Journal of Theoretical and Applied Information Technology
15th April 2025. Vol.103. No.7

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

THE VISUAL PERCEPTION LEARNING MODEL BASED ON INCLUSIVE DESIGN TO ENHANCE DATA STORYTELLING SKILLS IN DIGITAL VISUALIZATION

PARWAPUN KAMTAB[1]

[1]Department of Education Technology and Information, Faculty of Technical Education,

King Mongkut's University of Technology North Bangkok, Thailand

E-mail: [1]parwapun.k@fte.kmutnb.ac.th

ABSTRACT

This study investigates the impact of a visual perception learning model based on inclusive design principles on improving data storytelling skills in digital visualization—an important competency in the changing landscape of information technology (IT). As data-driven decision-making becomes more prevalent across industries, effective data storytelling is critical for communicating complex insights. This study contributes to IT by introducing a systematic learning framework and interactive digital tools that assist learners in creating accessible and impactful visual narratives. The framework has five major stages: exploration, conceptualization, application, evaluation and iteration, and reflection. These stages help learners understand the relationship between visual perception and inclusive design, promoting the creation of high-quality data visualizations. Expert evaluations gave the model a high overall rating of 4.86 out of 5 stars. Participants demonstrated significant improvement in their understanding of visual perception and inclusive design, with a strong correlation between the two concepts (r=0.784). The digital learning tools, which were designed to be accessible and engaging, received positive usability feedback (M=4.73, S.D.=0.41) and effectively motivated learners. Assessment results also showed that participants improved their data storytelling skills (M=4.41, S.D.=0.64), demonstrating proficiency in both tool usage and visualization design. While the study emphasizes strengths, it also identifies challenges in simplifying complex data, creating compelling narratives, and mastering advanced visualization tools. These findings highlight the importance of inclusive design in IT education, providing learners with the necessary digital skills to create professional, engaging, and accessible visualizations. This study emphasizes the importance of continued advancements in IT-driven learning models for improving storytelling techniques and digital data visualization skills.

Keywords: *Visual Perception, Inclusive Design, Data Storytelling, Digital Visualization, Learning Model*

1. INTRODUCTION

In the digital age, data has become an asset in a variety of industries, making effective digital data visualization a prerequisite. Digital data visualization is more than just presenting information visually; it must also include data storytelling to ensure that audiences understand and make informed decisions [1]. However, several persistent challenges impede the effectiveness of data storytelling and limit its reach to a larger audience. One significant issue is a lack of knowledge about visual perception principles in data visualization design. Effective data visualization is based on how humans perceive and interpret visual information [2]. However, current practices frequently make poor use of color, making data difficult to read, and rely too heavily on complex charts and graphs that lack adequate explanations. Furthermore, many visualizations ignore visual hierarchy, resulting in unclear and unstructured information presentation. Another critical concern is a lack of inclusive design principles, which limits accessibility for a wide range of user groups, including those with visual impairments or those with no prior knowledge of data interpretation [3-6].

Furthermore, an overemphasis on statistical representation in the absence of a compelling narrative structure frequently results in complex, difficult-to-understand visuals that fail to establish an emotional connection with the audience [7]. The use of excessively technical language, combined with a lack of cohesive storytelling structure, contributes to disengagement and poor comprehension. While there are numerous tools for creating data visualizations, many are either too complicated for beginners or do not provide

structured learning pathways to support the development of systematic data storytelling skills [8].

In the digital age, data has emerged as a vital asset across multiple sectors, rendering proficient digital data visualization an essential skill. Digital data visualization transcends mere aesthetic presentation; it must integrate data storytelling to facilitate audience comprehension and informed decision-making [7]. Nevertheless, numerous enduring challenges impede the efficacy of data storytelling and restrict its accessibility to a wider audience.

A major concern is the insufficient comprehension of visual perception principles in the design of data visualizations. Effective data visualization depends on human perception and interpretation of visual information. Nevertheless, prevailing practices frequently exhibit ineffective color utilization, rendering data challenging to interpret, alongside an overdependence on intricate charts and graphs lacking sufficient elucidation. Moreover, numerous visualizations neglect to incorporate visual hierarchy, leading to ambiguous and disorganized information presentation [8-9]. A significant issue is the absence of inclusive design principles, which limits accessibility for various user groups, including individuals with visual impairments and those lacking prior knowledge of data interpretation [10].

Furthermore, an excessive focus on statistical representation devoid of a compelling narrative structure frequently yields intricate, challenging visualizations that do not foster an emotional connection with the audience. The employment of excessively technical terminology, combined with an absence of a coherent narrative framework, exacerbates disengagement and diminishes understanding. Although numerous tools exist for data visualization, many are either overly intricate for novices or deficient in organized learning frameworks to facilitate the cultivation of systematic data storytelling competencies [11-12].

Visual perception is essential for effective digital data visualization and narrative construction [13]. Nevertheless, contemporary visualization design frequently neglects essential perceptual principles [14], resulting in superfluous complexity, diminished understanding, and compromised clarity. Implementing these principles can synchronize data presentation with human cognitive functions [15], reducing misinterpretations and improving the overall efficacy of data storytelling.

A crucial element is the strategic application of color to enhance clarity. Color is a crucial component that attracts attention and communicates relationships within data [16]. Nevertheless, inappropriate application such as insufficient contrast, excessive dependence on color differentiation without supplementary indicators, or non-intuitive color coding can render visualizations challenging to interpret. The implementation of high-contrast color schemes and purposeful color encoding can markedly improve clarity [17]. Moreover, visual hierarchy directs users' attention to essential information initially, employing elements like font size, weight, spacing, and graphical emphasis to steer focus. This principle mitigates information overload and enhances the coherence of the narrative process [18].

