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Developing Statistical Data Analytics Competencies through AI-Assisted Interactive Dashboard Development Using Tableau in Vocational Higher Education

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Abstract

The increasing demand for data-driven decision-making requires engineering graduates to possess strong statistical data analytics competencies. However, statistics learning in vocational higher education often provides limited opportunities for students to develop analytical competencies through authentic, AI-supported learning experiences. This study investigated the development of students' statistical data analytics competencies through AI-assisted interactive dashboard development using Tableau. A convergent mixed-methods design was employed involving undergraduate students enrolled in a Statistics course in the Informatics Engineering Department of Politeknik Negeri Semarang, Indonesia. Quantitative data were collected through competency-based assessment of students' interactive dashboard projects, while qualitative data were obtained through artifact analysis of three sequential authentic learning artifacts: AI-assisted authentic dataset development, interactive dashboard development, and AI-assisted analytical presentation. The findings indicate that students achieved proficient to advanced competency levels across technical, analytical, and professional competency dimensions. Qualitative findings further revealed that the three learning artifacts formed a progressive competency pathway, enabling students to move from knowing the data, to representing the data, and ultimately to reasoning and communicating with the data. These findings demonstrate that AI-assisted project-based learning provides an effective instructional approach for strengthening statistical data analytics competencies in engineering vocational higher education.

Keywords: Artificial Intelligence, Data Analytics Competency, Interactive Dashboard, Statistics Education, Tableau, Vocational Higher Education

1. INTRODUCTION

Data-driven decision-making has become an essential competency across engineering disciplines, where professionals are expected not only to understand statistical concepts [1], [2], [3] but also to transform complex datasets into meaningful insights for problem-solving and decision-making [4], [5]. The rapid advancement of digital technologies, artificial intelligence (AI), and big data analytics has fundamentally changed how engineering data are collected, analyzed, and interpreted [5], [6], [7]. Consequently, engineering graduates are increasingly required to possess statistical data analytics competencies that integrate statistical reasoning, data visualization, analytical interpretation, and digital literacy [8], [9]. These competencies have become indispensable in supporting evidence-based decision-making across various engineering

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sectors, including manufacturing, information technology, industrial systems, quality control, and business intelligence [10], [11].

In response to these industrial demands, statistics education in vocational higher education is expected to move beyond traditional computational approaches toward authentic, technology-enhanced learning experiences [2], [3]. Conventional statistics instruction frequently emphasizes mathematical calculations and hypothesis testing while providing limited opportunities for students to explore real-world datasets and communicate analytical findings through interactive visualizations. As a result, students may acquire procedural statistical knowledge without developing the analytical competencies required to interpret data, identify patterns, and communicate evidence-based conclusions in professional engineering environments [12], [13], [14].

Interactive dashboard technologies have emerged as effective tools for supporting data exploration, visualization, and communication [15], [16], [17]. Platforms such as Tableau enable users to transform raw datasets into dynamic visual representations that facilitate data interpretation and decision-making [18], [19], [20]. Rather than presenting statistical outputs in static tables or charts, interactive dashboards encourage users to investigate relationships among variables, identify trends, detect anomalies, and generate meaningful insights through visual analytics. Consequently, dashboard development has become an increasingly valuable competency for engineering students who are expected to communicate analytical findings effectively within data-driven workplaces.

Alongside the growing adoption of interactive visualization technologies, artificial intelligence has significantly influenced contemporary higher education [21], [22]. Generative AI tools such as ChatGPT and similar large language models have been widely utilized to support learning activities, including statistical explanation, coding assistance, data interpretation, and report preparation [11], [23]. Within statistics education, AI has the potential to function as a cognitive support tool by assisting students in understanding statistical concepts, interpreting analytical outputs, and refining data-driven arguments. Nevertheless, effective statistics learning requires students to critically evaluate AI-generated responses rather than rely on them unquestioningly. Therefore, integrating AI into statistics instruction should emphasize analytical reasoning and reflective thinking rather than simple automation of learning tasks.

Previous studies have extensively investigated the implementation of artificial intelligence in education [11], project-based learning [24], [25], and interactive dashboard technologies [16], [26], [27]. Existing research generally reports positive impacts on students' engagement, digital literacy, and learning achievement. Similarly, studies involving Tableau and other business intelligence platforms have demonstrated their effectiveness in enhancing students' visualization skills and facilitating data exploration (Fransiska & Raharja, 2024). However, these studies have largely examined AI utilization, dashboard development, and project-based learning as separate educational interventions. Limited attention has been given to how AI-assisted dashboard development can systematically foster students' statistical data analytics competencies, particularly within engineering vocational higher education where authentic industrial data analysis constitutes a core learning outcome.

