

A Human-Centred Framework for Ethical Data Visualization and Storytelling

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Abstract— As data visualization becomes central to decision-making across domains, educators must prepare students not only to master technical tools, but also to communicate data ethically and effectively. This paper presents a scaffolded instructional approach for teaching data storytelling in an undergraduate information visualization course. Students progressed from designing static infographic posters to building interactive dashboards using the same real-world dataset, guided by structured feedback, user experience (UX) principles, and reflective practice. The course design was informed by a faith-driven educational philosophy, embedding values from Tawhidic Epistemology (TE), such as intention (niyyah), responsibility (amanah), and reflective consultation (shura), into each stage of the learning process. Students worked in groups, selected socially relevant datasets (e.g., mental health, environment), and applied design principles grounded in cognitive theory and user empathy. Outcomes were measured through comparative grade analysis across two cohorts (before and after implementing the structured model), as well as qualitative reflections. Results indicate a marked improvement in academic performance and ethical awareness, with the later cohort achieving a higher proportion of A grades and reporting increased clarity, purpose, and confidence in their designs. This paper contributes a transferable pedagogical model that bridges technical training, design ethics, and values-based learning in data visualization education.

Keywords— Data Visualization Education, User Experience (UX) Design, Tawhidic Epistemology (TE), Scaffolded Learning, Data Storytelling.

I. INTRODUCTION

The increasing ubiquity of data in everyday life demands that graduates not only analyze information but also communicate it meaningfully and ethically. In the context of ICT education, teaching data visualization involves more than mastering tools such as Tableau; it also requires cultivating an understanding of audience, clarity, cognitive load, and design ethics. However, many visualization courses still emphasize tool usage and chart diversity, with less focus on narrative design, ethical awareness, or user-centered thinking [2], [3].

This paper addresses that gap by presenting a scaffolded instructional model for teaching data storytelling in an undergraduate visualization course. Students began with a data-driven infographic poster assignment, then expanded their work into an interactive dashboard, using the same dataset across both tasks. This approach emphasized progressive complexity, structured feedback, and iterative learning, aligning with UX and cognitive design principles [4]–[5], [10].

In addition, the course was framed within a faith-driven educational paradigm, inspired by the principles of Tawhidic

Epistemology (TE). Rather than being treated as an abstract philosophy, TE was integrated into the design process through practices such as weekly student-led tazkirah (spiritual reflections), ethical dataset selection, peer consultation (shura), and reflective journaling (muhasabah). These values acted as ethical anchors, encouraging students to approach visualization as a trust (amanah) and to consider the broader impact of their designs on audiences.

This study aims to 1)Design and implement a scaffolded instructional model informed by Tawhidic Epistemology (TE) for teaching ethical data storytelling in an undergraduate Information Visualization course, 2)Evaluate the impact of the proposed model on students' academic performance, ethical awareness, and confidence in visualization design, 3)Examine students' reflections and project artefacts for evidence of value-based thinking, visual communication skills, and user-centred design practices.

Accordingly, this study addresses the following research questions:

- **RQ1:** How does a scaffolded, TE-integrated instructional model influence students' performance in data storytelling assignments?

- **RQ2:** What ethical and user experience (UX) design values do students develop through the proposed instructional approach?
- **RQ3:** How do students perceive their growth in ethical awareness, visual communication, and narrative intentionality throughout the learning process?

This paper reports on the implementation of this model across two student cohorts (2024 vs. 2025), using both quantitative and qualitative measures to evaluate its impact. The findings suggest that structured, feedback-rich, and value-anchored instruction can significantly enhance student performance, ethical reasoning, and design confidence. The paper concludes by offering a transferable teaching model for visualization educators seeking to balance technical instruction with ethical and epistemological depth.

The remainder of this paper is organized as follows. Section 2 outlines the background and problem statement, establishing the context and rationale for the study. Section 3 describes the course design, materials, and instructional strategies implemented. Section 4 details the methodology used to evaluate the approach. Section 5 presents the results and analysis, focusing on student performance, reflections, and project outcomes. Finally, Section 6 offers a synthesis of key findings and implications for the implementation of a scaffolded, faith-informed model in undergraduate visualization education. Throughout, the paper has been structured to clearly articulate the problem addressed, contextualize the pedagogical intervention, and present its objectives in a focused and coherent manner.

II. RELATED WORK

A. Ethical Dimensions of Data Visualization and Storytelling

Ethical considerations in data visualization have emerged as a central research theme over the last decade. Correll [1] was among the first to systematically highlight how choices in visualization design, scales, aggregation, and annotation are not neutral but carry normative implications. Building on this foundation, Bach, Correll, and Kaur [2] identify emerging practices in ethical data storytelling, including transparency in data provenance, audience-centered framing, and the need to surface uncertainty rather than obscure it.

Recent work has advanced this agenda along three dimensions: trust, representation, and pedagogy. Elhamdadi et al. [6] introduced Vistrust, a multidimensional framework that dissects trust in visualizations into cognitive and affective components, showing that even subtle design variations can shift users' confidence in the underlying data. Similarly, Hepworth and Church [7] warn that visualizations embed "arguments" about social phenomena, and failures to account for racial and cultural context can reproduce

harm. Al-Hazwani et al. [8] extend this discussion through data humanism, advocating for design practices that deliberately foreground imperfection, emotion, and context to avoid the illusion of objectivity.

Educational perspectives reinforce the importance of early ethical training. Baynes et al. [9] present a case study of embedding ethics modules in introductory visualization courses, while recent efforts to revise teaching codes (2024) emphasize fairness, transparency, and context, moving beyond the narrow concern of "lying with charts." Together, these contributions mark a shift from treating ethics as an add-on to positioning it as a core design principle in visualization pedagogy.

