Senior High School Students' Statistical Discourse in Interpreting JAMOVI-Generated Outputs: A Commognitive Case Study

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ABSTRACT

Statistical software can broaden students' access to data analysis while also shaping what they notice, say, and treat as evidence. This qualitative case study examined how Senior High School students constructed statistical meaning while interpreting outputs generated in JAMOVI. Guided by Sfard's commognitive theory, the analysis focused on four features of discourse: word use, visual mediators, narratives, and routines. Three purposively selected student groups completed four structured tasks involving descriptive statistics, histograms and boxplots, correlation, and a paired-samples t test. The data corpus comprised completed worksheets, audio-recorded group discussions, and the corresponding JAMOVI outputs. Data were coded iteratively in NVivo and analyzed through commognitive discourse analysis. The students used increasingly formal terms—including mean, standard deviation, correlation coefficient, and p-value—but their explanations remained predominantly procedural. Across tasks, JAMOVI outputs frequently operated as epistemic anchors: students read values directly from tables or graphs, named the statistic, and moved quickly to a conclusion. Visual mediators supported participation but also encouraged surface-level interpretations based on salience, shape, or threshold rules. Four recurring explanatory patterns were identified: procedural repetition, definition-by-repetition, negotiated meaning, and value-based interpretation. Reasoning routines were stable, typically following a read–name–interpret–conclude sequence. The findings suggest an emerging but incomplete shift from ritualized toward exploratory statistical discourse. Because the study involved three groups in one bounded context and did not compare JAMOVI with another platform, the findings are analytically transferable rather than statistically generalizable and cannot isolate software effects from conceptual difficulty. The study highlights the need for teacher-led prompts that position software outputs as objects for explanation, comparison, and critique rather than as final answers.

Keywords: commognition, JAMOVI, statistical discourse, statistical reasoning, technology-mediated learning

INTRODUCTION

Statistical literacy has become increasingly important for meaningful participation in data-rich educational, professional, and civic environments. At the secondary level, this demand has shifted the emphasis of statistics education from the mechanical production of numerical results toward the interpretation, comparison, evaluation, and communication of evidence. Contemporary reforms increasingly promote sense-making with data, particularly in technology-supported classrooms where statistical software provides rapid access to numerical summaries, graphical representations, and inferential results (Borba et al., 2022; Engel & Ridgway, 2023). However, the availability of software-generated outputs does not necessarily ensure that learners understand what those outputs represent, how different statistical measures relate to one another, or how conclusions should be justified conceptually (Garfield & Ben-Zvi, 2021).

Technology should not be regarded as a neutral delivery channel in mathematics and statistics education. Digital interfaces organize learners' attention by foregrounding particular values, representations, and decision rules while potentially backgrounding other conceptually important features. Software-generated tables, graphs, and statistical summaries can therefore influence what students notice, how they describe patterns, and which forms of justification they regard as legitimate (Drijvers et al., 2021; Engel & Ridgway, 2023; Greefrath et al., 2025). Although digital tools can make movement between data, representations, and conclusions more efficient, conceptual development still depends on how learners interpret, discuss, and coordinate the representations produced. Research also indicates that the format and structure of digital tasks can shape students' strategies and responses, even when the underlying mathematical content remains comparable (Kinnear et al., 2025). These findings make students' discourse surrounding software-generated outputs an important object of investigation.

The present study adopts a commognitive perspective, which conceptualizes thinking as a form of communication and learning as a change in discourse (Sfard, 2008). From this perspective, statistical understanding becomes visible through four interrelated features: the words students use, the visual mediators to which they attend, the narratives they construct or endorse, and the routines they repeatedly enact. A learner who describes the mean only as the result of adding all observations and dividing by their number participates in statistical discourse differently from a learner who coordinates the mean, variability, and distributional shape to justify a comparison. The difference is not simply a matter of vocabulary or procedural accuracy; it concerns how statistical objects are constructed, interpreted, and used within discourse. Participation, positioning, and communicative norms are therefore central to understanding conceptual development in mathematics classrooms (Herbel-Eisenmann et al., 2022; Macchioni, 2025).

Research on statistical reasoning has consistently identified variability, distribution, and comparative reasoning as persistent areas of difficulty among secondary learners. Students frequently prioritize measures of central tendency while paying insufficient attention to variability, distributional overlap, and the relationships among multiple statistical indicators (Groth & Bergner, 2021; Leavy et al., 2022). They may also treat different measures of spread as interchangeable, rely on visually salient or numerically prominent features, or draw conclusions without coordinating the full distribution (Kinnear et al., 2025). Although technology can support the simultaneous examination of tables, graphs, and numerical summaries, it may also compress reasoning when students treat software outputs as self-explanatory or authoritative. In such circumstances, learners may report a mean, correlation coefficient, or p-value without explaining its contextual or conceptual significance (Engel & Ridgway, 2023; Garfield & Ben-Zvi, 2021).

These difficulties are not purely cognitive; they are also discursive and socially mediated. In group-based learning environments, statistical meanings are negotiated through interactions among students, software interfaces, task prompts, and classroom norms. Digital tools can redistribute epistemic authority by positioning the software-generated result as the primary source of correctness, thereby influencing how students formulate explanations and justify conclusions (Herbel-Eisenmann et al., 2022). At the same time, peer interaction may create opportunities for learners to question, refine, and reconstruct statistical meanings. Examining classroom discourse therefore provides access to the micro-level processes through which procedural statements, conceptual interpretations, and recurring reasoning routines are formed and stabilized.

Despite extensive scholarship on statistical reasoning and technology-mediated mathematics education, relatively few studies have examined how Senior High School students use statistical language, visual representations, narratives, and routines while interpreting outputs from a specific statistical software package. Evidence is particularly limited regarding JAMOVI-supported classroom activities analyzed through a commognitive lens. Existing research has established that digital technologies can transform mathematical communication and reorganize interpretive activity (Borba et al., 2022; Drijvers et al., 2021), yet less attention has been given to the fine-grained discourse through which students interpret software-generated descriptive statistics, graphs, correlations, and inferential results in authentic secondary classrooms. This gap is theoretically and pedagogically important because statistical software may simultaneously broaden access to complex representations and narrow the range of explanations students consider necessary or legitimate (Engel & Ridgway, 2023; Greefrath et al., 2025).