Furthermore, many previous investigations primarily evaluated learning outcomes through academic achievement, technology acceptance, or students' perceptions of learning technologies [11], [12], [14]. Comparatively fewer studies have examined students' competencies

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through direct assessment of authentic learning products, such as interactive dashboards that demonstrate statistical reasoning, visualization quality, analytical interpretation, and evidence-based insights. Evaluating students' three sequential authentic learning artifacts provides a more comprehensive understanding of how learners apply statistical knowledge to solve real-world analytical problems while integrating AI-assisted learning into the analytical process.

Although project-based learning has been widely adopted to promote authentic and experiential learning, its implementation in statistics education often emphasizes the completion of projects without explicitly describing how students progressively develop statistical data analytics competencies throughout the learning process [22], [29]. In many instructional practices, learning products such as datasets, dashboards, and presentations are treated as independent outputs rather than as interconnected evidence of competency development. Consequently, limited attention has been given to how sequential learning artifacts can represent students' progression from understanding data to communicating evidence-based analytical conclusions within authentic industrial contexts.

To address this issue, the present study conceptualizes AI-assisted project-based learning as a progressive learning process consisting of three sequential authentic learning artifacts: AI-assisted authentic dataset development, interactive dashboard development using Tableau, and AI-assisted analytical presentation. These artifacts not only represent tangible learning products but also reflect successive stages of statistical data analytics competency development. Through this perspective, students are expected to advance from understanding and preparing authentic datasets, to transforming data into meaningful visualizations, and ultimately to interpreting and communicating analytical insights supported by AI-assisted reasoning [3], [30]. This progression provides a comprehensive view of competency development that extends beyond technology utilization toward authentic analytical practice in engineering vocational education.

Based on these considerations, this study addresses the existing research gap by investigating the development of students' statistical data analytics competencies through AI-assisted interactive dashboard development using Tableau. Using a convergent mixed-methods design, the study combines competency-based assessment with qualitative analysis of three sequential authentic learning artifacts to examine how students progressively develop statistical data analytics competencies throughout the learning process. Unlike previous studies that primarily focused on technology adoption or learning perceptions, this study provides empirical evidence regarding the development of statistical reasoning, data visualization, analytical interpretation, and analytical communication within AI-assisted project-based learning. Furthermore, the study proposes a hierarchical perspective of competency development, progressing from *knowing the data*, to *representing the data*, and ultimately to *reasoning and communicating with the data* among engineering students in vocational higher education.

2. METHODS

This study employed a convergent mixed-methods design to investigate the development of students' statistical data analytics competencies through AI-assisted project-based learning [31], [32]. In this design, quantitative and qualitative data were collected concurrently, analyzed independently, and integrated during the interpretation stage to obtain a comprehensive understanding of students' competency development.

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The study was conducted in the Informatics Engineering, Politeknik Negeri Semarang, Indonesia, during the Statistics course. The participants consisted of 36 undergraduate students enrolled in the Statistics course in the Informatics Engineering Department at Politeknik Negeri Semarang. [24], [33]. A total sampling technique was employed because all students enrolled in the course participated in the study.

In the first stage, students collaborated with artificial intelligence (AI) to construct an authentic industrial dataset based on real-world quality control scenarios. In the second stage, students analyzed the dataset and developed an interactive dashboard using Tableau following the assessment guidelines provided by the instructor. In the final stage, students employed AI as a brainstorming partner to refine statistical interpretations, formulate analytical insights, and communicate their findings through analytical presentations. These three learning artifacts—AI-assisted authentic dataset development, interactive dashboard development, and AI-assisted analytical presentation—served as the primary evidence for evaluating students' statistical data analytics competencies. The overall research workflow is illustrated in Figure 1.

