlation, regression, *t*-tests, ANOVA, chi-square tests, non-parametric procedures, effect sizes, confidence intervals, and multivariate methods.

However, the review shows that software competence should not be equated with statistical literacy. Students may be



able to operate SPSS, R, Stata, or related statistical packages without understanding why a particular procedure is appropriate, what assumptions it requires, or how the resulting output should be interpreted. The evidence from the University of Ibadan's interdisciplinary statistical training experience indicates the importance of additional practical exposure to statistical tools, statistical consulting, statistical communication, and software such as R. The findings therefore indicate a distinction between doing statistics with software and understanding the statistics produced by the software. Effective statistical literacy requires students to make informed analytical decisions before, during, and after software use.

4.8 Statistical Problem-Solving and Research Application

The review found that students' statistical competence is strengthened when statistical learning is connected to authentic research problems. Research-oriented and active-learning approaches provide opportunities for students to formulate questions, engage with data, select appropriate methods, interpret findings, and construct evidence-based arguments. Huynh et al. (2024) reported improvements in statistical reasoning following a research-informed statistics course, while Alvarado Martínez et al. (2026) examined active methodologies for strengthening statistical reasoning among engineering students. These findings suggest that students benefit from learning environments that require them to apply statistical ideas to problems rather than merely memorise statistical procedures.

Nevertheless, the review identified an important research-application gap. Students may know individual statistical techniques without being able to select and apply the appropriate procedure to an authentic research problem. Nigerian evidence similarly indicates the need for greater practical exposure to real datasets, statistical consulting, collaboration, and statistical communication.

4.9 Statistical Literacy in Understanding Research Reports

A major finding of the review is that statistical literacy should be understood as an integrated research-report comprehension skill. Research reports require students to connect the research question, population, sample, variables, measurement procedures, statistical methods, tables, graphs, statistical outputs, discussion, and conclusions. The evidence indicates that students' ability to calculate statistical values does not necessarily translate into an ability to understand research findings. Statistical literacy requires students to determine whether the selected method is appropriate, interpret the statistical output accurately, evaluate the strength of the evidence, recognise limitations, and determine whether the researchers' conclusions are justified.

The review further indicates that critical and inferential comprehension presents greater challenges than simple recognition or literal understanding. This is particularly relevant because research-report comprehension requires students to integrate statistical evidence with written explanations and methodological information.

4.10 Affective Factors: Statistics Anxiety and Self-Efficacy

The reviewed evidence indicates that students' statistical learning is also influenced by affective factors. Ofem et al. (2022) developed and standardised measures of statistical

literacy, statistical reasoning, and statistical anxiety among 753 university undergraduates in Cross River State. Their findings indicated that statistical literacy was related to statistical reasoning but was distinct from statistical anxiety. This evidence suggests that statistical anxiety should not be treated as synonymous with low statistical literacy. Rather, affective factors may influence students' willingness to engage with statistical tasks, confidence in analysing data, and persistence when encountering difficult statistical concepts. The review consequently identifies statistics anxiety and self-efficacy as important contextual variables that warrant consideration in statistics education.

4.11 Instructional Approaches Associated with Statistical Development

The reviewed evidence indicates a general movement away from purely computational approaches towards research-informed, active, contextualised, and authentic statistics education. Students appear to benefit from opportunities to work with real-world datasets, engage in statistical investigations, explain their reasoning, and use technology to explore statistical concepts.

Real-world data are particularly valuable because they expose students to variability, uncertainty, missing information, unusual observations, and unexpected patterns. Such characteristics require students to make genuine statistical decisions rather than simply follow predetermined procedures. The evidence also indicates growing interest in technology-supported learning. Wahba et al. (2024) reported improvements in undergraduate students' statistical reasoning and attitudes following ChatGPT-supported statistics learning. However, the review identifies an emerging concern regarding whether technology and AI enhance independent statistical reasoning or simply make it easier for students to obtain statistical answers.