B. UX AND DESIGN LEARNING IN VISUALIZATION EDUCATION

Understanding the perceptual and cognitive underpinnings of visualization design remains foundational. Ware's [10] *Information Visualization: Perception for Design* continues to serve as a reference for mapping visual encoding to human perception. Yet, the conversation has moved toward embedding these perceptual insights into user experience (UX) frameworks tailored for learning. Nouri, Zhang, and Rapp [11] propose a UX design framework for digital learning environments that aligns usability, motivation, and inclusivity, demonstrating the value of holistic design in education.

Recent research highlights scaffolded and technology-mediated UX design. Menekse et al [12] show how real-time scaffolds can improve reflection quality and academic performance in large lecture courses, while Chaseley and Abercrombie [13] explore how scaffold types (descriptive vs critical prompts) influence reflective depth. Similarly, Liu and Wang [14] find that scaffolded reflective learning enhances both design performance and metacognitive growth in student teachers. From a technology lens, Børte et al. [15] emphasize aligning pedagogy with digital tool design, echoing Gkintoni et al. [16], who integrate AI and neuroscience insights to challenge traditional cognitive load assumptions in learning environments.

These findings suggest that UX in educational visualization must extend beyond interface usability to encompass reflective scaffolds, AI-driven personalization, and the cognitive demands of learners.

C. Faith-Based and Tawhidic Epistemology (TE) Pedagogy

Faith-based perspectives contribute a unique epistemological grounding to visualization education. Ibrahim and Osman [17] propose a conceptual model for integrating Islamic values into computing education, aligning learning processes with ethical virtues such as amanah (trustworthiness) and shura (consultation). Aljunied [18] frames this within the broader discourse of

Islamisation of knowledge, urging Islamic universities to harmonize empirical reasoning with Qur'anic principles.

Recent scholarship reflects increasing concern with digital transformation in Islamic pedagogy. Yunita [19] explores how educational technologies can support Islamic pedagogy by fostering justice and compassion, while Zahraini et al. [20] highlight the challenges of Islamic curriculum reform in the digital era. Other works [21, 22] illustrate the application of digital resources in Islamic religious education, showing both opportunities for innovation and risks of value dilution.

Together, these studies underscore that TE-aligned pedagogy provides more than cultural context: it establishes an ethical compass for visualization design, ensuring that narratives remain trustworthy, just, and spiritually grounded. This integration resonates with the call in visualization ethics for transparency and responsibility, offering a uniquely Islamic framing of the “why” behind ethical design.

D. Reflective and Scaffolded Learning for Visualization Pedagogy

Reflection is widely recognized as a driver of deep learning [23]. In visualization education, reflection helps students critique not only their design outputs but also their underlying assumptions and narrative framing. Recent empirical studies have sharpened our understanding of how scaffolding enhances reflective practice. Liu and Wang [14] demonstrate that scaffolded reflection improves both design performance and reflective thinking, while Rook et al. [24] report that students desire varied scaffolds and clear framing when reflection is integrated into higher education.

At the intersection of pedagogy and technology, new approaches leverage AI-mediated scaffolds. Yuan and Hu [25] speculate on how generative AI could serve as a reflective companion, delivering personalized feedback at scale. These developments align with the shift toward digital learning ecosystems where reflection is not an isolated activity but a guided, interactive process.

Scaffolded reflection also overlaps with ethical visualization practices. By prompting students to consider questions of representation, bias, and trust, scaffolds can bridge technical design skills with ethical awareness. This connection suggests that reflective pedagogy is not only about metacognition but also about cultivating professional responsibility.

E. Data Analysis as a Precursor to Visualization

A crucial but sometimes underemphasized component of visualization education is data analysis. Visualization is most effective when grounded in robust data wrangling, descriptive statistics, and exploratory analysis [26], [27]. Regression, clustering, and forecasting techniques not only

generate insights but also shape visualization choices and narrative framing.

An equally critical step is the choice of chart type, which serves as the bridge between analysis and visual communication. Chart selection is not arbitrary; it must align with the analytical task and the audience's interpretive needs. For instance, trends over time are best represented by line charts, distributions by histograms, comparisons by bar charts, and relationships by scatterplots [27]. Ware [10] emphasizes that perceptual principles such as clarity, salience, and cognitive efficiency determine whether a chart supports or hinders understanding.

From an educational standpoint, teaching chart choice cultivates both analytical literacy and visual reasoning. Students are challenged not only to analyze data but also to design visuals that truthfully represent distributions, comparisons, or correlations. Neri et al. [29] confirm in their review of data visualization in AI-assisted decision-making that the credibility of dashboards often hinges on whether the chosen charts faithfully represent the data's structure and uncertainty. Poor chart choice not only reduces interpretability but also raises ethical concerns by distorting meaning or amplifying bias.

Finally, the ethical dimension of visualization often originates in the analysis and charting stages. Okorie et al. [28] note that biases in sampling, cleaning, and modeling directly influence fairness and credibility. If these biases are compounded by inappropriate chart choice, the result can be highly misleading. Teaching students to interrogate both what the data says and how it is shown ensures accountability across the full pipeline, from raw analysis to final storytelling.

F. Implications for Visualization Education

The reviewed literature highlights that visualization education must evolve beyond tool proficiency toward a multidimensional model that equips students with both technical expertise and ethical responsibility. Five interconnected implications stand out as discussed below:

1) **Data Analysis and Chart Choice as Core Competence:** Visualization education must emphasize not only statistical literacy but also the ability to map analytical tasks to appropriate chart types. Choosing the right chart, line for trends, bar for comparisons, scatter for relationships, pie for part-to-whole, ensures that insights are communicated clearly and truthfully [27], [10]. Students who understand this analysis-to-visualization pipeline are better prepared to create visuals that are both informative and trustworthy.