The choice of suitable chart types influences data understanding. The improper use of visual elements, such as utilizing pie charts for closely related values or employing three-dimensional charts that distort data representation, can impede effective communication. Selecting appropriate visualization formats, integrating visual indicators, and reducing extraneous elements enhance clarity and facilitate interpretation [19].

Inclusive design is essential for enhancing the accessibility of data storytelling for diverse audiences, especially for those lacking robust data literacy skills. Utilizing alternative representations, including symbol-based indicators, audio descriptions, or additional text annotations, can improve accessibility for all users. Organizing content in an accessible format diminishes obstacles to data understanding [20].

Utilizing visual perception principles in data storytelling facilitates the development of narrative frameworks that correspond with human cognitive processing. Methods such as focal points, chronological sequencing, and significant visual metaphors augment engagement and facilitate intuitive information processing for audiences. Incorporating these principles into educational frameworks can assist learners in cultivating proficient data storytelling abilities and creating visualizations that meet users' requirements in a data-centric environment [21].

This study seeks to create a learning model that combines visual perception principles with inclusive design to improve data storytelling abilities in digital data visualization. This model will empower learners to produce clear, engaging, and accessible visualizations for varied audiences. This research enhances the efficacy of data storytelling in digital visualization, fostering a more inclusive and thorough method of data communication, thereby ensuring that information is accessible,

comprehensible, and influential across diverse contexts. The proposed learning model will rectify existing limitations and fulfill societal demands for more effective and inclusive digital data storytelling.

2. LITERATURE REVIEW

2.1 Visual Perception Learning

Visual perception learning is a fundamental cognitive process that allows people to effectively interpret, organize, and analyze visual information [22]. This learning process, which is based on theories such as Gestalt Theory and Gibson's Ecological Theory of Perception, is critical for improving pattern recognition, spatial organization, and visual interpretation skills in data storytelling. According to research, repeated exposure to structured visual stimuli improves perceptual abilities, especially in educational fields such as mathematics and science [23]. The use of digital tools such as interactive visualizations, augmented reality, and artificial intelligence-driven adaptive learning systems has increased the potential for visual perception learning. These technologies enable immersive and personalized learning experiences, promoting a deeper understanding of complex data representations. Furthermore, color theory, spatial arrangement, and appropriate graph selection all have a significant impact on the clarity and effectiveness of data visualization [24]. As neuroscience and artificial intelligence continue to shape this domain, future research should investigate adaptive models that optimize visual perception training, making data storytelling more engaging, inclusive, and effective in the digital age [25].

2.2 Inclusive Design

Inclusive design seeks to make information presentation accessible to people of varying abilities, cognitive perceptions, and cultural backgrounds. This approach's key principles include universal design, multimodal information presentation, and graphic element customization to meet the needs of individual users. Furthermore, cognitive load is an important factor in reducing the complexity of understanding information [26]. Cultural adaptability is also necessary to ensure that symbols, colors, and narrative structures are consistent with users' backgrounds. Inclusive design is critical in educational media because it allows learners with different abilities and learning styles to access and comprehend information in an equitable manner. The use of various instructional media, such as interactive videos, easily understandable infographics, animations, and learning platforms that encourage learner interaction, improves learning experiences [27-28]. According to research, inclusive educational media design promotes deeper understanding, more effective learner engagement, and the development of critical thinking skills by making complex data analysis more accessible [28]. However, challenges remain in tailoring content for diverse target groups and creating adaptable media that can be tailored to individual learners' needs. To ensure comprehensive and effective learning through data-driven approaches, flexible content must be designed, as well as educators trained to effectively use and create instructional materials that cater to diverse learners.

2.3 Data Storytelling Skills

Data storytelling is an essential skill for effective data-driven communication, as it combines data analysis, design, and storytelling to convey insights in an understandable manner [30]. Research indicates that storytelling improves audience perception and retention of information because humans process visual and narrative formats more effectively than raw data.

This skill includes important components such as data quality, which must be accurate, reliable, and relevant to the intended message; appropriate graphic representation, such as charts, graphs, or heatmaps, to aid comprehension of data trends and relationships; and structured storytelling, which organizes information in a logical sequence, allowing the audience to connect events and concepts systematically. Audience consideration is also necessary, as it requires an understanding of their background knowledge and interests to tailor the presentation appropriately [31-32].

Data storytelling is now widely used in education to help learners develop analytical and interpretative skills, improve critical thinking, and make more rational decisions. However, challenges remain in simplifying complex data without distorting facts, emphasizing the importance of neutral and bias-free presentation. The development of automated data analysis tools improves interactive and user-adaptive storytelling experiences.

2.4 Digital Visualization

Digital visualization is the process of creating digital representations of data to convert complex information into understandable and actionable insights [2]. Users can better perceive trends, relationships, and patterns when data is presented visually, using various formats such as charts, graphs, heat maps, and interactive visualizations

essential tools in an era of massive data volumes [33]. Digital visualization is critical to improving decision-making and data analysis accuracy. The core principle of digital visualization is to select the appropriate visualization type based on the nature of the data. For example, bar charts are useful for comparing grouped data, line graphs effectively depict trends over time, heat maps depict density variations in complex datasets, and geographic maps improve spatial data representation [34]. Effective visualization design must consider visual perception principles such as using color to highlight key information, structuring data hierarchies for better comprehension, and employing visual formats that reduce users' cognitive load. Tableau, Power BI, and Google Data Studio are popular digital visualization tools that allow users to create complex, customizable visual data representations [35-36]. In the educational sector, visualization techniques help learners and researchers understand complex concepts through graphical communication [37]. As digital visualization evolves, the emphasis remains on improving accessibility, ensuring adaptability across multiple contexts, and allowing users to effectively interpret and leverage data for maximum benefit.