This study therefore examines the statistical discourse of Senior High School students as they interpret JAMOVI-generated outputs across descriptive, graphical, correlational, and inferential tasks. It contributes to the literature in three ways. First, it extends commognitive analysis to software-mediated secondary statistics education by examining statistical thinking as a communicative achievement shaped by digital representations. Second, it documents recurring patterns of word use, visual mediation, narrative construction, and reasoning routines across several statistical domains rather than focusing on a single task or representation. Third, it offers pedagogical insights into how statistical software may be used as a starting point for explanation, comparison, critique, and conceptual discussion rather than as an endpoint of reasoning. In doing so, the study connects commognitive theory, research on statistical reasoning, and scholarship on digital mediation to provide a contextually grounded account of statistical meaning-making in a technology-supported classroom.

Research questions

1. How do Senior High School students use statistical language when interpreting JAMOVI-generated outputs?

2. What discursive patterns characterize their explanations and justifications of tables, graphs, and statistical results?

3. How do their narratives and routines reflect reasoning about center, variability, relationship, and comparison?

4. How do JAMOVI-generated visual mediators shape statistical meaning-making in the observed tasks?

5. What insights into students' statistical thinking can be drawn from a commognitive analysis of their discourse?

THEORETICAL FRAMEWORK

Commognitive theory provides the primary analytic lens for the study. Sfard (2008) proposes that thinking is an individualized form of communication and that learning involves changes in participation in a specialized discourse. Mathematical and statistical discourses can be characterized through four interrelated features: word use, visual mediators, endorsed narratives, and routines.

Word use refers to how disciplinary terms acquire meaning in use. In statistics, words such as mean, spread, correlation, and significance may be used procedurally, conceptually, or evaluatively. Visual mediators include tables, plots, symbols, and software displays through which statistical objects become available for communication. Narratives are statements about data that participants present as acceptable, such as claims about a relationship or a difference between groups. Routines are recurrent patterns for producing, interpreting, or validating such narratives.

The study also draws on a sociocultural view of technological mediation. Statistical software reorganizes activity by deciding what appears on the screen, how measures are grouped, and which visual features are emphasized. Biehler et al. (2013) describe digital tools as rapid means of travelling between data and conclusions while cautioning that learners still need support in making the conceptual journey. Engelbrecht and Borba (2024) similarly emphasize that knowledge production in digital mathematics environments is shaped by collectives of learners, teachers, and media. In this study, JAMOVI outputs are therefore treated as visual and epistemic mediators rather than neutral containers of results.

Combining these perspectives directs analysis to both the content and the organization of students' discourse. The question is not only whether an interpretation is correct, but how the interpretation is produced, what representation authorizes it, and whether the reasoning routine remains flexible across contexts. This framework supports a close examination of the transition from ritualized discourse—where accepted forms are reproduced—to exploratory discourse—where claims are explained, challenged, and connected conceptually.

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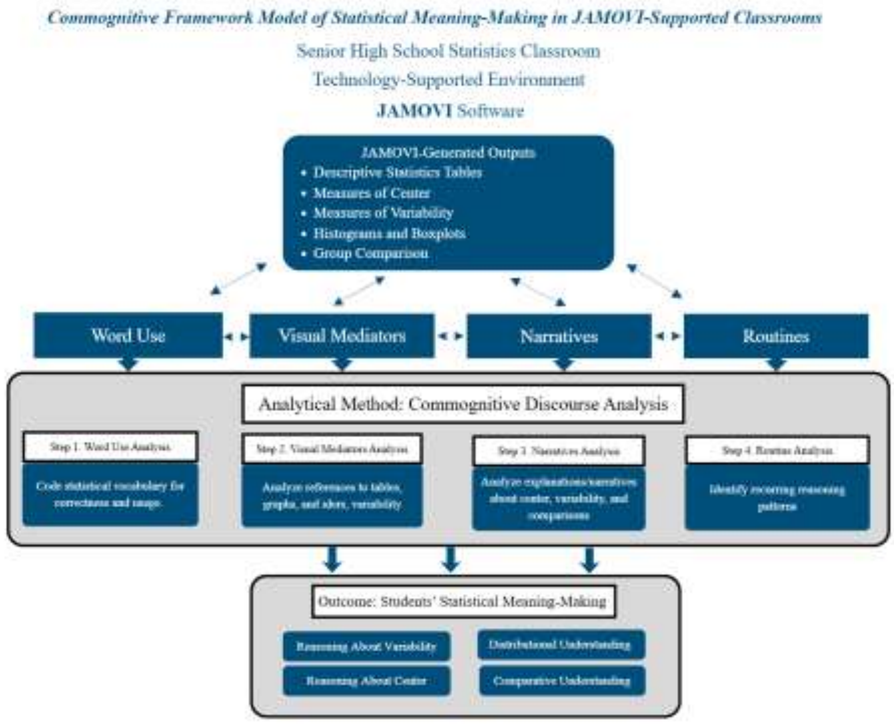

Figure 1. Commognitive model of statistical meaning-making in a JAMOVI-supported classroom

METHODOLOGY

Research design and case boundaries

The study used a qualitative case study design to examine discourse within a bounded, technology-supported statistics learning context. The case was defined by the participating Senior High School students, the four structured JAMOVI-based tasks, and the group discussions produced during the activity. A case study design was appropriate because the purpose was to develop a detailed account of meaning-making in context rather than estimate population parameters or test the effectiveness of an intervention.

The epistemological orientation was interpretivist-constructivist. Statistical understanding was treated as socially produced through talk, written work, and interaction with representations. The unit of analysis was the discourse segment in which students named, interpreted, justified, compared, or concluded from a statistical output.