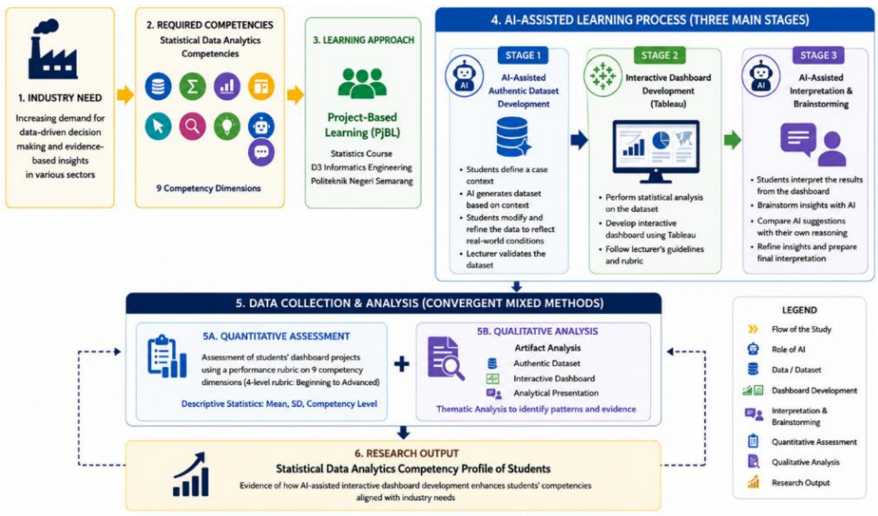

Figure 1. Research Workflow

To ensure a comprehensive evaluation of students' statistical data analytics competencies, the assessment instrument was developed to capture not only technical performance in dashboard construction but also students' analytical reasoning and professional communication throughout the AI-assisted project. The competency dimensions were derived from the expected learning outcomes of the project-based learning activities and aligned with the sequential development of authentic learning artifacts produced by the students. Accordingly, the assessment framework integrates technical, analytical, and professional competencies to provide a holistic evaluation of students' performance in statistical data analytics.

Quantitative data were collected through the assessment of students' interactive dashboard projects using a performance assessment rubric. The assessment instrument comprised nine competency dimensions (Table 1), namely data preparation, statistical analysis, data visualization, dashboard design, dashboard interactivity, data interpretation, analytical insight, AI utilization, and analytical communication.

Table 1. Statistical Data Analytics Competency Assessment Dimensions

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No	Competency Dimension	Description
1	Data Preparation	Ability to organize, clean, and prepare datasets for statistical analysis.
2	Statistical Analysis	Ability to apply appropriate statistical techniques and produce accurate analytical results.
3	Data Visualization	Ability to select suitable charts and visual representations to communicate data effectively.
4	Dashboard Design	Ability to develop dashboards with clear layout, readability, and visual consistency.
5	Dashboard Interactivity	Ability to implement interactive features such as filters, navigation, and user controls.
6	Data Interpretation	Ability to explain statistical findings accurately and meaningfully.
7	Analytical Insight	Ability to derive conclusions and recommendations based on analytical evidence.
8	AI Utilization	Ability to utilize artificial intelligence effectively, critically, and ethically during data analysis and dashboard development.
9	Analytical Communication	Ability to present, explain, and defend analytical findings clearly using evidence from the dashboard.

To ensure consistency and objectivity in the assessment process, each competency dimension was evaluated using a standardized performance rubric that reflects students' progressive levels of competency development. The rubric emphasizes competency mastery rather than simple task completion, enabling evaluators to distinguish different levels of performance demonstrated throughout the AI-assisted project-based learning activities. The four performance levels also align with the competency-based assessment approach adopted in this study, facilitating a systematic interpretation of students' achievements across all competency dimensions.

Each competency dimension was evaluated using a four-level performance rubric (Table 2) consisting of Beginning (1), Developing (2), Proficient (3), and Advanced (4). The quantitative data were analyzed descriptively using the mean, standard deviation, and competency level for each assessment dimension. The rubric was developed based on the intended learning outcomes and reviewed by experts in statistics education and educational assessment to ensure content validity.

Table 2. Performance Rubric

Score	Performance Level	General Description
1	Beginning	Demonstrates limited understanding and requires substantial guidance to complete the task.
2	Developing	Demonstrates partial competency with several inaccuracies or inconsistencies requiring improvement.
3	Proficient	Demonstrates competent performance with appropriate application of statistical and analytical skills.
4	Advanced	Demonstrates comprehensive competency with accurate analysis, effective visualization, meaningful insights, and professional communication.

Qualitative data were obtained through artifact analysis of students' three sequential authentic learning artifacts generated throughout the AI-assisted project-based learning process. The analysis focused on three sequential authentic learning artifacts: (1) AI-assisted authentic

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dataset development, (2) interactive dashboard development using Tableau, and (3) AI-assisted analytical presentation. Each artifact was systematically examined to identify evidence of students' competency development in data preparation, statistical reasoning, data visualization, dashboard design, analytical interpretation, AI utilization, and analytical communication. The qualitative findings were analyzed thematically to identify recurring patterns and relationships among the three learning artifacts, providing complementary evidence of the progressive development of students' statistical data analytics competencies.

Finally, the quantitative and qualitative findings were integrated during the interpretation stage to provide a comprehensive understanding of students' statistical data analytics competency development. The integration followed the convergent mixed-methods approach by comparing and synthesizing quantitative and qualitative findings during interpretation. The integration of competency-based assessment results with thematic artifact analysis enabled the researchers to explain how three sequential authentic learning artifacts—AI-assisted authentic dataset development, interactive dashboard development using Tableau, and AI-assisted analytical presentation—collectively contributed to the progressive development of students' technical, analytical, and professional competencies. This integrated interpretation also provided complementary evidence of how AI functioned as a cognitive support tool throughout the learning process, facilitating students' progression from *knowing the data*, to *representing the data*, and ultimately to *reasoning and communicating with the data* in engineering vocational higher education.