3. OBJECTIVES OF THE RESEARCH

3.1 To develop a learning model for visual perception based on the concept of inclusive design to enhance data storytelling skills in digital visualization.
3.2 To develop digital learning media for visual perception based on the concept of inclusive design.
3.3 To examine the effects of enhancing data storytelling skills in digital visualization.

4. RESEARCH METHODOLOGY

This study addresses potential threats to validity, including internal, external, and construct validity, using data triangulation, expert validation, and diverse participant inclusion. To ensure rigor, the critique criteria are structured using established frameworks in visual perception, inclusive design, and data storytelling. The key criteria are clarity and comprehensibility, engagement and interactivity, inclusivity and accessibility, and skill transferability, all of which are supported by relevant literature. By systematically addressing these issues, the findings' credibility and applicability in the context of digital data visualization and storytelling are improved.

The research methodology was divided into three phases and five steps based on the following research objectives:

Phase 1: Development of a learning model for visual perception based on the concept of inclusive design to enhance data storytelling skills in digital visualization

This study begins with a thorough review of relevant literature and research, concentrating on theories and concepts related to visual perception, inclusive design, data storytelling, and digital data visualization. The synthesis of key insights from this review helps to identify the learning model's essential components and stages.

The next step is to assess actual needs and challenges. Data is gathered through interviews with learners, instructors, and relevant stakeholders to identify specific issues and requirements for improving data storytelling skills in digital data visualization. The findings of this analysis form the basis for developing an initial prototype of the learning model.

Following that, a draft learning model is created, which outlines the learning objectives, content, activities, and learning materials that are consistent with visual perception principles and inclusive design concepts. Furthermore, a conceptual framework is established that includes the following aspects:

- The learning process involves exploring, setting goals, conceptualizing, applying, evaluating, iterating, reflecting, and sharing knowledge.
- Evaluation methods include formative assessment during learning, summative assessment based on outcomes, and feedback mechanisms.
- Tools and technologies include digital visualization tools, accessibility checkers, and collaborative digital platforms.
- Learning outcomes include data analysis and interpretation, visualization design, data storytelling, tool proficiency, and presentation skills, as shown in the conceptual framework in Figure 1.

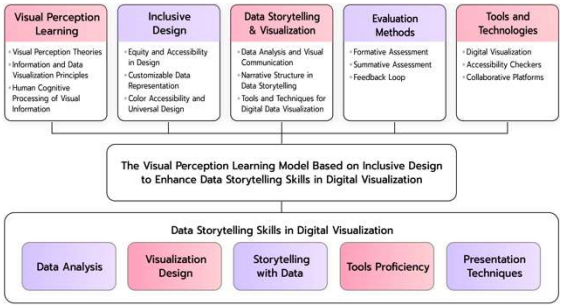

Figure 1: The Conceptual Framework of The Visual Perception Learning Model Based on Inclusive Design

The final step is to evaluate and refine the draft learning model with expert feedback. Five learning design specialists evaluate the model's feasibility and effectiveness using the conceptual framework, learning process, and expected learning outcomes. This evaluation is carried out using a five-point Likert scale. Expert review insights are then used to refine the learning model, ensuring its quality and practical applicability.

Phase 2: Development of digital learning media for visual perception based on the concept of inclusive design

The development process of this learning media follows the System Development Life Cycle (SDLC), which consists of five main stages as follows:

1) Planning and Requirement Analysis

This stage entails gathering basic information about visual perception and inclusive design concepts, as well as guidelines for creating accessible and effective web-based learning materials for the intended audience. It also includes an analysis of learners' needs for data storytelling skills in digital visualization via expert interviews and surveys. The collected data is then used to define the essential features of the learning media that are consistent with the research objectives.

2) Media Design

The design of digital learning media in a web-based learning format focuses on creating a variety of content types, such as infographics to visually explain key concepts, motion graphics to simplify complex information, micro-videos for short, engaging knowledge delivery, and interactive digital media to create an engaging and interactive learning environment. The design process adheres to user-centered design and universal design for learning principles to ensure accessibility and usability for learners of various abilities and learning contexts.

3) Development and Testing

The media is created using the rapid prototyping approach, which involves multiple iterations of testing and refinement. The quality assessment process includes expert review by specialists in visual perception, inclusive design, and digital learning media, as well as user testing with the intended learners. The evaluation prioritizes accessibility, effectiveness, and user experience to ensure high-quality and efficient learning media.

4) Deployment

The learning media is delivered to the target audience via a web-based platform, ensuring broad accessibility. Training sessions and user guidelines are provided, as well as feedback to help refine the media further. The deployment phase focuses on accessibility and flexibility to improve the overall learning experience.

5) Maintenance

Ongoing maintenance and updates ensure that the learning media is effective and sustainable in the long run. This includes updating content to reflect emerging trends in visual perception and digital data visualization, improving UX/UI based on user feedback, and resolving system errors to ensure proper operation. Regular maintenance ensures that web-based learning media remain adaptable and meet learners' changing needs.

Phase 3: Study of the effects of enhancing data storytelling skills in digital visualization.

1) Experimental Research Design

This study uses an experimental research design with a population of graduate learners from the Faculty of Education. The sample group for this study is made up of 25 graduate learners from the Department of Education Technology and Information, Faculty of Technical Education, King Mongkut's University of Technology North Bangkok. These learners are enrolled in courses focused on design and data analysis. The sample is drawn using a purposive sampling method.