Participants and sampling

The participants were 88 Grade 11 learners from three public secondary schools in the Dinagat District, Schools Division of Dinagat Islands. These included 30 learners from Primitivo J. Ebol Memorial National High School, classified as a medium-sized school; 35 learners from Dinagat School of Fisheries, classified as a large school; and 23 learners from Cab-ilan National High School, classified as a medium-sized school. The participants ranged from 15 to 17 years of age.

Purposive sampling was employed to select one Grade 11 section from each school. To be included in the study, the learners had to be enrolled in the Statistics and Probability subject during the second semester of School Year 2025–2026 under the Senior High School curriculum. The selected learners had already completed the relevant lessons in Statistics and Probability before the conduct of the study. Data collection was undertaken after classroom instruction had been completed to examine how learners drew on their prior statistical knowledge when interpreting JAMOVI-generated outputs. The study therefore focused on analyzing the students' statistical interpretations, explanations, and discourse rather than assessing their first exposure to statistical concepts or software.

For the classroom activities, the learners in each selected section were organized into three to four small groups, depending on the number of students in the class. These groups served as the units for collaborative discussion and interpretation across the descriptive, graphical, correlational, and inferential statistical tasks. The sampling strategy was intended to obtain information-rich cases from schools with different enrollment classifications rather than to produce a statistically representative sample of the wider Senior High School population.

To protect confidentiality, school-based group and speaker codes were used in the transcripts, worksheets, and reported quotations. The findings are therefore presented as context-specific interpretations of the selected cases and are not intended to establish the prevalence of similar discourse patterns across other schools or student populations.

Tasks and data sources

The students completed four structured tasks. Each task required them to generate or inspect JAMOVI outputs and explain the meaning of the results in writing and group discussion.

Task	Dataset/domain	JAMOVI output	Primary discourse focus
1	Descriptive statistics: mathematics test scores	Mean, median, mode, range, standard deviation	Use of terms for center and spread; procedural versus conceptual explanations
2	Visual mediators: height data	Histogram and boxplot	Attention to shape, distribution, spread, center, and outliers
3	Correlation: price and sales	Correlation matrix and coefficient	Direction and strength of relationship; distinction between association and causal language
4	Paired comparison: pre-test and post-test scores	Paired-samples t test and p-value	Statistical significance, difference, improvement, and decision routines

The analyzed corpus consisted of completed student worksheets, classroom observation notes, audio-recorded group discussions, and JAMOVI-generated outputs used during the statistical activities. Data collection was conducted from March 9 to 13, 2026, covering a one-week observation period across the three participating schools. The classroom activities were aligned with the Statistics and Probability Curriculum Guide prescribed by the Department of Education under the Senior High School curriculum.

Only data sources that were actually collected were included in the final analysis. These comprised classroom observation notes, audio recordings of students' group and classroom discussions, completed activity sheets, and the corresponding statistical outputs generated through JAMOVI. No video recordings or post-task interviews formed part of the analyzed dataset.

Four researcher-developed modules or activity sheets were administered to elicit students' statistical discourse across different statistical domains. The activities covered descriptive statistics, graphical representations, correlation analysis, and inferential statistics. They were designed to generate evidence relevant to the four dimensions of commognitive discourse analysis: word use, visual mediators, narratives, and routines. The JAMOVI-generated tables, graphs, and statistical summaries served both as instructional materials and as visual mediators through which students interpreted, negotiated, and communicated statistical meanings.

The statistical analyses and outputs were generated using JAMOVI version 2.7.37 in a Windows operating environment. The collected observation notes, discussion transcripts, completed worksheets, and software-

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generated outputs were organized and coded using NVivo 15. NVivo supported the iterative coding, categorization, retrieval, and comparison of discourse segments across the four commognitive dimensions and the four statistical tasks.

Data Collection Procedure

Students completed the four modules in their assigned groups over four instructional days within the one-week data-collection period. Module 1 was administered on Day 1, Module 2 on Day 2, Module 3 on Day 3, and Module 4 on Day 4. Each session lasted approximately one hour. All participating groups completed all four modules and their corresponding statistical tasks.

During each session, students examined the relevant JAMOVI-generated outputs, discussed their interpretations within their groups, and recorded their responses on the activity sheets. Their group discussions were audio-recorded to capture how they used statistical language, referred to visual mediators, constructed explanatory narratives, and enacted recurring reasoning routines. The researcher also collected the completed worksheets, classroom observation notes, and copies of the corresponding JAMOVI outputs to preserve the representational context associated with each recorded statement.

The procedure was designed to elicit naturally occurring collaborative interpretations within the structure of the assigned tasks. The researcher facilitated access to the modules and the statistical software but did not provide interpretations of the statistical results during the recorded discussions. This approach was intended to minimize researcher influence on students' explanations and allow their emerging statistical discourse to be documented as authentically as possible.

Following data collection, the audio recordings were transcribed and organized according to school, group, module, and statistical task. The transcripts were subsequently checked against the original audio recordings to improve their accuracy and ensure that the students' statements were represented faithfully in the analysis.

Data Analysis

Data analysis combined iterative thematic coding in NVivo 15 with commognitive discourse analysis. First, the audio transcripts, classroom observation notes, and students' written responses were read repeatedly to identify discourse segments in which learners interpreted a statistical value, graph, relationship, or inferential decision. Initial in vivo and descriptive codes were assigned as closely as possible to the students' own words and expressions. This stage preserved the participants' language while identifying recurring forms of statistical interpretation.

Second, the initial codes were compared within and across the four modules and consolidated into focused codes representing broader discourse patterns. Constant comparison was used to examine similarities and differences across the three schools, student groups, statistical tasks, and data sources. Third, the focused codes were interpreted using the four components of the commognitive framework: word use, visual mediators, narratives, and routines.

Word-use analysis examined whether statistical terms functioned as procedural cues, conceptual descriptors, or evaluative labels. Visual-mediator analysis traced how students referred to JAMOVI-generated tables, graphs, numerical values, signs, coefficients, and significance thresholds. Narrative analysis identified recurring explanations, claims, and forms of justification. Routine analysis examined the repeated sequences through which students moved from reading an output to stating an interpretation and drawing a conclusion. Comparisons across the four modules were conducted to identify discourse patterns that remained stable and those that varied according to the statistical domain.