To address the increasing industrial demand for graduates with statistical data analytics competencies, this study adopted a Project-Based Learning (PjBL) approach integrated with artificial intelligence (AI) throughout the learning process. Students progressively developed their competencies through three sequential authentic learning artifacts: AI-assisted authentic dataset development, interactive dashboard development using Tableau, and AI-assisted analytical presentation. These learning activities were designed to facilitate the development of technical, analytical, and professional competencies required for data-driven problem-solving in engineering vocational education. Quantitative and qualitative data were collected concurrently to provide complementary evidence of students' competency development through these authentic learning experiences.

3. RESULTS AND DISCUSSION

3.1. Quantitative Findings

The quantitative findings were derived from the assessment of students' interactive dashboard projects using a performance assessment rubric consisting of nine competency dimensions grouped into three major competency categories: Technical Competencies, Analytical Competencies, and Professional Competencies. Each competency dimension was evaluated using a four-level performance rubric ranging from Beginning (1) to Advanced (4). Descriptive statistical analysis, including the mean, standard deviation, and competency level, was employed to describe students' performance across all competency dimensions. The results of the quantitative assessment are presented in Table 3.

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Table 3. Descriptive Statistics of Students' Statistical Data Analytics Competencies

Competency Group	Competency Dimension	Mean	SD	Competency Level
Technical Competencies	Data Preparation	3.28	0.41	Proficient
	Data Visualization	3.54	0.36	Advanced
	Dashboard Design	3.47	0.39	Advanced
	Dashboard Interactivity	3.51	0.34	Advanced
Analytical Competencies	Statistical Analysis	3.18	0.47	Proficient
	Data Interpretation	3.12	0.45	Proficient
	Analytical Insight	2.96	0.51	Proficient
Professional Competencies	AI Utilization	3.61	0.31	Advanced
	Analytical Communication	3.33	0.42	Advanced

As presented in Table 3, students generally demonstrated competency levels ranging from *Proficient* to *Advanced* across the nine dimensions of statistical data analytics competencies. Among the three competency groups, the highest performance was observed in Professional Competencies, particularly in AI Utilization (M = 3.61, SD = 0.31), indicating that students were able to effectively integrate artificial intelligence throughout the learning process. Within the Technical Competencies group, students also achieved *Advanced* levels in Data Visualization, Dashboard Design, and Dashboard Interactivity, suggesting strong technical abilities in developing interactive dashboards using Tableau.

In contrast, the Analytical Competencies group recorded comparatively lower mean scores, with Analytical Insight (M = 2.96, SD = 0.51) representing the lowest-performing dimension despite remaining within the *Proficient* category. Similarly, Statistical Analysis and Data Interpretation achieved proficient levels, indicating that while students were able to conduct statistical analyses and interpret results appropriately, generating deeper analytical insights from the findings remained relatively more challenging. These quantitative findings provide an initial overview of students' statistical data analytics competencies, which are further explored through qualitative artifact analysis in the subsequent section.

3.2. Qualitative Findings

To complement the quantitative findings, a qualitative artifact analysis was conducted to examine the authentic learning artifacts generated by students during the AI-assisted project-based learning process. Three sequential authentic learning artifacts were analyzed were analyzed, namely AI-assisted authentic dataset development, interactive dashboard development using Tableau, and AI-assisted analytical presentation. The analysis explored how each artifact reflected the progressive development of students' statistical data analytics competencies from data construction and visualization to interpretation and professional communication. Representative examples of the three learning artifacts are presented in the following figures.

As presented in Figure 2, students began the project by constructing an authentic dataset through AI-assisted brainstorming based on a real-world quality testing scenario in the biscuit manufacturing industry. AI was utilized to propose the initial dataset structure and production records, while students critically evaluated, modified, and validated the generated data to ensure consistency with the selected industrial context. The resulting dataset served as the primary learning artifact and provided the foundation for subsequent statistical analysis, interactive dashboard development, and AI-assisted interpretation. This process demonstrates that AI