4.12 Measurement of Statistical Literacy

Measurement represents one of the clearest areas of methodological variation identified by the review. Oh et al. (2026) identified 51 papers containing 25 unique measures of statistical ability, with approximately 60% of the measures focusing on knowledge-based competencies. This finding demonstrates that statistical ability is assessed through diverse instruments and that many existing measures emphasise knowledge rather than students' ability to apply statistical understanding in authentic situations. Consequently, comparisons across studies should be undertaken cautiously because different instruments may measure different aspects of statistical competence. The Nigerian evidence provides a similar illustration. Ofem et al. (2022) developed measures specifically addressing statistical literacy, statistical reasoning, and statistical anxiety, demonstrating the feasibility of multidimensional assessment. However, the review indicates that further work is needed to establish broader, context-sensitive measures that directly assess students' ability to interpret and evaluate statistical information in research contexts.

4.13 Findings from the Nigerian Evidence

The Nigerian evidence reveals several consistent patterns. First, statistics education appears to have a limited practical orientation, with evidence pointing to an emphasis on



theoretical or textbook-based learning rather than authentic statistical applications. Adelodun and Awe (2013) highlighted continuing challenges in the development and appreciation of statistics education in Nigeria, while subsequent evidence has called for greater use of statistical computing and real-world datasets. Second, Nigerian students experience difficulties with higher-order statistical competencies. Although basic statistical concepts may be understood, difficulties remain in hypothesis testing, software use, and interpretation of statistical results. Third, the evidence indicates an infrastructure and technology constraint. Limited access to computers, statistical software, electricity, electronic teaching facilities, and internet resources may restrict students' opportunities to practice statistical analysis using authentic datasets. Fourth, the Nigerian evidence suggests a persistent disconnect between statistical computation and interpretation. Statistics may be encountered primarily as a technical requirement for completing research projects rather than as a means of reasoning about evidence. Most importantly, the review identified limited Nigerian evidence directly examining students' ability to understand complete research reports. Existing studies tend to focus on individual elements such as statistical skills, statistical anxiety, statistical significance, software use, or statistics education. Comparatively little evidence examines whether students can integrate the statistical components of a complete empirical report, from the research question and sampling procedure through statistical analysis, interpretation, discussion, and conclusions.

4.15 Summary of the Principal Findings

The principal findings of the systematic review can therefore be summarised as follows:

Theme	Finding from the reviewed evidence
Statistical knowledge	Students demonstrate greater competence in basic statistical concepts and computational procedures than in higher-order statistical interpretation.
Statistical analysis	Students may know individual procedures but experience difficulty selecting appropriate methods for particular research questions.
Statistical interpretation	Difficulties are particularly evident in interpreting <i>p</i> -values, statistical significance, hypothesis tests, relationships, and statistical outputs.
Tables and graphs	Students may experience difficulties interpreting distributions, variability, graphical patterns, and statistical representations.
Statistical inference	Persistent problems occur in understanding sampling, variability, uncertainty, and inferential conclusions.
Critical evaluation	Students need stronger capacity to evaluate assumptions, limitations, bias, causality, and the adequacy of research conclusions.
Statistical software	Software improves computational efficiency but does not necessarily produce statistical literacy or sound statistical reasoning.
Research application	Authentic datasets, research-oriented activities, active learning, and statistical communication provide stronger opportunities for developing statistical reasoning.
Affective factors	Statistics anxiety and self-efficacy are relevant to students' engagement with statistical learning but should be distinguished from statistical literacy itself.
Measurement	Existing measures vary considerably, with many focusing on knowledge rather than authentic interpretation and application.
Nigerian context	Evidence indicates limited practical training, infrastructural constraints, difficulties with higher-order statistical skills, and insufficient research-report comprehension.
Major research gap	Limited evidence directly examines Nigerian university students' ability to integrate statistical information across complete empirical research reports.