The analysis prioritized the meaning, structure, and recurrence of discourse rather than numerical frequency counts. Representative quotations were selected because they illustrated recurring discourse patterns, important conceptual difficulties, or meaningful contrasts among students' interpretations. Claims regarding JAMOVI were framed as interpretations of how the software mediated students' reasoning within the observed classroom contexts and not as causal estimates of the software's effects.

The author served as the primary coder and conducted the initial coding, focused coding, and commognitive interpretation of the dataset. To strengthen the credibility and dependability of the analysis, a division researcher specializing in qualitative research served as the peer debriefer. The peer debriefer reviewed approximately 25% of the coded materials, purposively selected to include data from all three participating schools and all four statistical modules. The review examined whether the assigned codes were supported by the original transcripts, observation notes, written responses, and JAMOVI-generated outputs, and whether the interpretations were consistent with the four commognitive constructs.

The teachers handling the participating sections also reviewed the preliminary findings and selected interpretations. Their review focused on the contextual accuracy and plausibility of the interpretations in relation to the classroom activities, students' usual communication patterns, and the implementation of the four modules. This process provided an additional form of contextual validation while preserving the researcher's responsibility for the final analytical decisions.

Differences in coding or interpretation were resolved through discussion among the author, the peer debriefer, and, when contextual clarification was needed, the teachers handling the participating sections. Codes were retained only when they were supported by the corresponding data excerpts. Overlapping codes were merged, unclear definitions were refined, and previously coded segments were re-examined after revisions to the coding framework. Coding consistency was further supported through repeated reading of the dataset, comparison across groups and tasks, triangulation of transcripts, observation notes, worksheets, and software outputs, and the maintenance of analytic memos and an audit trail in NVivo 15. Because no formal inter-coder reliability coefficient was calculated, the study does not report percentage agreement, Cohen's kappa, or any other numerical reliability measure

Trustworthiness and Reflexivity

The trustworthiness of the study was strengthened through triangulation, maintenance of an analytic audit trail, reflexive memoing, peer debriefing, and contextual review by the teachers handling the participating sections. These procedures were used to enhance the credibility, dependability, confirmability, and transferability of the findings.

Credibility was supported by triangulating multiple sources of evidence, including audio-recorded group discussions, classroom observation notes, completed activity sheets, and the corresponding JAMOVI-generated outputs. Each interpretation was examined in relation to the representational context in which the students' statements occurred. For example, transcript excerpts were compared with students' written responses and the specific tables, graphs, coefficients, or inferential results being discussed. This process helped determine whether an interpretation was consistently supported across spoken, written, observational, and software-generated evidence rather than being based on a single data source.

Cross-task and cross-site comparisons were also conducted. Emerging patterns were examined across the four modules, student groups, and three participating schools. A discourse pattern was treated as analytically meaningful when it recurred across multiple excerpts or represented an important contrast in students' interpretations. This procedure reduced the risk of developing themes from isolated statements and allowed the researcher to distinguish stable discourse routines from patterns specific to a particular statistical task.

An analytic audit trail was maintained throughout the coding process in NVivo 15. The audit trail documented the progression from original transcript excerpts and written responses to initial in vivo and descriptive codes, focused codes, and theoretically informed categories based on word use, visual mediators, narratives, and routines. Revisions to code definitions, the merging or separation of codes, and decisions concerning the interpretation and inclusion of representative excerpts were documented through analytic memos. This record provided a transparent account of how the findings were developed from the original data.

Reflexive memoing was conducted throughout data organization, coding, and interpretation. The researcher recorded assumptions, emerging interpretations, possible biases, and decisions regarding the distinction between students' expressed meanings and expert statistical interpretations. Particular attention was given to avoiding the imposition of technically advanced statistical meanings on statements that were primarily procedural, perceptual, or evaluative. Reflexive memos were revisited during later coding stages to determine whether interpretations remained grounded in the participants' actual language, actions, and representational contexts.

Peer debriefing provided an additional check on the credibility and dependability of the analysis. A **division researcher specializing in qualitative research** reviewed approximately **25% of the coded materials**, purposively selected to represent all three participating schools and all four modules. The peer debriefer examined the correspondence among the original data excerpts, assigned codes, focused patterns, and commognitive interpretations. Differences in interpretation were discussed with the author, after which code definitions were clarified, overlapping categories were consolidated, and relevant portions of the dataset were re-examined.

The teachers who handled the participating Grade 11 sections also reviewed the preliminary interpretations and selected findings. Their review focused on whether the interpretations were contextually plausible in relation to the classroom activities, task implementation, and students' usual communication practices. Their involvement served as contextual validation rather than formal inter-coder assessment, while the author retained responsibility for the final analytical decisions.

Transferability was supported through detailed descriptions of the participating schools, learners, grouping arrangements, modules, statistical domains, data-collection procedures, and identified discourse patterns. The study does not claim statistical generalizability because the participants were purposively selected from three schools within one district. Instead, it provides sufficient contextual and methodological detail to enable readers to determine whether the findings may be relevant to comparable Senior High School statistics classrooms using technology-supported instruction.

No numerical inter-coder reliability coefficient was calculated. Accordingly, the study does not report percentage agreement, Cohen's kappa, or similar statistical measures. Trustworthiness was established through transparent qualitative procedures, including triangulation, documented coding decisions, reflexive analysis, peer debriefing, contextual review, and sustained comparison across tasks, groups, and schools.

Use the audit-trail and reflexive-memoing statements only if these records were actually maintained during the study.

Ethical Considerations

The study did not undergo formal review by an institutional ethics review board; therefore, no ethics approval number or approval date is reported. This circumstance is disclosed transparently. Before data collection, permission to conduct the study was obtained from the appropriate school authorities, and the actual consent, confidentiality, data-protection, and withdrawal procedures implemented during the study are described below.