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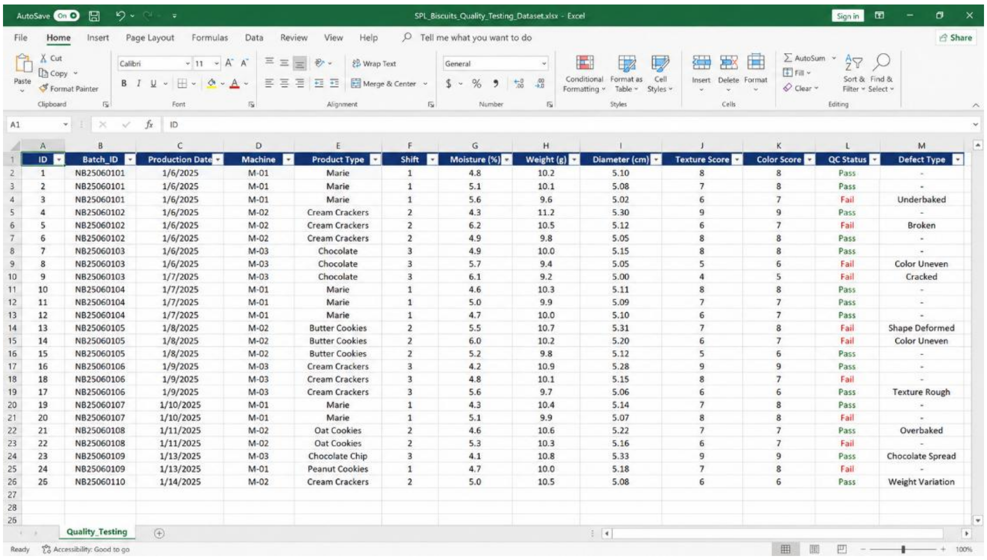
functioned as a cognitive support tool, whereas students remained responsible for validating, refining, and contextualizing the data before further analysis.



ID	Batch_ID	Production Date	Machine	Product Type	Shift	Moisture (%)	Weight (g)	Diameter (cm)	Texture Score	Color Score	QC Status	Defect Type
1	NB25060101	1/6/2025	M-01	Marie	1	4.8	10.2	5.10	8	8	Pass	-
2	NB25060101	1/6/2025	M-01	Marie	1	5.1	10.1	5.08	7	8	Pass	-
3	NB25060101	1/6/2025	M-01	Marie	1	5.6	9.6	5.02	6	7	Fail	Underbaked
4	NB25060102	1/6/2025	M-02	Cream Crackers	2	4.3	11.2	5.30	9	9	Pass	-
5	NB25060102	1/6/2025	M-02	Cream Crackers	2	6.2	10.5	5.12	6	7	Fail	Broken
6	NB25060102	1/6/2025	M-02	Cream Crackers	2	4.9	9.8	5.05	8	8	Pass	-
7	NB25060103	1/6/2025	M-03	Chocolate	3	4.9	10.0	5.15	8	8	Pass	-
8	NB25060103	1/6/2025	M-03	Chocolate	3	5.7	9.4	5.05	5	6	Fail	Color Uneven
9	NB25060103	1/7/2025	M-03	Chocolate	3	6.1	9.2	5.00	4	5	Fail	Cracked
10	NB25060104	1/7/2025	M-01	Marie	1	4.6	10.3	5.11	8	8	Pass	-
11	NB25060104	1/7/2025	M-01	Marie	1	5.0	9.9	5.09	7	7	Pass	-
12	NB25060104	1/7/2025	M-01	Marie	1	4.7	10.0	5.10	6	7	Pass	-
13	NB25060105	1/8/2025	M-02	Butter Cookies	2	5.5	10.7	5.31	7	8	Fail	Shape Deformed
14	NB25060105	1/8/2025	M-02	Butter Cookies	2	6.0	10.2	5.20	6	7	Fail	Color Uneven
15	NB25060105	1/8/2025	M-02	Butter Cookies	2	5.2	9.8	5.12	5	6	Pass	-
16	NB25060106	1/9/2025	M-03	Cream Crackers	3	4.2	10.9	5.28	9	9	Pass	-
18	NB25060106	1/9/2025	M-03	Cream Crackers	3	4.8	10.1	5.15	8	7	Fail	-
17	NB25060106	1/9/2025	M-03	Cream Crackers	3	5.6	9.7	5.06	6	6	Pass	Texture Rough
19	NB25060107	1/10/2025	M-01	Marie	1	4.3	10.4	5.14	7	8	Pass	-
20	NB25060107	1/10/2025	M-01	Marie	1	5.1	9.9	5.07	8	8	Fail	-
21	NB25060108	1/11/2025	M-02	Oat Cookies	2	4.6	10.6	5.22	7	7	Pass	Overbaked
22	NB25060108	1/11/2025	M-02	Oat Cookies	2	5.3	10.3	5.16	6	7	Fail	-
23	NB25060109	1/13/2025	M-03	Chocolate Chip	3	4.1	10.8	5.33	9	9	Pass	Chocolate Spread
24	NB25060109	1/13/2025	M-01	Peanut Cookies	1	4.7	10.0	5.18	7	8	Fail	-
25	NB25060110	1/14/2025	M-02	Cream Crackers	2	5.0	10.5	5.08	6	6	Pass	Weight Variation

Figure 2. Data Set in Excel for SPL Biscuits Quality Testing

Figure 3 presents the second authentic learning artifact, namely an interactive dashboard developed by students using Tableau based on the AI-assisted authentic dataset constructed during the previous stage. The dashboard illustrates how raw statistical data were transformed into meaningful visual representations through the integration of key performance indicators (KPIs), interactive charts, dynamic filters, and quality control summaries. Beyond serving as a visualization tool, the dashboard functioned as an analytical interface that enabled students to explore production patterns, identify quality issues, and generate evidence-based insights. Furthermore, the dashboard became the primary analytical resource for AI-assisted interpretation and presentation, demonstrating the integration of statistical analysis, interactive visualization, and reflective reasoning throughout the project.