A quasi-experimental design approach is used, with a one-group pre-test and post-test design. The research instruments include a knowledge test that assesses visual perception and inclusive design concepts before and after the intervention. Additionally, a rubric-based assessment of data storytelling skills in digital data visualization is performed both during and after the experiment. The quality of these instruments is validated by five educational measurement and evaluation experts using the item objective congruence index (IOC), ensuring that all measures achieve a validity score greater than 0.50, confirming their suitability and reliability for the study.

2) Experimental Procedure

The experimental procedure begins with a pre-test that is given before the learning intervention. This test evaluates learners' fundamental skills in data storytelling, visual perception, understanding of digital data visualization principles, and accessibility and usability evaluation. The test consists of structured questions and tasks that are intended to reflect learners' perceptual and storytelling abilities with data.

The learning intervention takes a structured approach based on the visual perception learning model, which was created specifically to improve visual perception and promote inclusive accessibility. The learning activities include the following:

- Interactive Learning Modules: These modules provide instructional content on visual perception principles and practical exercises in creating accessible and inclusive data visualizations.
- Hands-on Digital Data Visualization Exercises: Learners engage in creating data visualizations using various tools and techniques to effectively communicate data-driven narratives.
- Inclusive Design Simulations: This activity involves practical applications of inclusive design techniques to ensure data accessibility for diverse audiences.

After completing the learning intervention, learners take a post-test with the same format as the pre-test to assess their progress in data storytelling, visual perception, and the ability to create inclusive data visualizations. In addition to the post-test, data storytelling skills in digital visualization are evaluated during and after the intervention using a five-point quality scoring rubric.

3) Data Collection and Analysis

The data is analyzed quantitatively and qualitatively. The quantitative data consists of pre-test and post-test scores that are statistically analyzed to determine differences in learning outcomes using t-tests. Mean scores and standard deviations are calculated to provide additional information about performance trends.

Qualitative data is collected via participant feedback, structured surveys, and interviews. The intervention includes observations of learning behaviors and levels of engagement. A feedback loop mechanism is used to gather learner insights and refine future instructional designs based on their experiences.

The use of both quantitative and qualitative analyses ensures a thorough evaluation of the visual perception learning model-based learning approach's impact on data storytelling skills, visual perception, and the ability to create inclusive digital data visualizations.

5. RESEARCH RESULTS

5.1 Learning model for visual perception based on the concept of inclusive design to enhance data storytelling skills in digital visualization.

The key components include:

1) The conceptual framework

Visual perception is the process by which the brain interprets and comprehends information through vision, and it is critical to the effective design and presentation of data in visual form, known as data visualization.

Inclusive design is a methodology that focuses on creating experiences that are equally accessible and usable by everyone, regardless of physical, cognitive, or environmental constraints.

Data storytelling and data visualization are methods of presenting information that combine data science, narrative techniques, and visual design to make data more meaningful, understandable, and impactful to the audience.

2) Learning Process Stages

Exploration Stage: This stage focuses on learning the fundamentals of visual perception and inclusive design concepts. Learners will examine examples of successful and unsuccessful data visualizations and discuss the role of visual perception in data interpretation.

Conceptualization Stage: This stage focuses on learning key concepts about visual perception and inclusive design through interactive lessons on visual perception theories like color, shapes, and layouts. Learners will also be introduced to accessibility design principles and data-driven storytelling techniques.

Application Stage: This stage focuses on using concepts to create data visualizations that emphasize storytelling and inclusive design. Learners will create a data storytelling project that combines inclusive design principles and data visualization tools.

Evaluation and Iteration Stage: This stage aims to review and improve the work. Learners will present their projects and get feedback from their peers. The evaluation will consider a variety of criteria, including information clarity, aesthetics, and accessibility. After receiving feedback, they will revise and improve their work.

Reflection and Knowledge Sharing Stage: This stage focuses on fostering long-term knowledge and sharing insights with others. Learners will reflect on their acquired knowledge and experiences, allowing them to apply their insights in the long run, as shown in learning process stages in Figure 2.

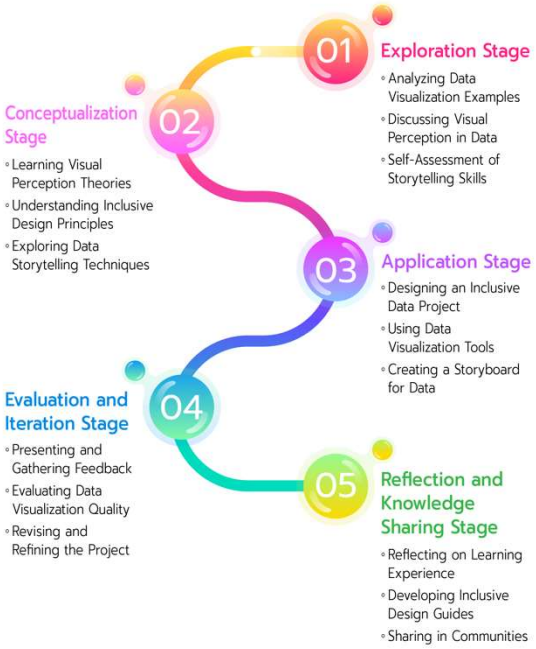

Figure 2: Learning Process Stages of The Visual Perception Learning Model Based on Inclusive Design

3) Evaluation Methods

Formative Assessment: Continuous assessments are used throughout the learning process, such as observational analysis, checkpoint activities, and real-time feedback from instructors. These methods assist learners in continuously honing their data storytelling skills by providing insights and necessary adjustments.

Summative Assessment: The final assessment compares pre-test, and post-test results to determine learning outcomes. Four items are used to assess knowledge and understanding of visual perception: Gestalt perception, color theory, pre-attentive attributes, and visual hierarchy. Inclusive design is assessed using five criteria: accessibility, clarity, adaptability, usability, and inclusivity. A final data visualization project is also evaluated using a rubric-based performance evaluation. Data analysis, visualization design, data storytelling, tool proficiency, and presentation techniques are the five key assessment criteria, which ensure a comprehensive evaluation of learners' skills.