In summary, the results show that the central challenge is not simply students' ability to calculate statistical values or operate statistical software, but their ability to transform

4.14 Overall Synthesis of the Results

Overall, the systematic review demonstrates that students' statistical competence is uneven across cognitive levels. The strongest evidence concerns students' exposure to and ability to perform basic statistical procedures, while greater difficulties emerge when students are required to select appropriate statistical methods, interpret statistical outputs, evaluate uncertainty, critique research evidence, and connect statistical findings to substantive research questions. The results further demonstrate that statistical literacy is best understood as a progression from statistical knowledge to method selection, analysis, interpretation, critical evaluation, and communication. This framework distinguishes the ability to *do* statistics from the ability to *understand and reason with* statistical evidence. The evidence also reveals substantial conceptual and methodological heterogeneity across the literature. Statistical literacy, statistical reasoning, statistical thinking, statistical knowledge, statistics anxiety, attitudes towards statistics, software competence, and research competence are related but distinct constructs. The diversity of definitions and measurement approaches therefore represents a significant challenge for evidence synthesis.

Finally, the Nigerian evidence remains comparatively fragmented across institutions, states, educational levels, disciplines, and measurement approaches. Studies from Cross River State, Akwa Ibom State, the University of Ibadan, and other Nigerian contexts provide valuable evidence, but they do not yet establish a comprehensive national picture of students' statistical literacy.

statistical outputs into meaningful, contextually appropriate, and critically evaluated research evidence. The Nigerian evidence is consistent with this broader pattern, but remains



insufficiently comprehensive to establish a national picture. This provides a strong justification for further research examining students' ability to understand, analyse, interpret, evaluate, and communicate statistical information in authentic research contexts within Nigerian higher institutions.

The systematic review indicates that statistical literacy has developed from a relatively narrow emphasis on computational proficiency toward a broader conception involving understanding, reasoning, interpretation, evaluation, decision-making, and communication. The reviewed literature consistently suggests that students may demonstrate procedural competence without necessarily demonstrating the ability to interpret statistical evidence appropriately.

The evidence also reveals substantial conceptual and methodological diversity. Researchers have used terms such as *statistical literacy*, *statistical reasoning*, *statistical thinking*, *statistical competence*, *statistical ability*, and *data literacy*. Although these constructs overlap, the reviewed studies indicate that they should not automatically be treated as synonymous.

5. IMPLICATIONS FOR STATISTICS EDUCATION

The reviewed evidence has several implications for statistics education, particularly regarding how students are taught to understand, analyse, interpret, and communicate statistical information in academic and research contexts.

1. Statistics instruction should move beyond formula memorisation and computational exercises towards conceptual understanding and authentic statistical inquiry

The reviewed evidence suggests that statistics education should not be centred primarily on memorising formulas, following predetermined computational procedures, or obtaining correct numerical answers. Although computational competence remains important, students need to understand the meaning, purpose, and appropriate application of the statistical procedures they use. A student who can calculate a mean, standard deviation, correlation coefficient, or regression coefficient may still have limited statistical literacy if they cannot explain the result or determine whether the procedure is appropriate for the research question. Consequently, statistics instruction should emphasise conceptual understanding, reasoning, problem-solving, and statistical inquiry. Students should be encouraged to begin with a research question, identify the type of data required, consider appropriate methods of analysis, conduct the analysis, interpret the findings, and evaluate the conclusions. Such an approach would help students understand statistics as a tool for answering research questions rather than as a collection of mathematical formulas. Authentic statistical inquiry can also provide opportunities for students to encounter the uncertainty, variability, and complexity that characterise real research data.

2. Students should regularly work with real-world datasets containing variability, uncertainty, missing information, and potentially conflicting patterns

The evidence indicates that students need regular exposure to authentic datasets rather than relying exclusively on simplified textbook examples. Real-world data often contain variability, missing observations, unusual values, measurement problems, and patterns that are not immediately obvious.

Working with such data can help students develop the capacity to make statistical decisions and recognise that statistical analysis rarely produces perfectly straightforward answers. Using real-world datasets can also strengthen students' understanding of uncertainty. Rather than presenting statistical analysis as a process that always produces a single unquestionable answer, lecturers can encourage students to consider alternative explanations, limitations of the data, sampling variability, and the uncertainty surrounding statistical estimates. This approach can help students develop more realistic expectations about research and improve their ability to critically evaluate statistical information presented in research reports.