2) **Visual Design Principles as Foundational Literacy:** At the heart of effective visualization lies perceptual alignment. Ware [10] underscores that clarity, salience, and hierarchy reduce cognitive load, while Gkintoni et al. [16] show how

poor design can overwhelm learners. Embedding design principles ensures students move beyond attractive visuals toward perceptually efficient and cognitively accessible representations.

3) Ethics as a Central Learning Outcome: Correll [1] and Bach et al. [2] emphasize that visualizations are never neutral, they carry arguments. Ethical education in visualization must therefore cover transparency, fairness, uncertainty, and context. Students should learn to anticipate ethical risks, from misleading encodings to biased data sources, and develop habits of responsible design.

4) UX and Reflective Scaffolding as Pedagogical Drivers: Research on scaffolded reflection [14], [12] demonstrates that structured support enhances both design quality and critical judgment. Incorporating UX frameworks [11] ensures that learning environments are inclusive and user-centered. Together, scaffolding and UX make visualization education more reflective, interactive, and adaptive to diverse learners.

5) Faith-Based and TE-Aligned Values as Ethical Anchors: In Islamic and values-driven contexts, visualization is also a moral and spiritual act. TE-aligned pedagogy [17] situates visualization within the virtues of amanah (trust), shura (consultation), and ihsan (excellence). This approach complements global ethical discourses by embedding visualization practice within cultural and spiritual integrity.

Together, these five pillars, data analysis and chart choice, visual design principles, ethics, UX and reflection, and TE values, form the foundation of a holistic model of visualization education. Such a model prepares graduates not only to use tools but also to design with clarity, empathy, and integrity in an era where visualization is central to decision-making, storytelling, and public trust.

III. COURSE DESIGN AND IMPLEMENTATION

This section outlines the instructional framework for the course, with a focus on the pedagogical strategies and philosophical principles that guided the design and delivery of the course. The approach centers on scaffolded learning, integration of TE, UX principles, and reflective teaching methods.

A. Course Overview and Learning Outcomes

The study was conducted in the undergraduate course for Information Visualization, offered at the Kulliyyah of ICT, International Islamic University Malaysia (IIUM). It aims to equip students with both technical and cognitive skills in designing effective, purposeful data visualizations. The course is a core requirement for final-year students from multiple ICT specializations, including Business Intelligence, Information Security and Assurance, and Digital Media Design, Enterprise Management and Technology, and

general specialization. While most students had prior exposure to Human-Computer Interaction (HCI) concepts through a prerequisite course, they had no prior experience in data visualization tools such as Tableau, nor in information or communication design theory.

The Course Learning Outcomes (CLOs) included, 1)Describe the underlying principles, techniques, and practices of the information visualization for effective decision making, 2)Demonstrate the ability to use a structured design process and an industrial tool to create effective visualizations, 3)Develop an interactive visualization system based on the storytelling principles to design coherent and insightful visualizations.

A total of 45 students were involved in the 2025 cohort, split across two sections (classes). The diversity of specializations, combined with their inexperience in visualization tools, made this course an ideal setting for implementing a scaffolded, ethically grounded instructional model.

B. Teaching Methodology: Scaffolded Project-Based Learning

The instructional strategy adopted a scaffolded learning model, where students progressed from a data-driven infographic poster assignment to an interactive dashboard project, using the same real-world dataset throughout. This approach enabled students to develop a strong conceptual understanding of data storytelling before translating it into interactive, functional formats.

Each stage of the project was supported by structured consultations, peer critiques, and iterative feedback loops that emphasized design clarity, ethical communication, and user orientation. The dataset selection was left to the students, who were guided to choose socially relevant, ethically safe topics such as mental health awareness, blood donation trends, food insecurity, or environmental sustainability.

C. Integration of Tawhidic Epistemology (TE)

The course was designed in alignment with the TE, which emphasizes the integration of faith, ethics, and knowledge. This philosophical foundation was embedded both explicitly and implicitly throughout the course delivery and assessments.

Key values included:

- 1) Niyyah (intentionality): Encouraging students to begin with ethical and purposeful design intentions.
- 2) Amanah (trust): Emphasizing the responsibility of data representation.
- 3) Ihsan (excellence): Striving for clarity, integrity, and balance in visual communication.

- 4) Shura (consultation): Practiced through class critique sessions and peer feedback.
- 5) Muhasabah (self-reflection): Embedded in the post-project reflections submitted by students.

Weekly 5-minute student-led tazkirah sessions were also integrated to strengthen spiritual engagement and ethical awareness.

D. UX, Visual Cognition, and Design Principles

The instructional content emphasized a human-centered, design-first approach rooted in principles from user experience (UX) and cognitive design theory. Students were introduced to:

- 1) Visual hierarchy and pre-attentive attributes (e.g., color, shape, size, alignment)
- 2) Gestalt principles (e.g., proximity, similarity, closure)
- 3) Story-first vs. chart-first design strategies
- 4) Accessibility guidelines for colour and layout (e.g., users with colour-blindness)
- 5) Ethical considerations in representing marginalized data or sensitive issues

These concepts were integrated through lectures, critique activities, and visual storytelling tasks that mirrored real-world scenarios.

E. Assignment and Project Structure

Both tasks were group-based, and together contributed 30% of the students’ total coursework marks (Infographic: 10%, Dashboard: 20%). The rubrics assessed data analysis, and interpretation, storytelling clarity, visual hierarchy, ethical alignment, UX considerations, and presentation.