Because the participants were minors, written parental or guardian consent was secured before their inclusion in the study. Signed consent forms were returned by the parents or legal guardians, and student assent was also documented. The learners were informed in age-appropriate language about the purpose of the research, the activities involved, the voluntary nature of participation, the use of audio recordings, and the intended use of the collected data for research and publication purposes.

Participation was entirely voluntary. The learners and their parents or guardians were informed that refusal to participate would not affect the learners' grades, class standing, access to instruction, or relationship with their teachers and school. Participants were also informed that they could withdraw from the study at any time without penalty by notifying the researcher or the teacher handling the participating section. When a withdrawal request was made before the data had been fully anonymized and incorporated into the analysis,

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the participant's audio recordings, written responses, and related records would be removed from the dataset. Once the data had been irreversibly anonymized and incorporated into aggregated findings, withdrawal of individual data might no longer be possible.

Confidentiality was maintained throughout the research process. Participants' names and other identifying information were removed from transcripts, worksheets, observation notes, and reported findings. Participant, group, and school codes were used in place of personally identifiable information. Reported quotations were reviewed to ensure that they did not contain details that could reasonably reveal the identity of individual learners.

Data-protection safeguards were also implemented. Audio recordings, electronic transcripts, NVivo project files, completed worksheets, and JAMOVI-generated outputs were stored in password-protected digital folders accessible only to the researcher. Printed documents, including signed consent forms and completed activity sheets, were kept in a secure location. Identifying records were stored separately from the anonymized research dataset.

The collected information was used exclusively for research and publication purposes and was not shared with unauthorized individuals. Research records will be retained securely **for two years after publication. At the end of the retention period, electronic files will be permanently deleted, while printed materials** will be destroyed through shredding.

RESULTS

The analysis produced four interconnected findings: (1) statistical vocabulary was emerging but remained procedurally anchored; (2) explanations followed a small number of recurring narrative patterns; (3) reasoning routines were stable across domains; and (4) JAMOVI outputs operated as strong visual and epistemic mediators. These findings are presented as patterns within the bounded case.

Emerging statistical vocabulary with procedural anchoring

Across the four tasks, students used formal terms such as mean, median, range, standard deviation, correlation coefficient, inverse relationship, p-value, and significant difference. The presence of these terms showed increasing participation in statistical discourse. However, the terms frequently functioned as labels for an operation or displayed value rather than as resources for conceptual explanation.

S1-G1: "Mean is 84.4… so we just add all scores then divide by number of students."

S2-G1: "Yes, that is how we get average."

In this exchange, mean was defined through a calculation routine. The students correctly named the statistic, but they did not discuss why the mean represented the distribution's center or how it should be interpreted alongside spread. The discourse was therefore mathematically recognizable but predominantly ritualized.

When interpreting visual outputs, students adopted terms such as distribution, spread, normal, and outlier. Yet the explanations were often based on appearance.

S1-G2: "The bar graph is bigger here, so it means more students are in that range."

S3-G2: "It looks normal because it is balanced."

The statements linked visible features to conclusions, but the students rarely articulated the statistical structure encoded by the graph. The visual vocabulary was emerging, while distributional reasoning remained limited.

Correlation produced somewhat stronger relational language. One student correctly connected a negative coefficient to an inverse relationship:

S2-G3: "Negative 0.925 means inverse relationship, so when price increases, sales decrease."

However, another statement—"Positive 0.8 means sales go down together"—showed that the sign-direction mapping was not stable across speakers. The coefficient was recognized as important, but its meaning was vulnerable to symbolic misreading.

In the paired-samples task, students used inferential terminology accurately at the level of a decision rule:

S3-G1: "Since p-value is less than 0.05, it is significant… so there is difference."

The statement followed the conventional threshold rule but did not explain what the p-value represented, what uncertainty was being considered, or how the result related to the magnitude and variability of the observed change. Inferential discourse was therefore procedurally correct but conceptually compressed.

Recurring explanatory and justificatory patterns

Four recurring narrative patterns characterized students' explanations.

First, procedural repetition involved reporting a value as if reporting completed the interpretation. Statements such as "The mean is 84.4" and "Range is 23" presented the output but did not explain its contextual meaning.

Second, definition-by-repetition relied on compact textbook equivalences, including "Mean is average" and "Range is highest minus lowest." These statements were not incorrect, but they remained detached from the dataset and did not support comparison or judgment.

Third, negotiated meaning appeared when students questioned and refined one another's explanations.

S1-G2: "I think SD means spread?"

S2-G2: "Yes, like how far scores are from mean."

S3-G2: "So if SD is high, answers are not similar."

This sequence showed a movement toward exploratory discourse. Meaning was not simply read from the software; it was collaboratively proposed, confirmed, and elaborated. Although the final explanation remained informal, the interaction displayed emerging statistical agency.

Fourth, value-based interpretation shifted from statistical description to everyday evaluation. Statements such as "Performance is good because mean is high" and "Scores are fair already" used summary statistics as direct indicators of quality or fairness. The shift blurred the distinction between describing a distribution and judging an outcome.

Stable reasoning routines across statistical domains

The students' reasoning was organized by a stable sequence that appeared in descriptive, correlational, and inferential tasks: read a value or feature, name the statistic, attach a short interpretation, and conclude. The routine supported efficient task completion but limited adaptation to the conceptual demands of each domain.

For measures of center, the routine was compute or read → state the mean → interpret as average performance. For variability, range, variance, and standard deviation were frequently collapsed into the broad notion of spread. For pre-test and post-test comparison, the routine was compare values → identify an increase → conclude improvement. In the t-test task, checking whether $p < .05$ was added to this sequence but did not substantially change its structure.

These routines were useful entry points into statistical discourse, yet they became constraints when they replaced coordination among center, variability, distribution, context, and uncertainty. Their stability across tasks suggests that students were applying a generalized reporting script rather than constructing task-specific statistical arguments.

JAMOVI as visual mediator and epistemic anchor

JAMOVI influenced the discourse in four related ways. First, it operated as an epistemic authority. Students often prefaced conclusions with "based on the correlation matrix," "as shown in the JAMOVI result," or similar formulations. The output was treated as validated knowledge rather than a representation requiring interpretation.