Feedback Loop: A continuous improvement cycle is implemented by analyzing assessment data, soliciting learner feedback, and adjusting adaptive learning strategies. This iterative process improves the learning model's ability to meet the needs of a diverse student population.

4) Tools and Technologies

Digital Visualization: Tools and technologies used to create and analyze data in visual formats, with a focus on visual perception and data storytelling.

Accessibility Checkers: To ensure that data visualization design adheres to inclusive design principles and accommodates a wide range of users, including those with visual impairments and cognitive disabilities, essential tools.

Collaborative Platforms: Platforms that enable collaborative learning, data visualization design, and data storytelling creation.

5) Learning Outcomes

Data Analysis: Learners can collect, clean, analyze, and validate data to extract accurate insights for storytelling.

Visualization Design: Learners can design and select appropriate data visualization formats based on visual perception principles and inclusive design concepts.

Storytelling with Data: Learners can craft compelling narratives by integrating quantitative and qualitative data to convey meaning, evoke emotions, and support decision-making.

Tools Proficiency: Learners can effectively use digital tools and platforms and other visualization tools to create dynamic and interactive visualizations.

Presentation Techniques: Learners can develop communication and presentation skills to deliver data-driven stories effectively, adapting techniques to different platforms for enhanced audience engagement.

Table 1: Results of the Evaluation of Visual Perception Learning Model Based on Inclusive Design

Components of Visual Perception Learning Model	Expert Opinion		
	Mean	*S.D.*	Appropriateness
1. Conceptual Framework			
1.1 Visual Perception	4.60	0.55	High
1.2 Inclusive Design	4.80	0.45	Highest
1.3 Data Storytelling & Visualization	5.00	0.00	Highest
Sum	**4.80**	**0.33**	**Highest**
2. Learning Process Stages			
2.1 Exploration	5.00	0.00	Highest
2.2 Conceptualization	4.60	0.55	Highest
2.3 Application	4.80	0.45	Highest
2.4 Evaluation	5.00	0.00	Highest
2.5 Reflection	5.00	0.00	Highest
Sum	**4.88**	**0.20**	**Highest**
3. Evaluation Methods			
3.1 Formative Assessment	4.60	0.55	Highest
3.2 Summative Assessment	5.00	0.00	Highest
3.3 Feedback Loop	4.80	0.45	Highest
Sum	**4.80**	**0.33**	**Highest**
4. Tools and Technologies			
4.1 Digital Visualization	5.00	0.00	Highest

Components of Visual Perception Learning Model	Expert Opinion		
	Mean	*S.D.*	Appropriateness
4.2 Accessibility Checkers	5.00	0.00	Highest
4.3 Collaborative Platforms	5.00	0.00	Highest
Sum	**5.00**	**0.00**	**Highest**
5. Learning Outcomes			
5.1 Data Analysis	4.80	0.45	Highest
5.2 Visualization Design	4.80	0.45	Highest
5.3 Storytelling with Data	5.00	0.00	Highest
5.4 Tools Proficiency	5.00	0.00	Highest
5.4 Presentation Techniques	4.40	0.55	High
Sum	**4.80**	**0.29**	**Highest**
Overall	**4.86**	**0.23**	**Highest**

The evaluation results in Table 1 indicate the model evaluation was conducted by five experts in the field of learning models using the learning model quality evaluation form. This tool was used to assess the quality of the model based on theoretical validity, completeness of components, and practical applicability, utilizing a five-point Likert scale. The evaluation results indicate that the overall quality is rated as highest (mean = 4.86, S.D. = 0.23). This indicates that the learning model is highly suitable for implementation.

The expert to improve its effectiveness and accommodate diverse learners, several additional strategies could be implemented. One significant improvement is the use of adaptive learning approaches, which allow students to tailor their learning paths based on their proficiency levels. Intelligent systems could be used to dynamically adjust the complexity of content and activities based on learner progress. Furthermore, emphasizing experiential learning through hands-on activities like simulations and real-world data storytelling projects would help learners gain a better understanding and practical application of concepts.

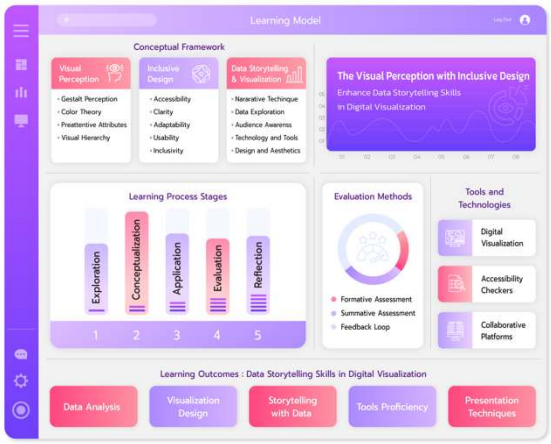

Figure 3: A Learning Model for Visual Perception Based on The Concept of Inclusive Design to Enhance Data Storytelling Skills in Digital Visualization

A Learning Model in Figure 3 indicate that the developed learning model is of high quality and well-suited for both theoretical design and practical application in education. It effectively enhances learners' ability to create and communicate information through visual storytelling. Moreover, the model promotes awareness of accessible design principles, making it applicable to various fields related to digital data presentation.