TABLE 1:
THE FLOW OF ASSIGNMENT AND PROJECT STRUCTURE

Flow	Task	Description	Learning Outcome
1	infographic poster	static visual narrative using real-world dataset	understand basic visual encoding, structure, and narrative clarity
2	feedback & consultation	instructor-led critiques and peer feedback	develop critical thinking and reflective revision
3	interactive dashboard (tableau)	functional, multi-screen dashboard based on the same dataset	apply UX and storytelling principles in interactive design
4	presentation & reflection	final walkthrough of dashboard and student reflection	communicate design choices, receive live critique, and reflect on process

F. Tools and Instructional Support

To support the scaffolded learning process, students were equipped with a range of accessible tools. For data preparation and basic cleaning, most groups utilized Google Sheets or Microsoft Excel. For visual storytelling, students developed their infographic posters using Canva or, in some cases, Adobe Illustrator, enabling them to experiment with layout, visual hierarchy, and colour schemes. The interactive dashboards were built using Tableau, chosen for its intuitive drag-and-drop interface, industry relevance and strong support from its global user community.

Instructional support was delivered through multiple channels. The course included guided tutorials and hands-on activities to build foundational skills. Throughout the semester, students participated in in-class UX critiques and visual construction exercises, allowing them to refine their ideas collaboratively. The instructor provided formative, iterative feedback during consultation slots, reinforcing design intent, ethical framing, and alignment with storytelling objectives. Additionally, both the infographic assignment and the final dashboard project were evaluated using rubric-based assessments, providing structured expectations and reinforcing key learning outcomes.

G. Cohort Comparison and Iteration

This model was iteratively improved based on feedback from the 2024 cohort, who followed a more open-ended, less scaffolded project structure. The 2025 cohort received clearer milestones, integrated feedback points, and stronger ethical framing. This study compares outcomes between both cohorts to evaluate the pedagogical effectiveness of the structured model.

IV. METHODOLOGY

This study adopts a design-based research (DBR) approach, integrating pedagogical innovation with iterative evaluation in a real-world classroom context. The aim is to explore how a scaffolded, faith-informed instructional model anchored in the Tawhidic paradigm and UX principles affects student engagement, ethical awareness, and visual communication performance in an undergraduate Information Visualization course.

A. Research Design and Approach

A mixed-methods design was employed, combining quantitative data (e.g., assessment performance, grade distributions) with qualitative insights (e.g., open-ended reflections, student feedback, artifact analysis). The study design draws from constructivist learning theory, emphasizing the role of structure, reflection, and ethical intention in the development of data storytelling skills.

A pre-test and post-test structure was implemented to compare students' conceptual understanding before and after completing the course. Additionally, project artifacts and student reflections were collected to triangulate learning outcomes and assess deeper impacts beyond grades.

B. Participants and Course Context

The study involved Level 3 and final-year undergraduate students enrolled in the Information Visualization course across two different cohorts, Cohort 1 (2024, Semester 1) as the pre-intervention and Cohort 2 (2025, Semester 2) as the post-intervention.

Both cohorts were taught by the same instructor and followed the same syllabus structure. Students came from diverse ICT specializations, as mentioned in Section 3, but shared the same prerequisites, including a prior course in Human-Computer Interaction (HCI). Importantly, none had prior experience in Tableau or formal visualization training, as confirmed through a pre-test survey conducted in the beginning of the semester.

C. Learning Model and Interventions

The five-phase scaffolded model was designed to support students' growth from ideation to ethical communication, integrating modern UX principles with faith-based values. Each phase was aligned with practical tools and corresponding TE principles. Students in the 2025 cohort received a redesigned, scaffolded model with the features as depicted in the Figure 1.

The scaffolded structure emphasized intentionality in design, iterative feedback, and reflection, both cognitive and spiritual. Weekly 5-minute tazkirah sessions, led by students, provided a rhythm for ethical anchoring and peer connection. The 2024 cohort, in contrast, used the same assessment tasks but received minimal scaffolding, no formal design critique sessions, and no embedded reflective components.

The scaffolded learning model comprises five interconnected phases that progressively develop students' technical competence, ethical awareness, and reflective practice:

- Plan: Students identify a real-world problem, select an appropriate dataset, and define the intended audience while embedding niyyah (purposeful intention) and amanah (responsibility) in the design process.
- Design: Students transform the dataset into an infographic poster by applying principles of visual hierarchy, colour, typography, and storytelling, reflecting ihsan (excellence) and 'aql (intellectual reasoning).

- Critique: Students present their work for instructor consultation and peer review, practising shura (consultation), constructive feedback, and iterative refinement.
- Build: Students extend the infographic into an interactive Tableau dashboard, integrating usability, interaction, and analytical exploration while applying hikmah (wisdom) and tadabbur (thoughtful reflection).
- Reflect: Students complete reflective activities and participate in weekly student-led tazkirah, encouraging muhasabah (self-reflection) and reinforcing ethical responsibility in communicating data.

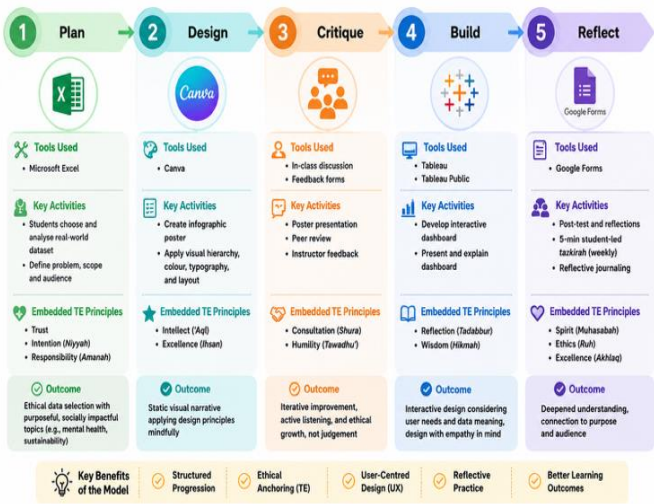


Fig. 1: Scaffolded Learning Model with Ethical Anchors from Tawhidic Epistemology (TE)

D. Instruments and Data Collection

To assess the impact of the revised model, data was collected using the following instruments in Table 2.