Second, JAMOVI functioned as a meaning generator. A displayed number was often translated directly into a conclusion, as in "Since SD is 7.2, data is spread out." The missing step was a contextual standard for deciding whether 7.2 represented little or substantial variation.

Third, the interface enabled cognitive shortcuts. One student remarked, "Just look at the graph, then we already know the answer." The comment captured the efficiency of visual inspection while also revealing how the graph could substitute for an articulated statistical argument.

Fourth, the interface constrained attention by foregrounding visible summaries such as the mean, standard deviation, coefficient, and p-value. Other considerations—distributional overlap, practical magnitude, uncertainty, and contextual plausibility—were less prominent in the students' talk. The study does not establish that JAMOVI caused these patterns. Rather, within this case, the interface and the students' prior conceptual resources jointly shaped what became salient and reportable.

Cross-task synthesis

Domain	**Word use**	**Mediator orientation**	**Dominant routine**	**Commognitive interpretation**
Descriptive statistics	Terms correctly named but tied to formulas	Table values read as final answers	Compute/read → state → call it average	Procedural anchoring
Histogram and boxplot	Visual terms used informally	Salient bars, balance, and shape foregrounded	Look → describe appearance → conclude	Perceptual interpretation
Correlation	Formal terms emerging; sign meaning unstable	Coefficient and matrix treated as authority	Read r → assign direction → conclude relationship	Partial relational reasoning
Paired t test	Significance vocabulary used mechanically	p-value threshold dominated	Compare means → check .05 → conclude difference/improvement	Ritualized inference

Across tasks, the students demonstrated an emerging capacity to participate in statistical discourse, but their narratives and routines remained predominantly procedural, output-driven, and conceptually constrained. Negotiated group talk provided the clearest evidence of movement toward exploratory reasoning.

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DISCUSSION

The findings indicate a transitional form of statistical discourse. Students were able to use recognizable disciplinary terms and navigate several JAMOVI outputs, yet much of their talk remained organized by reporting routines. From a commognitive perspective, this pattern is more precise than describing students as either knowledgeable or unknowledgeable. They had entered the discourse, but the meanings of several statistical objects were not yet stabilized across contexts.

The distinction between ritualized and exploratory discourse is especially visible in the contrast between individual reporting and negotiated group talk. Statements that merely repeated a value or definition relied on established forms of correctness. By contrast, the exchange about standard deviation showed students proposing, testing, and refining meaning. This suggests that conceptual development may be supported when classroom norms require students to respond to one another's interpretations rather than only produce an answer for the teacher.

The persistent compression of variability is consistent with long-standing concerns in statistics education. Beginning learners often rely on center and have difficulty coordinating it with spread when comparing distributions. Technology can display both measures simultaneously, but their co-presence on a screen does not ensure conceptual coordination. The students' tendency to treat range, variance, and standard deviation as interchangeable shows that exposure to multiple outputs should be paired with tasks that clarify what each measure captures, how it responds to data, and when it is useful.

The results also illustrate the double role of digital tools. Technology can reduce computational burden and make multiple representations immediately available. Biehler et al. (2013) emphasize precisely this potential. At the same time, digital task formats can alter students' approaches (Kinnear et al., 2025), and contemporary digital mathematics scholarship recognizes that knowledge is produced by collectives of people and media (Engelbrecht & Borba, 2024). In the present case, JAMOVI supported participation but also became a strong epistemic anchor. When students treated the displayed result as the explanation, the interface effectively narrowed the discourse.

This interpretation should not be read as a claim that JAMOVI uniquely produces shallow reasoning. The design did not include a paper-based condition or a comparison platform. The observed patterns may reflect prior instruction, conceptual difficulty, task wording, group norms, or interface features in combination. The warranted conclusion is therefore that JAMOVI participated in the observed meaning-making, not that the software independently caused the difficulties.

The pedagogical implication is that software outputs should be positioned as claims to be interpreted and justified. Teachers can ask students to explain what a statistic means in the dataset, identify what information the output does not show, compare numerical and graphical evidence, and describe how a conclusion would change under a different value or distribution. Such prompts may disrupt the read–name–conclude routine and create opportunities for exploratory discourse.

For inferential tasks, instruction should go beyond threshold language. A statement that $p < .05$ should be followed by questions about the tested difference, the direction and magnitude of change, the role of variability, the assumptions of the analysis, and the practical meaning of the result. Similarly, correlation tasks should require students to distinguish direction from strength and association from causation. These practices can help software function as a scaffold for reasoning rather than a substitute for it.

Implications For Teaching and Curriculum

- Design prompts that require students to connect every reported statistic to the context and to another representation.
- Use comparison questions that require simultaneous attention to center, variability, shape, and overlap rather than the mean alone.

- Ask students to critique a software-generated conclusion, identify missing information, and propose an alternative interpretation.
- Structure group roles so that one student reports the output, another explains its meaning, and another challenges the justification.
- Teach p-values, coefficients, and measures of spread as conceptual objects, not only as rules for obtaining or classifying results.
- Assess statistical communication through explanation and justification in addition to successful software operation.

LIMITATIONS AND FUTURE RESEARCH

The first limitation is the small and bounded sample. The case involved only three groups from one Senior High School context. This design supported close analysis of discourse but does not establish how common the identified patterns are across schools, grade levels, strands, linguistic communities, or levels of statistical preparation. The findings should therefore be understood as analytically transferable propositions that require examination in other settings.

Second, the study was qualitative and cross-sectional. It captured discourse during four tasks but did not measure the prevalence of specific misconceptions or track developmental change over an extended period. Larger mixed-methods studies could combine discourse analysis with validated assessments, surveys, or task-performance measures. Longitudinal work could examine whether teacher scaffolding changes students' word use, narratives, and routines over time.

Third, the exclusive focus on JAMOVI limits software-level attribution. Without a comparison condition, the study cannot determine whether a pattern arose primarily from the statistical concept, the wording of the task, students' prior instruction, or a feature of the JAMOVI interface. Future research should compare equivalent tasks in JAMOVI, spreadsheet environments, graphing tools, and other statistical packages while holding the data and prompts constant.