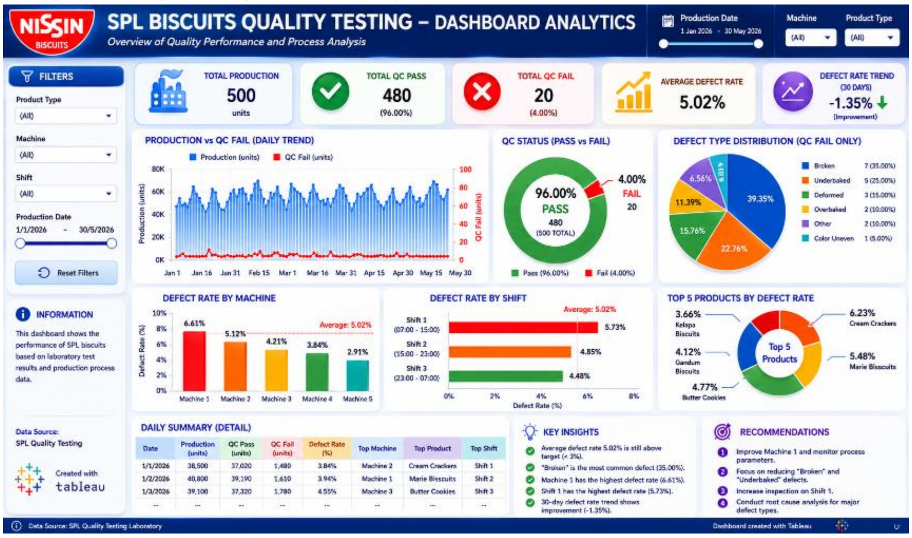


Figure 3. Interactive Dashboard using Tableau

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As illustrated in Figure 3, the dashboard presents a comprehensive visualization of quality testing data for biscuit production, integrating key performance indicators (KPIs), production trends, quality control status, defect distributions, machine performance, shift analysis, and operational recommendations within a single interactive interface. Interactive filtering features enable users to dynamically explore the dataset by production date, machine, product type, and production shift, allowing analytical views to be adjusted according to specific operational contexts. The dashboard also summarizes critical quality metrics, including total production, QC pass and fail rates, defect percentages, and production trends, providing a concise overview that supports efficient monitoring and evidence-based decision-making.

The dashboard artifact further demonstrates students' ability to integrate statistical analysis with interactive data visualization to communicate meaningful analytical insights. Students utilized AI throughout the project to construct realistic datasets, refine dashboard content, and validate statistical interpretations before presenting their findings. During the presentation session, students explained the rationale for selecting specific visualizations, interpreted quality control patterns, responded to analytical questions, and proposed data-driven recommendations based on dashboard evidence. These observations indicate that the dashboard functioned not only as a visualization product but also as evidence of students' technical, analytical, and professional competencies in statistical data analytics.

Following the development of the interactive dashboard, students proceeded to the final stage of the project by conducting AI-assisted analytical presentations. At this stage, the completed dashboard served as the primary evidence for communicating statistical findings, while AI was utilized as a brainstorming partner to refine interpretations, validate analytical reasoning, and formulate data-driven recommendations. Students were also required to justify their analytical conclusions using statistical evidence presented in the dashboard, respond to questions, and critically evaluate alternative interpretations generated by AI. This stage provided authentic opportunities for students to demonstrate not only their analytical reasoning but also their professional communication skills in presenting data-driven solutions to engineering-related problems. This stage emphasized higher-order thinking by encouraging students to critically compare AI-generated suggestions with their own interpretations before presenting the final analytical conclusions. Figure 4 illustrates a representative example of the integration between the interactive dashboard, AI-assisted interpretation, and students' final presentation.