TABLE 2:
INSTRUMENTS USED IN THE STUDY

Instrument	Purpose	Data Type
Pre-test survey	Establish baseline for visualization and tool knowledge	Quantitative
Post-test survey	Assess understanding, confidence, ethical awareness, and students reflections (to capture student perception and personal growth)	Quantitative Qualitative
Final grade records	Measure academic performance across cohorts	Quantitative
Assignment artifacts	Evaluate design quality, storytelling clarity, UX and presentation	Qualitative (rubric-based)

V. RESULTS AND DISCUSSION

A. Data Analysis

1) Quantitative Analysis

The grade distribution comparison was conducted across both cohorts using the percentage of students achieving each final grade category as a descriptive indicator of academic performance. As shown in Figure 2, the 2025 cohort recorded a higher proportion of A grades (85%) compared with the 2024 cohort (55%), while the proportion of students obtaining A- and B+ or below decreased from 24% to 12% and from 21% to 3%, respectively. These descriptive findings suggest that the scaffolded, feedback-rich instructional model was associated with improved learning outcomes and more consistent student performance. The observed improvements align with previous studies highlighting the value of structured feedback [3], iterative design practice [30], and student agency [31] in promoting deeper learning and design quality. The embedded TE values may have further amplified student motivation and ethical awareness, encouraging purposeful work and deeper engagement.

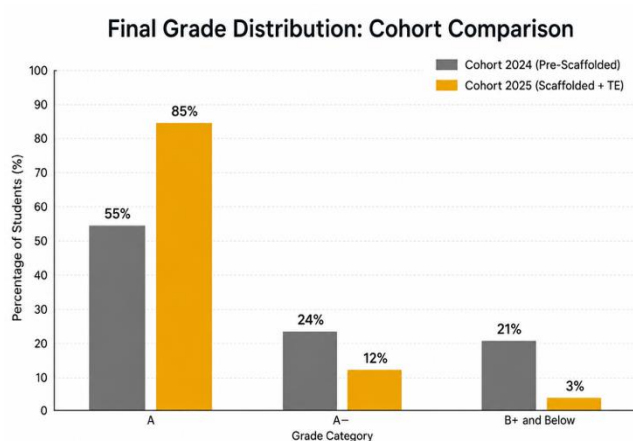


Fig. 2: Comparison of final grade distributions between the 2024 and 2025 cohorts. The scaffolded TE-integrated approach was associated with a higher proportion of A grades and fewer students in the B+ and below category.

2) Qualitative Analysis

The open-ended responses (students' reflections) were coded thematically using inductive analysis. Categories included: learning clarity, ethical decision-making, user empathy, confidence in storytelling, and value reflection (e.g., niyyah, amanah). Sample quotes were extracted to demonstrate students' evolving mindset regarding purpose-driven design and responsibility in communicating data.

B. Validity Considerations

Both cohorts used the same instructor, syllabus, and grading rubric, reducing instructional bias. While pre/post tests were anonymous, baseline analysis confirmed all students began with zero prior exposure to Tableau or information visualization. Although small in size, the study focused on depth of reflection and impact, typical of design-based research. The inclusion of student-led tazkirah and values reflection was not treated as a religious evaluation but as a pedagogical strategy to embed intentionality and ethics, consistent with TE-based education [31]-[32].

C. Thematic Insights from Student Reflections

Open-ended responses gathered from both sections revealed strong qualitative support for the scaffolded, reflective learning model. Five dominant themes emerged: intentional design, confidence growth, peer empathy, UX awareness, and faith-driven reflection.

1) Many students expressed increased confidence through hands-on practice:

"Tableau made it easy for me by drag and drop I could design without needing to code."

"I work better by doing. The Tableau project helped me explore data and tell the story I want."

2) Others highlighted the value of critique and teamwork:

"Critique sessions helped me see my blind spots and improve with confidence."

"We learn from the feedback, how to be better, not just what's wrong."

3) Several reflections revealed awareness of design as ethical communication, not just visual creativity:

"The most challenging part was making sure the dashboard is clean and not misleading."

"It's hard to balance between beauty and usefulness."

"Now I know how colours and layout can change what users feel."

4) Students also recognized their growth in applying UX and design principles intentionally:

"I learned how to reduce clutter and highlight what matters to the user."

"Visual hierarchy is so important, I didn't realize it before this class."

D. Impact of TE-Embedded Reflection

Beyond technical competence, the integration of Tawhidic Epistemology (TE) encouraged students to reflect on the ethical and social responsibilities associated with

data visualization. Analysis of the students' reflective responses revealed four key outcomes:

- Purposeful design through *niyyah*: Students became more intentional in selecting socially relevant topics and designing visualizations that conveyed meaningful messages.
- Ethical responsibility through *amanah*: Students recognised that visualizations should communicate information truthfully, clearly, and without misleading the intended audience.
- Continuous self-improvement through *muhasabah*: Reflection activities encouraged students to evaluate their own design decisions and identify opportunities for refinement.
- Values reinforcement through weekly *tazkirah*: Short student-led reflections strengthened awareness of ethical communication and connected technical work with broader personal and professional responsibilities.

These findings are illustrated through representative student reflections:

"The *tazkirah* helped me think of design as part of responsibility and ethics."