5.2 Digital learning media for visual perception based on the concept of inclusive design

A learning platform designed with inclusive design principles improves accessibility and usability for diverse learners. According to the evaluation results, learners found the platform to be user-friendly and responsive. The platform also boosts learning motivation by including multimedia elements rather than relying solely on text. Additionally, it supports multiple devices, includes screen reader functionality, and allows for visual customization to accommodate learners with varying visual perception requirements.

Various types of digital learning media play an important role in improving learners' visual perception abilities. Infographics improve the ability to effectively analyze and summarize data trends. Motion graphics help people understand patterns and compare data more effectively. Micro-videos offer concise explanations and improve information retention. Meanwhile, interactive digital media increases engagement and learners' ability to create compelling, data-driven narratives when compared to non-interactive content.

Learning designs that combine visual perception training and inclusive design principles significantly improve learners' data storytelling abilities. Learners improve their ability to interpret and extract key insights from data, gain a better understanding of appropriate data visualization structures for specific audiences, and use storytelling techniques to create engaging and understandable visual content.

Table 2: Results of The Quality Evaluation of Digital Learning Media for Visual Perception Based on The Concept of Inclusive Design

Evaluation Criteria for Digital Learning Media	Evaluation Results		
	Mean	*S.D.*	Appropriateness
1. Usability Design			
1.1 Accessibility	4.80	0.45	Highest
1.2 Ease of Use	4.60	0.55	Highest
1.3 User Experience	4.80	0.45	Highest
Sum	**4.73**	**0.48**	**Highest**
2. Interactive Design			
2.1 Learner Engagement	4.80	0.45	Highest
2.2 User Responsiveness	4.80	0.45	Highest

Evaluation Criteria for Digital Learning Media	Evaluation Results		
	Mean	*S.D.*	Appropriateness
2.3 Interactivity Level	4.40	0.55	Highest
Sum	**4.67**	**0.48**	**Highest**
3. Information & Content Design			
3.1 Clarity of Information	4.80	0.45	Highest
3.2 Aesthetic Design	5.00	0.00	Highest
3.3 Multimedia Support	5.00	0.00	Highest
Sum	**4.93**	**0.15**	**Highest**
4. Technology & Performance			
4.1 Technology & Performance Quality	4.80	0.45	Highest
4.2 Performance & Stability	4.60	0.55	Highest
4.3 Security & Privacy	4.40	0.55	High
Sum	**4.60**	**0.51**	**Highest**
Overall	**4.73**	**0.41**	**Highest**

The evaluation results in Table 2 indicate that the evaluation of the digital learning media for visual perception is based on the concept of inclusive design, conducted by five experts in digital learning media. The evaluation results indicate that the overall quality is rated as highest (mean = 4.73, S.D. = 0.41).

The experts also suggest that digital learning media be designed to accommodate a wide range of learner perceptions, including differences in visual and cognitive ability. The use of adaptive learning technologies can help reduce accessibility barriers by personalizing content to meet individual needs. Furthermore, the design should prioritize ease of use and flexibility to provide an inclusive and effective learning experience for all users.

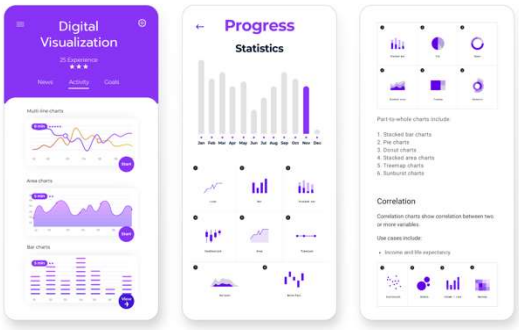

Figure 4: Digital Learning Media for Visual Perception Based on The Concept of Inclusive Design

Digital learning media in Figure 4 show that digital learning media created using inclusive design and visual perception principles are of the highest quality and effectiveness in supporting diverse learners. This approach promotes equitable learning opportunities, improves data storytelling skills, and ensures a welcoming and accessible learning environment for all.

5.3 The effects of enhancing data storytelling skills in digital visualization.

1) Knowledge and understanding in inclusive visual perception design concepts

The analysis results in Table 3 show that the learners made significant improvements in their knowledge and understanding of visual perception, which consists of four assessment items: gestalt perception, color theory, pre-attentive attributes, and visual hierarchy, and inclusive design, which consists of five assessment items: accessibility, clarity, adaptability, usability, and inclusivity. The average post-test scores were significantly higher than the pre-test results. The statistical analysis showed a significant difference at the $p<0.05$ level, indicating that the learning model improved learners' outcomes.

A more in-depth examination of specific question categories revealed that fundamental concepts related to visual perception and inclusive design principles were significantly better understood. However, some concepts, such as the use of visual perception in data design, required additional support. To address this, more hands-on activities or exercises could assist learners in better connecting theoretical concepts to practical applications.

Table 3: Results of Knowledge and Understanding in Inclusive Visual Perception Design Concepts

Knowledge	Before		After		t	Sig.
	M	S.D.	M	S.D.		
Visual Perception	3.40	0.87	4.52	0.51	8.41	.000*
Inclusive Design	3.60	0.65	4.60	0.50	7.75	.000*

*p < 0.05

The analysis results in Table 3 indicate that the implemented learning significantly enhanced knowledge and understanding of inclusive visual perception design concepts. The mean score for visual perception increased from 3.40 to 4.52, while the mean score for inclusive design improved from 3.60 to 4.60. Both aspects showed statistically significant differences at the $p < 0.05$ level (Sig. = .000), demonstrating the effectiveness of the learning process in positively impacting learners. Additionally, the high t-test values (8.41 and 7.75) suggest that the learning had a substantial influence on knowledge acquisition. These findings highlight the effectiveness of the instructional approach in fostering a deeper understanding of inclusive visual perception design.