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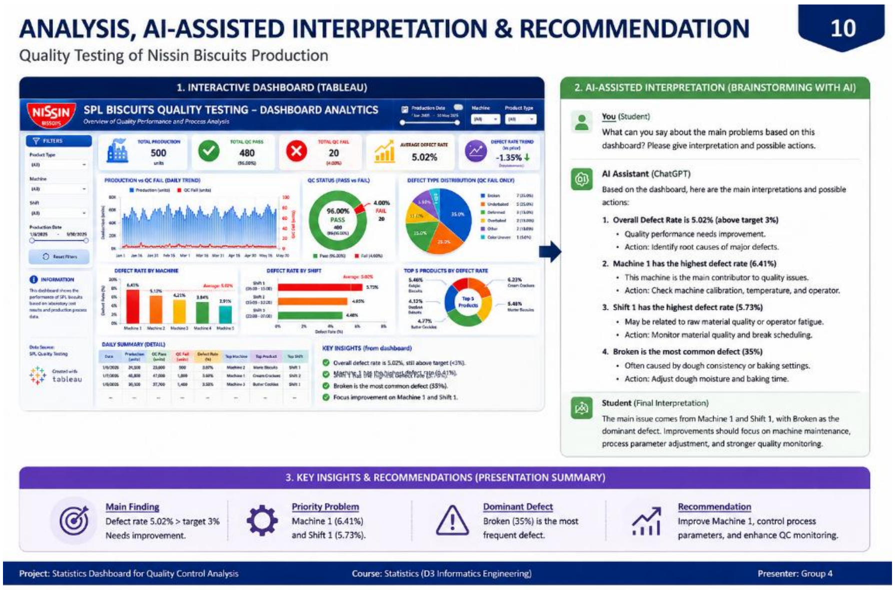

Figure 4. Integration of Interactive Dashboard, AI-Assisted Interpretation, and Students' Analytical Presentation

3.3. Discussion

The findings of this study indicate that students' statistical data analytics competencies were developed through a progressive learning process supported by three sequential authentic learning artifacts: AI-assisted authentic dataset development, interactive dashboard development, and AI-assisted analytical presentation [23], [34]. Rather than functioning as isolated learning products, these artifacts formed an interconnected competency pathway in which each artifact provided the foundation for the subsequent stage. This progression reflects the nature of statistical data analytics as a process that extends beyond technical computation to include data interpretation, critical reasoning, and evidence-based communication [3].

The first learning artifact, AI-assisted authentic dataset development, represents the stage of *knowing the data*. At this stage, students identified an industrial case, collaborated with AI to generate an initial dataset, and critically refined the generated data to ensure consistency with real-world conditions. This process required students to understand variable selection, data structures, contextual relevance, and data quality before conducting statistical analysis. Consequently, AI functioned as a cognitive support tool rather than an automatic solution, while students remained responsible for validating and contextualizing the dataset according to the selected industrial scenario.

The second learning artifact, interactive dashboard development using Tableau, reflects the stage of *representing the data*. Students transformed the validated dataset into meaningful statistical visualizations through key performance indicators, trend analyses, interactive filters, and quality control dashboards. This stage required the integration of statistical analysis, visual communication, dashboard design principles, and user interaction. The quantitative findings, which showed relatively high performance in data visualization, dashboard design, and dashboard interactivity, support the qualitative evidence that students were able to organize complex datasets into accessible and informative analytical displays [18].

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The findings also extend the current understanding of AI-enhanced learning by demonstrating that artificial intelligence can effectively function as a cognitive partner throughout different stages of statistical data analytics learning rather than merely serving as a technological assistant. In this study, AI supported students during authentic dataset construction, facilitated reflective interpretation of statistical findings, and encouraged evidence-based refinement of analytical conclusions. These findings are consistent with recent studies suggesting that generative AI promotes higher-order thinking when integrated into inquiry-oriented and problem-based learning environments [13], [24]. However, the present study further emphasizes that students remained actively responsible for evaluating, validating, and contextualizing AI-generated outputs, thereby preserving critical thinking and analytical autonomy throughout the learning process.

Another important finding concerns the role of authentic project-based learning in supporting competency development. Unlike conventional statistics instruction that frequently separates statistical analysis from practical application, the present learning design required students to engage with an authentic industrial case from the initial construction of the dataset to the final presentation of analytical recommendations. Such continuity enabled students to experience the complete analytical workflow commonly encountered in engineering and industrial practice [3], [35]. Consequently, statistical concepts were learned not as isolated computational procedures but as integral components of evidence-based problem-solving, reinforcing the practical relevance of statistics within vocational engineering education.

The competency hierarchy identified in this study also reflects the evolving competency requirements of data-driven industries. Contemporary engineering professionals are increasingly expected not only to analyze and visualize data but also to communicate analytical findings, justify recommendations, and collaborate with intelligent technologies in decision-making processes [36], [37]. By integrating AI-assisted dataset development, dashboard construction, and analytical presentation within a single project, the proposed learning approach mirrors authentic workplace practices where technical expertise, analytical reasoning, and professional communication are equally essential. Therefore, the learning design presented in this study provides a practical framework for strengthening graduates' readiness to participate in increasingly AI-supported engineering and industrial environments.