Fourth, group discourse may not fully represent each participant's individual understanding. Collaborative talk can reveal negotiated meaning, but it may also obscure quieter or dissenting interpretations. Future studies could triangulate group interaction with individual interviews, stimulated recall, written explanations, or think-aloud protocols.

Finally, the study's claims depend on interpretive coding. Detailed reporting of coding decisions, negative cases, peer review of themes, and the researcher's positionality is therefore essential. Replication using additional analysts and comparable datasets would strengthen the dependability of the proposed discourse patterns.

CONCLUSION

This study examined how Senior High School students participated in statistical discourse while interpreting JAMOVI-generated outputs. Students demonstrated emerging command of statistical vocabulary and could navigate descriptive, graphical, correlational, and inferential outputs. However, their explanations were usually procedural, their narratives were brief, and their routines repeatedly moved from reading an output to naming a statistic and drawing a conclusion.

JAMOVI supported access to representations and reduced computational demands, but it also became a strong source of epistemic authority within the observed tasks. The most important evidence of conceptual movement appeared when students negotiated meaning with peers rather than merely repeated a displayed value or memorized rule. The findings therefore support an instructional approach in which software outputs initiate discussion, comparison, and critique.

Because the case was small, bounded, and limited to one software environment, the study does not claim broad generalizability or causal software effects. Its contribution lies in making visible the discourse through which statistical meaning was constructed. Developing statistical literacy in technology-supported classrooms requires not only learning to obtain an output but also learning to explain what it means, what it does not mean, and why a conclusion is warranted.

DECLARATIONS

Ethics approval and consent to participate

The study did not undergo formal review by an institutional ethics review board; therefore, no ethics approval body, reference number, or approval date is reported. Permission to conduct the study was obtained from the appropriate school authorities before data collection.

Because the participants were minors, written informed consent was obtained from their parents or legal guardians. Signed parental or guardian consent forms were returned before the learners were included in the study. Student assent was also documented after the learners were informed, in age-appropriate language, about the purpose of the research, the activities involved, the use of audio recording, the voluntary nature of participation, and the intended use of the data for research and publication.

Participants were informed that they could decline to participate or withdraw from the study without penalty and without any effect on their grades, class standing, access to instruction, or relationship with their teachers and schools. Confidentiality was maintained through the use of participant, group, and school codes, and personally identifying information was removed from the transcripts, worksheets, observation notes, and reported findings.

Because no formal ethics approval was obtained, the manuscript should not state that the study was “approved by” an ethics committee. Instead, the statement should transparently report the actual school permissions, guardian consent, student assent, confidentiality safeguards, and withdrawal procedures implemented during the study.

Conflict of interest

The author declares no conflict of interest.

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Data availability

The research data are not publicly available because the study involved minor participants and the consent obtained was limited to the conduct, analysis, and publication of the study. Public release of the complete transcripts, audio recordings, worksheets, or other raw materials could create a risk of indirect identification, even after the removal of names and other direct identifiers.

De-identified portions of the transcripts, selected anonymized worksheets, the coding framework or codebook, and copies of non-identifying JAMOVI outputs may be made available by the corresponding author upon reasonable written request. Any request will be evaluated based on its academic purpose, the adequacy of the proposed data-protection measures, and its consistency with the consent and assent provided by the participants and their parents or guardians.

Audio recordings will not be shared because participants may be identifiable through their voices and conversational context. Materials containing school-specific, group-specific, or participant-specific information will also be withheld or further redacted when disclosure could reasonably lead to identification.

Approved data sharing, when permitted, will be limited to the minimum information necessary for verification or scholarly use. Recipients will be required to maintain confidentiality, refrain from attempting to identify participants, avoid redistribution, and use the materials only for the approved purpose. The corresponding author reserves the right to decline requests that may compromise participant privacy, exceed the scope of the original consent, or conflict with the ethical safeguards established for research involving minors.

Author contribution

Angel M. Dionaldo: Conceptualization, methodology, investigation, formal analysis, writing—original draft, writing—review and editing.

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The author remains solely responsible for the interpretations, conclusions, and any remaining limitations of the research.

REFERENCES

1. Albano, G., Pierri, A., & Sabena, C. (2023). Grasping criteria for success: Engaging undergraduate students in formative feedback by means of digital peer workshops. Teaching Mathematics and Its Applications, 42(2), 187–203. https://academic.oup.com/teamat/article-abstract/42/2/187/6649845
2. Biehler, R., Ben-Zvi, D., & Bakker, A. (2021). Technology-enhanced statistics education: Coordinating multiple representations in dynamic learning environments. Statistics Education Research Journal, 20(1), 1–18.*
3. Borba, M. C., Engelbrecht, J., Llinares, S., & Aguilar, M. (2022). Blended learning, online learning, and digital technologies in mathematics education. ZDM–Mathematics Education, 54(5), 1061–1074. https://doi.org/10.1007/s11858-022-01363-3
4. Dindyal, J., & Beswick, K. (2021). The role of classroom discourse in supporting mathematical reasoning. Mathematics Education Research Journal, 33(3), 409–427.
5. Drijvers, P., Thurm, D., Vandervieren, E., Klinger, M., Moons, F., & Trouche, L. (2021). Digital tools in mathematics education: A meta-analysis of orchestration and discourse. Educational Studies in Mathematics, 106(3), 381–402.*
6. Engel, J. (2021). Students' reasoning with dynamic data visualizations. Statistics Education Research Journal, 20(3), 45–63.*