"I chose a topic that aligns with my values, because I believe in doing what matters."

"Designing with *niyyah* made me rethink how I communicate visually."

"This course reminded me that data is not just numbers, it's trust."

These reflections support TE emphasis on integrating 'aql (intellect) and ruh (spirituality) in the pursuit of knowledge. By embedding Islamic values into the learning process, not through overt preaching, but through reflective design, the course facilitated not only technical growth but also moral and spiritual development.

E. Representative Students' Projects

The following student projects were selected to illustrate how the scaffolded, TE-embedded instructional model fostered ethical, purposeful, and visually effective data storytelling. Each group was required to conceptualize a real-world problem, design a data-driven infographic poster, and later extend it into an interactive Tableau dashboard. Weekly critique sessions, peer feedback, and reflective prompts were embedded throughout the project timeline.

1) Project 1 – Plastic Waste and Environmental Impact in Malaysia

This group focused on plastic pollution in Malaysia by integrating diverse datasets from local environmental agencies (CAP, Ministry of Housing) to academic sources (NCBI). Their infographic poster provided a well-structured

visual narrative showing the lifecycle of plastic waste, recycling challenges, and microplastic effects on marine life. The message-first layout incorporated iconography, simplified graphs, and color harmony, conveying urgency without overwhelming the viewer.

Their Tableau dashboard extended the narrative with interactive components:

- A forecasting chart on recycling rates from 2020–2030 using polynomial regression
- A geospatial map visualizing countries exporting plastic waste to Malaysia
- Treemaps and donut charts showing composition of waste types and environmental impact

The team used annotations, guided titles, and clear legends to maintain readability. Through this, they demonstrated mastery of ethical framing (*amanah*), visual hierarchy (*ihsan*), and intentionality (*niyyah*). Their topic choice and design decisions reflected both data literacy and spiritual responsibility.

2) Project 2 – Public Transport Ridership Trends in Klang Valley (2020–2024)

This group investigated shifts in public transport usage across MRT, LRT, BRT, and KTM systems in Klang Valley. Their infographic highlighted yearly ridership trends, weekday vs. weekend differences, and the effect of government initiatives. Strategic colour use and visual storytelling created a narrative flow titled "From Monday Rush to Sunday Calm."

The Tableau dashboard evolved into a robust, multi-layered system featuring:

- Time-series ridership trends annotated with public holidays and MRT expansion phases
- A calendar-based view mapping spikes in travel to national events
- Fare structure comparisons using stacked bars and custom tooltips

"We didn't just visualize numbers, we started seeing patterns in society."

"The dashboard answered a real-world question for us."

This project showcased the ability to move beyond descriptive charts into interpretive storytelling. They exemplified *hikmah* (wisdom) in visual synthesis, *shura* (consultation) through weekly feedback loops, and *muhasabah* (reflection) in their ethical consideration of design bias.

Both projects illustrate the pedagogical value of combining structured scaffolding with reflective and ethical framing. Students not only developed technical proficiency

but demonstrated sensitivity toward audience, ethics, and narrative integrity. The outcomes support the central claim of this study that scaffolded, TE-informed instruction cultivates holistic data storytellers ready for real-world impact. Figures 3–5 present representative examples of students’ progression from static infographic posters to interactive Tableau dashboards.

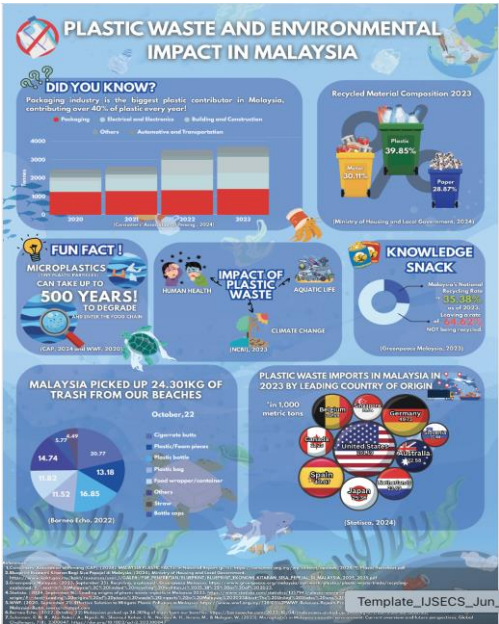


Fig. 3: Scaffolded progression of the plastic-waste project 1, from a static infographic poster to selected interactive Tableau dashboard views using the same dataset.