3. Published research reports should be incorporated into statistics instruction so that students learn to interpret statistical findings within their methodological context

The reviewed evidence suggests that statistics education should be connected more directly to published research. Students frequently encounter statistical information through empirical articles, dissertations, theses, reports, and other academic publications. Therefore, learning how to interpret statistical results should not be separated from learning how those results are presented in actual research. Lecturers can use published research reports as instructional materials and ask students to examine the research questions, sampling procedures, variables, statistical methods, tables, graphs, results, and conclusions. Students can then assess whether the statistical procedures correspond to the research questions and whether the conclusions are supported by the evidence. This approach can strengthen students' ability to integrate statistical information with methodological and contextual information. It is particularly important for higher education because students are expected to read research literature and conduct their own empirical studies.

4. Students should be required to explain statistical outputs using ordinary language rather than merely reproducing statistical terminology

Statistical literacy involves the ability to communicate statistical meaning, not simply the ability to reproduce technical terminology. Students may be able to report that a result is "statistically significant" or that there is a "positive correlation" without actually understanding what those statements mean in the context of the study. Statistics instruction should therefore require students to explain statistical results in clear, ordinary language. For example, after interpreting a correlation coefficient, students could be asked to explain the direction and strength of the relationship and what the finding means for the variables under investigation. Similarly, after interpreting a regression result, students should explain the meaning of the coefficient within the research context rather than merely reporting the coefficient and its *p*-value. This practice can help lecturers identify whether students genuinely understand statistical outputs. It can also improve students' ability to communicate research findings to readers who may not have advanced statistical knowledge. In this respect, writing and oral explanation should form an integral part of statistics education rather than being treated as activities separate from statistical analysis.

5. Statistical software should be taught alongside statistical reasoning rather than as a substitute for it



The growing use of statistical software has made data analysis faster and more accessible. However, the ability to operate statistical software does not necessarily demonstrate statistical literacy. Software can calculate statistical tests, generate tables and graphs, and produce sophisticated outputs, but it cannot replace the researcher's responsibility to determine whether an analysis is appropriate or whether its findings are meaningful. Statistics education should therefore integrate software training with statistical reasoning. Students should first understand the research question, nature of the data, assumptions of the statistical procedure, and rationale for selecting a particular method. They should then use software to conduct the analysis and interpret the resulting output. This approach would help students understand software as a tool that supports statistical reasoning rather than as an automated substitute for it. Students should also be encouraged to critically examine computer-generated outputs. For example, they should be able to identify whether the appropriate variables were entered, whether the assumptions of the analysis were considered, and whether the resulting statistics have been interpreted correctly. Such training is increasingly important as students gain access to more automated statistical and analytical technologies.

6. Lecturers should explicitly address persistent misconceptions involving statistical significance, correlation, regression, confidence intervals, probability, and causal inference

The reviewed evidence indicates that misconceptions can persist even after students have received formal instruction in statistics. This suggests that simply presenting statistical concepts and procedures may not be sufficient to develop genuine understanding. Lecturers should therefore identify common misconceptions and address them explicitly during instruction. For example, students should understand that statistical significance does not automatically imply practical importance and that a p -value does not represent the probability that a research hypothesis is true. Similarly, students should understand that correlation indicates an association between variables and does not, by itself, establish causation. Confidence intervals should be interpreted as measures of uncertainty surrounding estimates rather than as simple statements about the probability that an individual parameter lies within a particular interval. Regression analysis should likewise be taught as a method for modelling relationships and making appropriate statistical inferences rather than simply as a procedure for obtaining coefficients. Probability should be connected to uncertainty and evidence rather than treated solely as a mathematical calculation. Explicitly confronting these misconceptions can help students develop more accurate interpretations of statistical information and reduce errors when reading or conducting research.