7. Engel, J., & Ridgway, J. (2023). Data dashboards and statistical literacy: Discursive practices in digital data environments. Statistics Education Research Journal, 22(2), 1–20.*
8. Garfield, J., & Ben-Zvi, D. (2021). Supporting statistical reasoning in the era of big data and technology. Statistics Education Research Journal, 20(2), 1–18.
9. Greefrath, G., Li, S., Radmehr, F., & Swidan, O. (2025). Theorizing digital curriculum resources: Recent cases from research in mathematics education. In Proceedings of the Fifth International Conference on Mathematics Education. https://hal.science/hal-05411587/document
10. Groth, R. E., & Bergner, J. A. (2021). High school students' reasoning about variability and distribution. Journal of Statistics and Data Science Education, 29(3), 205–218. https://doi.org/10.1080/26939169.2021.1927803
11. Herbel-Eisenmann, B., Wagner, D., Johnson, K., Suh, H., & Figueras, H. (2022). Positioning and authority in mathematics classrooms: Discursive practices and participation. Journal for Research in Mathematics Education, 53(4), 256–284.*
12. Kinnear, G., Iannone, P., & Davies, B. (2025). Student approaches to generating mathematical examples: Comparing e-assessment and paper-based tasks. Educational Studies in Mathematics. https://link.springer.com/article/10.1007/s10649-024-10361-1
13. Lave, J., & Wenger, E. (1991). Situated learning: Legitimate peripheral participation. Cambridge University Press.
14. Leavy, A. M., Hourigan, M., & Carroll, C. (2022). Adolescents' reasoning about comparing distributions: Challenges and opportunities. Educational Studies in Mathematics, 110(2), 243–262. https://doi.org/10.1007/s10649-021-10124-7
15. Listiani, T., Wustqa, D. U., Hernawati, K., & Setyaningrum, W. (2026). Mapping the research landscape of statistical reasoning in education using PRISMA: A bibliometric analysis. International Research Journal of Mathematics Studies. https://www.irjms.com/wp-content/uploads/2026/01/Manuscript_IRJMS_08191_WS.pdf
16. Macchioni, E. (2025). Capturing struggling students' mathematics difficulties holistically: Towards a characterization of mathematics discourse participation profiles (Doctoral dissertation). https://tesidottorato.depositolegale.it/handle/20.500.14242/216259
17. Planas, N., & Morgan, C. (2021). Classroom discourse in multilingual mathematics classrooms. Educational Studies in Mathematics, 108(1–2), 7–24.*
18. Prediger, S., Bikner-Ahsbahs, A., & Arzarello, F. (2023). Dialogic teaching and conceptual discourse in mathematics classrooms. ZDM–Mathematics Education, 55(2), 315–330.*
19. Rabardel, P. (2002). People and technology: A cognitive approach to contemporary instruments. Université Paris 8.
20. Ridgway, J. (2023). Statistical literacy and reasoning in secondary education: Challenges in modern data contexts. Statistics Education Research Journal, 22(1), 45–62.*
21. Sfard, A. (2008). Thinking as communicating: Human development, the growth of discourses, and mathematizing. Cambridge University Press.
22. Tabach, M., & Nachlieli, T. (2020). Co-constructing mathematical narratives in classroom discourse: A commognitive perspective. Educational Studies in Mathematics, 105(3), 321–338.*
23. Viirman, O. (2022). Mathematical discourse and visual mediators in university mathematics. Educational Studies in Mathematics, 110(1), 1–20.*
24. Vygotsky, L. S. (1978). Mind in society: The development of higher psychological processes. Harvard University Press.
25. Wei, H., Bos, R., & Drijvers, P. (2026). An embodied approach to covariational reasoning: A hand-tracking study. Educational Studies in Mathematics. https://link.springer.com/article/10.1007/s10649-025-10435-8
26. Wild, C. J., & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. International Statistical Review, 67(3), 223–248. https://doi.org/10.1111/j.1751-5823.1999.tb00442.x
27. Zieffler, A., Garfield, J., & Fry, E. (2020). Students' reasoning about variability in simulation-based learning environments. Journal of Statistics Education, 28(2), 123–135. https://doi.org/10.1080/10691898.2020.1730722

28. Borba, M. C., Engelbrecht, J., Llinares, S., & Aguilar, M. (2022). Blended learning, online learning, and digital technologies in mathematics education. ZDM–Mathematics Education, 54(5), 1061–1074. https://doi.org/10.1007/s11858-022-01363-3
29. Drijvers, P., Thurm, D., Vandervieren, E., Klinger, M., Moons, F., & Trouche, L. (2021). Digital tools in mathematics education: A meta-analysis of orchestration and discourse. Educational Studies in Mathematics, 106(3), 381–402. https://doi.org/10.1007/s10649-020-10011-8
30. Engel, J., & Ridgway, J. (2023). Statistical literacy in the age of data visualization. Statistics Education Research Journal, 22(1), 45–62.
31. Garfield, J., & Ben-Zvi, D. (2021). Supporting statistical reasoning in the era of big data and technology. Statistics Education Research Journal, 20(2), 1–18.
32. Greefrath, G., Li, S., Radmehr, F., & Swidan, O. (2025). Theorizing digital curriculum resources: Recent cases from research in mathematics education. In Proceedings of the Fifth International Conference on Mathematics Education.
33. Groth, R. E., & Bergner, J. A. (2021). High school students' reasoning about variability and distribution. Journal of Statistics and Data Science Education, 29(3), 205–218. https://doi.org/10.1080/26939169.2021.1927803
34. Herbel-Eisenmann, B., Wagner, D., Johnson, K., Suh, H., & Figueras, H. (2022). Positioning and authority in mathematics classrooms: Discursive practices and participation. Journal for Research in Mathematics Education, 53(4), 256–284.
35. Kinnear, G., Iannone, P., & Davies, B. (2025). Student approaches to generating mathematical examples: Comparing e-assessment and paper-based tasks. Educational Studies in Mathematics. Advance online publication. https://doi.org/10.1007/s10649-024-10361-1
36. Leavy, A. M., Hourigan, M., & Carroll, C. (2022). Adolescents' reasoning about comparing distributions: Challenges and opportunities. Educational Studies in Mathematics, 110(2), 243–262. https://doi.org/10.1007/s10649-021-10124-7
37. Macchioni, E. (2025). Capturing struggling students' mathematics difficulties holistically: Towards a characterization of mathematics discourse participation profiles (Doctoral dissertation).
38. Sfard, A. (2008). Thinking as communicating: Human development, the growth of discourses, and mathematizing. Cambridge University Press.