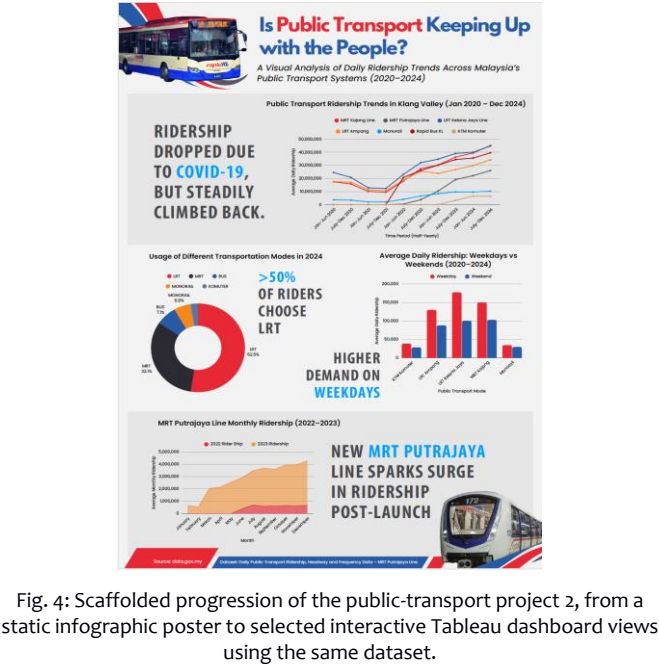
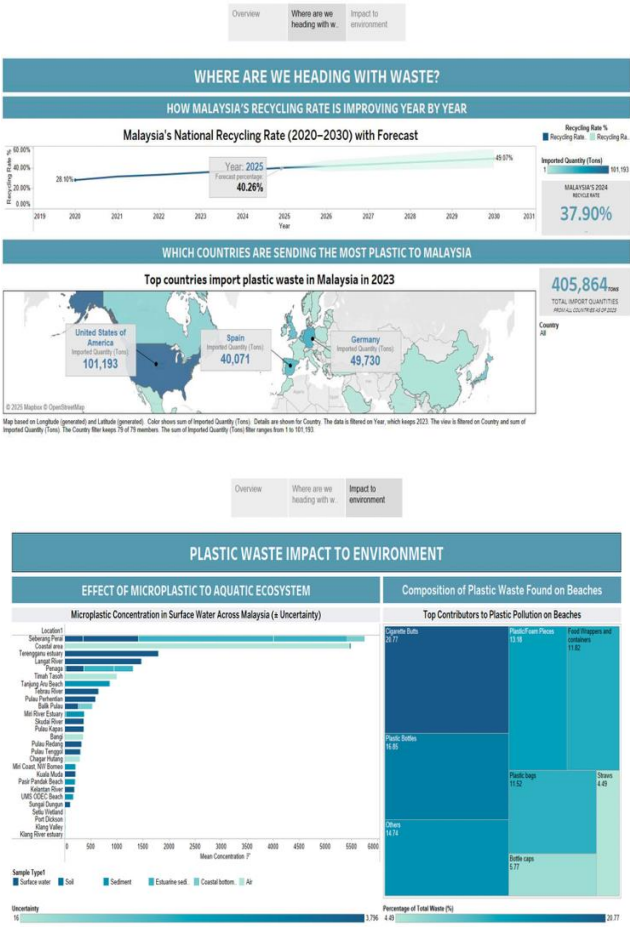
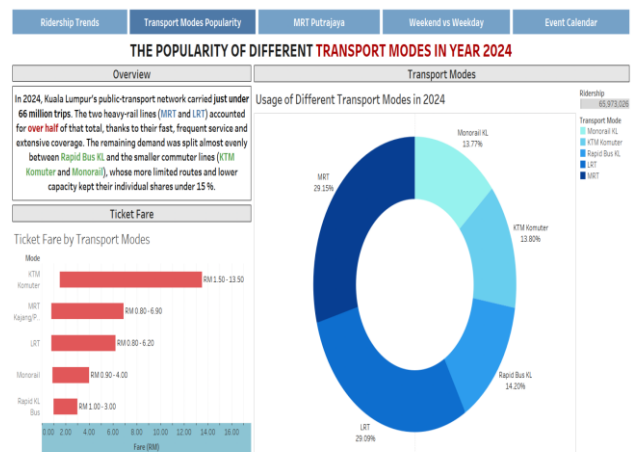
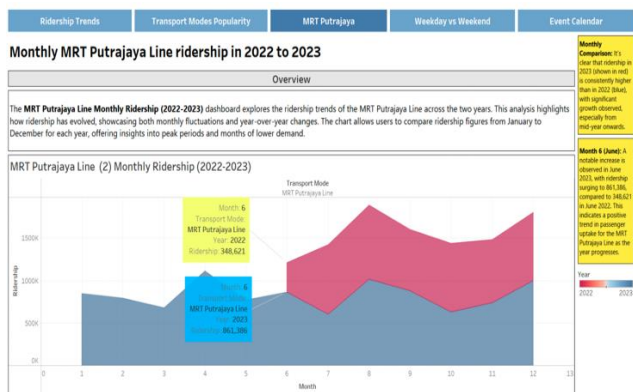
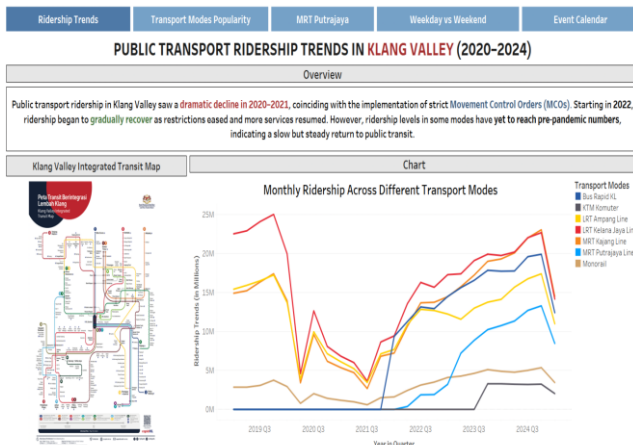


Fig. 4: Scaffolded progression of the public-transport project 2, from a static infographic poster to selected interactive Tableau dashboard views using the same dataset.



Together, the paired artefacts illustrate how students retained continuity in topic, dataset, and narrative purpose while progressing from static visual communication to interactive analytical exploration. The transition demonstrates the development of visual hierarchy, user-centred interaction, data storytelling, and ethical design judgement through the scaffolded learning process.

VI. LIMITATIONS AND LESSONS LEARNED

While the outcomes of the scaffolded, TE-integrated teaching model are encouraging, several limitations must be acknowledged. Firstly, the study did not employ a matched pre-test/post-test design, which limits the ability to conduct rigorous statistical analysis of individual learning gains. Although all students reported no prior knowledge of Tableau or data storytelling concepts, this claim was self-reported and not validated through standardized measurement instruments.