7. Affective factors such as statistics anxiety and self-efficacy should be considered when designing statistics-learning environments

The reviewed evidence also indicates that statistical learning is influenced by affective factors, including statistics anxiety and students' confidence in their ability to learn and apply statistical concepts. Students who experience high levels of anxiety may avoid statistical tasks, lack confidence when interpreting statistical results, or become overly dependent on software and other forms of assistance. Statistics education

should therefore provide supportive learning environments in which students have opportunities to practise statistical skills progressively and receive constructive feedback. Lecturers can reduce unnecessary anxiety by connecting statistical concepts to familiar research problems and real-world situations rather than presenting statistics exclusively through abstract mathematical procedures. Developing students' statistical self-efficacy is equally important. Students should be given opportunities to solve problems independently, explain their reasoning, interpret outputs, and communicate conclusions. Successful experiences with authentic statistical tasks can strengthen confidence and encourage students to engage more actively with statistical analysis. However, confidence should be developed alongside competence so that students become both willing and able to evaluate statistical evidence critically.

Taken together, these implications suggest that statistics education should undergo a shift from procedural and calculation-oriented instruction towards conceptual, contextual, inquiry-based, and research-oriented learning. Students need opportunities to work with authentic data, interpret published research, use statistical software critically, explain statistical findings in accessible language, identify misconceptions, and develop confidence in applying statistical reasoning. Such an approach would better prepare students to understand, analyse, interpret, and communicate statistical information in their academic research and future professional contexts.

6. SUGGESTIONS FOR FUTURE RESEARCH

Future studies should:

1. develop multidimensional measures of statistical literacy;
2. clearly distinguish statistical literacy from statistical reasoning and statistical thinking;
3. assess demonstrated interpretation rather than relying primarily on self-reported competence;
4. examine students' ability to select appropriate statistical tools;
5. investigate the relationship between software proficiency and statistical reasoning;
6. conduct longitudinal studies of statistical-literacy development;
7. employ authentic research tasks and datasets;
8. investigate the roles of statistics anxiety and self-efficacy;
9. increase representation of African and Nigerian university students;
10. conduct rigorous experimental and quasi-experimental intervention studies;
11. report sufficient statistical information to facilitate future quantitative synthesis; and
12. use comparable outcome measures and effect-size metrics where scientifically appropriate.

7. CONCLUSION

Statistical literacy has become an increasingly important component of higher education and research competence because students are expected to consume, produce, interpret, and critically evaluate quantitative information. The reviewed evidence demonstrates that statistical literacy extends



substantially beyond computational proficiency. It encompasses conceptual knowledge, statistical reasoning, appropriate selection of analytical procedures, interpretation of statistical outputs, critical evaluation of evidence, and effective communication of conclusions.

Systematic reviews and meta-analyses demonstrate substantial growth in statistical literacy research but also reveal considerable diversity in definitions, measurement approaches, instructional strategies, and educational contexts. This diversity presents a challenge for cumulative evidence synthesis because statistical knowledge, statistical reasoning, statistical thinking, statistics anxiety, attitudes toward statistics, software competence, and research competence represent related but distinct constructs.

The central conclusion is that statistical literacy should not be equated with the ability to operate statistical software or calculate statistical values. A student who can generate an ANOVA table but cannot explain its meaning demonstrates procedural competence without necessarily demonstrating statistical literacy. Similarly, recognising that a result is statistically significant does not demonstrate full statistical competence if the student cannot distinguish statistical significance from practical importance or understand the limitations imposed by the research design.

The literature therefore reveals a substantial research agenda involving conceptual clarity, measurement, authentic assessment, statistical-tool selection, technology-supported learning, longitudinal development, and research interpretation. Evidence from African and particularly Nigerian higher education remains comparatively limited, creating an important contextual opportunity for future empirical investigation. Future research should therefore examine whether students can transfer statistical knowledge and software skills into authentic research situations requiring them to select, interpret, evaluate, and communicate statistical evidence appropriately.

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