The third learning artifact, AI-assisted analytical presentation, represents the highest level of competency development, namely *reasoning and communicating with the data*. Students were required to interpret statistical findings, compare their interpretations with AI-generated suggestions, formulate evidence-based recommendations, and communicate their conclusions during presentations [27], [38], [39]. This stage shifted students' focus from producing analytical outputs to defending analytical arguments supported by statistical evidence. Such activities demonstrate that AI can effectively facilitate reflective thinking and strengthen analytical communication when employed as a collaborative learning partner rather than a substitute for human reasoning.

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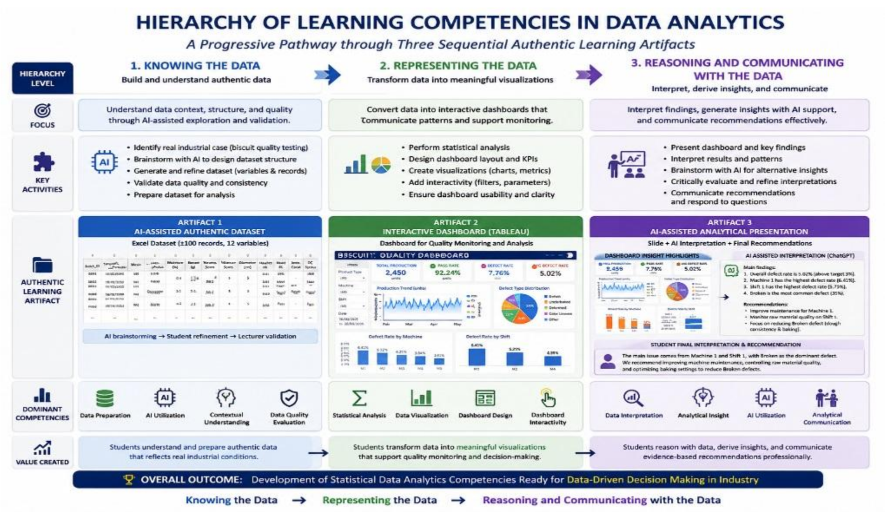

Figure 5. Hierarchical Development of Statistical Data Analytics Competencies

Collectively, the three learning artifacts illustrate a hierarchical model of statistical data analytics competency development . Students first learned to know the data, then represent the data, and ultimately reason and communicate with the data. This progression aligns with competency-based learning principles, in which higher-order competencies are developed upon the successful mastery of foundational and technical competencies. The integration of AI across all three stages further enriched the learning process by providing continuous cognitive support while preserving students' active role in data validation, analysis, interpretation, and communication.

From an educational perspective, these findings suggest that AI-assisted project-based learning offers a promising approach for developing statistical data analytics competencies in vocational higher education. Instead of emphasizing the use of AI or Tableau as instructional objectives, this study demonstrates that both technologies function as learning enablers that support authentic problem-solving experiences. The proposed sequence of learning artifacts may therefore serve as a practical instructional model for statistics and data analytics courses seeking to prepare students with the technical, analytical, and professional competencies required in contemporary data-driven industries.

Beyond its empirical findings, this study offers a conceptual contribution to statistics education by proposing a progressive pathway for developing statistical data analytics competencies through three sequential authentic learning artifacts. Rather than merely demonstrating students' ability to construct datasets, develop interactive dashboards, and deliver analytical presentations, the findings reveal that these artifacts collectively represent hierarchical stages of competency development: *knowing the data*, *representing the data*, and *reasoning and communicating with the data*. This competency hierarchy provides a structured pedagogical perspective that can be adapted to statistics and data analytics courses in vocational higher education, particularly those integrating AI-assisted Project-Based Learning to better prepare students for the analytical demands of data-driven industries.

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4. CONCLUSION

This study demonstrated that AI-assisted Project-Based Learning effectively supported the development of statistical data analytics competencies among engineering students in vocational higher education. Using a convergent mixed-methods design, the study combined competency-based assessment of interactive dashboard projects with qualitative analysis of three sequential authentic learning artifacts, providing complementary evidence of students' competency development. The findings indicate that AI-assisted dashboard development enhanced students' statistical reasoning, data visualization, and analytical interpretation, while simultaneously strengthening their ability to communicate analytical insights based on authentic industrial datasets.

Beyond its empirical contribution, this study proposes a hierarchical perspective of statistical data analytics competency development, progressing from *Knowing the Data, to Representing the Data, and ultimately to Reasoning and Communicating with the Data*. This hierarchy extends the current understanding of AI-enhanced statistics education by illustrating how authentic learning artifacts can progressively support competency development rather than merely facilitating technology use. The proposed approach provides a practical instructional reference for statistics and data analytics courses in vocational higher education and offers a foundation for future studies seeking to validate the competency hierarchy across different educational and industrial contexts.

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CONFLICT OF INTEREST

The author declares that there are no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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