Secondly, the final grade distribution used for quantitative comparison reflects students' overall course performance, which includes assessments beyond the infographic and dashboard project. As such, isolating the direct impact of the scaffolded design process on those specific assessments requires a more focused grading structure in future iterations.

Additionally, the study was conducted in a single-instructor, single-course context within one institution, involving a relatively small number of students across two cohorts. These factors may limit the generalizability of the findings to broader educational settings. Despite this, the structured approach supported by shared rubrics, datasets, and reflective activities provides a transparent and replicable model that can inform similar interventions in other UX, HCI, or visualization-related courses.

VII. SUMMARY OF INSIGHTS

The findings from both quantitative and qualitative analyses offer strong support for the effectiveness of the scaffolded, TE-informed instructional model. Across both sections, students demonstrated clear gains in performance, design maturity, and ethical awareness. This section synthesizes key observations in relation to the study's three research questions.

- RQ1: How does a scaffolded, TE-integrated instructional model affect students' performance in data storytelling assignments?

The comparative grade distribution across cohorts revealed that the 2025 cohort who engaged in the scaffolded assignment-to-dashboard model achieved higher proportions of A grades, with substantially fewer lower-grade outcomes than the previous cohort. This contrasts with the previous semester where similar project outcomes showed more grade variability. These results suggest that the structured and reflective approach not only enhanced design quality but also supported consistency in learning outcomes.

- RQ2: What ethical and UX design values do students develop through this approach?

Students consistently applied UX and visual design principles such as clarity, hierarchy, alignment, and narrative

sequencing in both infographics and dashboards. Moreover, qualitative responses and final project artifacts reflected an awareness of amanah (trust in representing data truthfully), niyyah (purposeful storytelling), and ihsan (excellence in design). Weekly tazkirah sessions and critique activities supported ethical reflection and the translation of Islamic values into visual communication practice.

- RQ3: How do students perceive their growth in ethical awareness, visual communication, and narrative intentionality?

Post-course reflections and quotes revealed increased confidence in decision-making, heightened awareness of design ethics, and appreciation for the connection between intention and audience impact. Students expressed that they no longer saw data visualization as “just charts,” but as a form of communication with meaning and consequence. The integration of faith-based values with technical content deepened their engagement and sense of accountability in design work.

In summary, the model fostered technical proficiency, ethical literacy, and narrative empathy attributes critical for future-ready, faith-conscious digital storytellers.

In addition to project outcomes and post-course reflections, the Student Feedback on Teaching and Learning (SFS) data provided further validation of the course's effectiveness. Across both sections, students rated the instructor's teaching effectiveness between 95.96% and 97.69%, and overall course satisfaction between 94.34% and 97.36%. Notably high scores were given in areas such as critical thinking development, Islamic integration, constructive feedback, and respect for students. Written feedback praised the structured, step-by-step delivery, clarity of instruction, and engaging classroom environment. As one student remarked:

“Arguably the best course I've ever enrolled in. The productive classes made me not want to skip any sessions.”

These results strengthen the qualitative findings and suggest that the scaffolded, TE-informed instructional model not only enhanced performance and ethical design awareness but also contributed to a highly positive and motivating learning experience.

VIII. CONCLUSIONS AND FUTURE WORK

This study presents a structured and ethically anchored teaching model for data storytelling, implemented in an undergraduate Information Visualization course. Rooted in Tawhidic Epistemology and guided by scaffolded learning principles, the model moved students through a five-phase progression from dataset selection to visual reflection framing visualization not merely as a technical output but as a trust-bearing act of communication.

The integration of spiritual reflection (via weekly tazkirah), guided design tools (Canva and Tableau), and iterative feedback (UX) led to improvements in student engagement, academic performance, and ethical awareness. Students not only demonstrated design competence but developed a deeper sense of niyyah (intention) and amanah (responsibility) in how they represented and narrated data. These findings echo emerging perspectives on holistic education [23], [31]-[32], where technical mastery is balanced with spiritual, ethical, and emotional intelligence.

For future iterations, improvements may include matched pre- and post-assessments, rubric-linked tracking of narrative and visual clarity, and the expansion of this model to postgraduate or interdisciplinary contexts. Additionally, future research may explore the longitudinal impact of this approach on students' ethical reasoning, professional decision-making, and design mindset beyond the classroom.

Ultimately, this study contributes a practical and transferable framework for integrating scaffolded learning, user experience principles, and Tawhidic Epistemology into data visualization education. By demonstrating how ethical reflection can be embedded alongside technical skill development, the proposed model extends conventional visualization pedagogy beyond tool proficiency towards purposeful, human-centred, and responsible data storytelling. The framework may serve as a useful reference for educators seeking to cultivate technically competent, ethically grounded, and socially responsible future data storytellers.

CONFLICT OF INTEREST

The author declares that there is no conflict of interest regarding the research, authorship, and publication of this article.

AUTHOR CONTRIBUTION STATEMENT

Madihah Sheikh Abdul Aziz solely conceived and designed the study, developed the instructional framework, conducted the course implementation, collected and analysed the data, interpreted the findings, prepared the figures, and wrote, reviewed, and revised the manuscript.

DATA AVAILABILITY STATEMENT

The data supporting the findings of this study consist of anonymized student assessment records, reflective responses, and project artefacts collected during the Information Visualization course. Due to institutional and ethical considerations, these data are not publicly available but may be made available by the corresponding author upon reasonable request, subject to institutional approval.

ETHICS STATEMENT

This study was conducted within the context of normal teaching and learning activities in an undergraduate Information Visualization course. Student assessment records, reflections, and project artefacts were anonymized prior to analysis, and no personally identifiable information is reported. The study complies with the ethical principles governing educational research at the authors' institution.

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