Table 4: Correlation Between Visual Perception and Inclusive Design

Variable	Visual Perception	Inclusive Design
Visual Perception	1.000	.784**
Inclusive Design	.784**	1.000

**. Correlation is significant at the 0.005 level (2-tailed).

Pearson's correlation coefficient was used to analyze relationships, and the statistical results are summarized in Table 4. Pearson correlation reveals a strong positive correlation between visual perception and inclusive design (correlation coefficient = 0.784). This implies that as visual perception improves, inclusive design does as well. Furthermore, the statistical significance test yields a p-value (Sig. 2-tailed) of less than 0.005, indicating that this correlation is statistically significant and not due to chance. The analysis was conducted on a sample of 25 participants, providing a solid foundation for interpretation. Finally, the findings indicate a strong link between visual perception and inclusive design, which could serve as a foundational insight for developing learning models based on visual perception and inclusive design principles in digital education.

As a result, the designed learning approach significantly improved learners' understanding of visual perception and inclusive design. However, there are opportunities for additional development to promote deeper and more sustainable learning.

2) Data storytelling skills in digital data visualization

The assessment results for data storytelling skills in digital data visualization show that learners have a solid foundation in data analysis, demonstrating the ability to differentiate, synthesize, and use basic statistical methods to effectively identify trends. However, there is still room for improvement in selecting advanced analytical techniques and interpreting data on a deeper level. In terms of visualization design, learners can select graph types and design elements that are appropriate for the data while also understanding key data aesthetic principles. However, there are difficulties in communicating complex data in a more digestible format. When it comes to data storytelling, learners can create structured narratives that logically connect with the data, but in some cases, the link between the data and the audience's experience is unclear, making the storytelling less engaging.

In terms of tool proficiency, learners demonstrate basic skills in using data visualization tools like Tableau, Power BI, and Python libraries, but they lack expertise in advanced features like creating interactive visualizations or coding complex customizations for data presentation. Furthermore, in presentation techniques, learners effectively communicate data using visualizations that are clear and easy to understand. However, more practice is needed in answering audience questions and tailoring presentations to different target groups.

Table 5: Results of the Assessment of Data Storytelling Skills in Digital Data Visualization

Data Storytelling Skills in Digital Data Visualization	Assessment Results		
	Mean	***S.D.***	**Appropriateness**
1. Data Analysis			
1.1 Understanding and interpreting data types and relationships	4.32	0.48	High
1.2 Data cleaning and preprocessing	4.16	0.75	High
1.3 Selecting appropriate analysis methods	4.48	0.59	High
1.4 Accuracy and reliability of data insights	4.28	0.68	High
Sum	**4.31**	**0.62**	**High**
2. Visualization Design			
2.1 Choosing suitable visualization types	4.36	0.81	High
2.2 Clarity and effectiveness of visual representation	4.60	0.65	Highest
2.3 Consistency in color and design	4.68	0.56	Highest
2.4 Layout and composition for better readability	4.28	0.68	High
2.5 Accessibility and inclusive design considerations	4.44	0.71	High
Sum	**4.47**	**0.68**	**High**
3. Storytelling with Data			
3.1 Structuring a compelling data narrative	4.32	0.63	High
3.2 Using data as supporting evidence	4.16	0.75	High
3.3 Balancing technical and simple language	4.32	0.80	High
3.4 Engaging the audience with storytelling techniques	4.56	0.51	Highest
3.5 Organizing data flow for coherence	4.58	0.50	Highest
Sum	**4.39**	**0.64**	**High**
4. Tools Proficiency			
4.1 Mastery of visualization tools	4.68	0.48	Highest
4.2 Proficiency in data analysis tools	4.48	0.59	High
4.3 Use of storytelling & presentation tools	4.56	0.51	Highest
4.4 Integrating data from multiple sources	4.32	0.69	High
4.5 Applying automation and interactive features	4.52	0.59	Highest
Sum	**4.51**	**0.57**	**Highest**
5. Presentation Techniques			
5.1 Effective communication of data insights	4.28	0.74	High
5.2 Using visuals to enhance presentations	4.32	0.80	High

Data Storytelling Skills in Digital Data Visualization	Assessment Results		
	Mean	*S.D.*	Appropriateness
5.5 Incorporating storytelling techniques	4.56	0.58	Highest
Sum	**4.39**	**0.71**	**High**
Overall	**4.41**	**0.64**	**High**

The assessment results in Table 5 show that data storytelling skills in digital data visualization have an overall high proficiency level (mean = 4.41, SD = 0.64), reflecting participants' strong abilities in data analysis, visualization design, storytelling techniques, tool proficiency, and presentation skills. The highest-scoring category was tools proficiency (mean = 4.51, S.D. = 0.57), particularly visualization tool mastery and storytelling & presentation tool usage, which both received the highest rating. In visualization design (mean = 4.47, SD = 0.68), participants excelled in color consistency, design, and visual representation clarity. However, layout and composition for better readability received a relatively low score, indicating room for improvement. The storytelling with data category (mean = 4.39, SD = 0.64) excelled at engaging audiences with storytelling techniques and organizing data flow for coherence (4.58). Similarly, presentation techniques (mean = 4.39, S.D. = 0.71) received high marks for incorporating storytelling techniques into presentations but indicated potential areas for improvement in clarity and data communication. Finally, data analysis (mean = 4.31, S.D. = 0.62) demonstrated that participants had a strong understanding of selecting appropriate analysis methods and data cleaning.

Overall, learners show great potential in data storytelling and digital data visualization, but there is still room for improvement. These include honing deep analytical skills, improving storytelling techniques to make narratives more engaging and emotionally resonant, selecting visualizations that simplify the communication of complex data, and improving proficiency in using sophisticated tools to create more effective and impactful data visualizations. As a result, in-depth training and hands-on practice are critical for honing these skills, allowing learners to present data professionally and tailor their storytelling techniques to the needs of various audiences and contexts.

6. DISCUSSION

1) Key findings from learning model development

Designing a visual perception learning model using inclusive design principles can significantly improve data storytelling skills in digital presentations [2]. The developed learning model focuses on practicing and applying visual perception theories in conjunction with digital learning materials that address learners' diverse needs [38]. This approach teaches learners how to organize and select data, as well as create graphics that clearly convey key information to a variety of target audiences.

Furthermore, learning evaluations show that learners are making progress in integrating storytelling techniques. They also demonstrate improved narrative structuring and media selection skills. Thus, it is possible to conclude that the learning model and digital media created under the Inclusive Design concept not only improve data storytelling skills in digital presentations but also serve as an important framework for designing learning experiences that meet the needs of all learners equitably [28-29]. This is consistent with the current era's emphasis on using digital technologies to advance education and enable high-quality, data-driven communication.

The development of data storytelling skills in digital visualization necessitates careful consideration of several factors, including selecting appropriate data, conducting in-depth data analysis and comparison, structuring narratives systematically, and creating engaging and accessible media [30-31]. These aspects should be consistent with human visual perception principles and inclusive design to ensure that all learners, regardless of visual limitations or levels of digital proficiency, can effectively perceive and interpret information. When learners have equitable access to and understanding of data, they can participate in a deep learning experience that encourages creativity and interaction both in and out of the classroom.

Furthermore, the ability to select visual formats, tools, and infographics that are appropriate for the audience's context and objectives is critical to making data storytelling engaging and understandable [32]. Educators must therefore play the role of facilitators, guiding and coaching learners while encouraging their creativity. They should also encourage interactive exchanges of ideas to foster collaborative learning.

In the long run, the creation of adaptive learning materials tailored to individual needs and learning preferences is critical. Continuous follow-up assessments should be carried out to assess the retention and practical application of data storytelling in a variety of domains, including business communication, digital media production, and education. This approach will improve the effectiveness and sustainability of data-driven

communication, ensuring long-term impact in a variety of fields.

Developing data storytelling skills in digital visualization entails more than just teaching learners how to design graphs or create visually appealing infographics. It also entails comprehending human factors on multiple levels, from visual perception and digital literacy to collaborative knowledge exchange in the classroom. Integrating these principles with the concept of inclusive design will allow all learners to have equitable access to data, create more creative and impactful presentations, and effectively apply their skills in various professional and academic contexts in the future.

2) Key Findings from Digital Learning Media Development

The development of digital learning media based on inclusive design and visual perception principles has made a significant contribution to improving data storytelling skills in digital visualization [36]. The findings show that the designed learning platform improves accessibility and usability by supporting diverse learners with features like multi-device compatibility, screen reader functionality, and customizable visual settings. These features ensure that learners with different visual perception abilities can interact with the content equally [22-23]. Furthermore, the use of interactive multimedia elements such as infographics, motion graphics, micro-videos, and interactive digital media increases engagement and allows for a more in-depth understanding of data structures, trend analysis, and visual storytelling [37].

Furthermore, combining visual perception training with inclusive design principles helps learners improve their ability to interpret data insights and create structured data narratives that are tailored to different audiences. The quality evaluation of digital learning media received the highest ratings, particularly in terms of information clarity and multimedia support, emphasizing the efficacy of visual-based learning approaches [25]. The results also highlight the platform's technological stability and seamless learning experience, which ensure a high-quality and efficient learning process.

In conclusion, digital learning media designed with visual perception and inclusive design principles can significantly improve learners' data storytelling abilities while also providing an accessible and engaging learning environment. Future advancements in digital learning may include AI-powered adaptive learning models to personalize content based on learner needs, as well as gamification strategies to boost motivation and engagement. These innovations will provide learners with essential data storytelling skills for the digital age, resulting in more effective and inclusive learning experiences.

3) Quantitative Analysis of Skills Development

The quantitative analysis of skill development in data storytelling for digital visualization shows significant improvements in a variety of competencies. Learners have demonstrated improvement in data analysis, visualization design, storytelling techniques, tool proficiency, and presentation skills. The most notable improvement was seen in tool proficiency, specifically mastery of visualization tools and storytelling and presentation tool usage, which reflected learners' ability to use software such as Tableau, Power BI, and Python libraries. While learners were able to effectively use basic visualization features, they showed limitations in advanced functionalities such as interactive visualizations and automation.

In terms of visualization design, learners demonstrated excellent color consistency, design clarity, and effective visual representation. However, poor performance in layout and composition for readability indicates the need for additional assistance in structuring visual elements to improve comprehension [35]. Learners excelled at engaging audiences with storytelling techniques and organizing data flow coherently, but there are still challenges in balancing technical and simple language and effectively using data as supporting evidence.

In terms of presentation techniques, learners successfully incorporated storytelling elements into their presentations; however, some struggled to clearly communicate complex data insights. Meanwhile, in data analysis, learners demonstrated a solid foundational understanding of data preprocessing, cleaning, and selecting appropriate analysis methods, though there is still room for improvement in applying advanced analytical techniques [32]. Furthermore, the study found a strong positive relationship between visual perception and inclusive design, implying that improved visual perception skills significantly contribute to the ability to create inclusive and accessible data narratives.

Despite these advancements, several areas require further development. Developing deeper analytical skills, particularly advanced data interpretation, will assist learners in extracting meaningful insights. Strengthening storytelling techniques to create emotionally engaging

narratives, as well as honing skills in selecting appropriate visualizations for complex datasets, will improve data communication effectiveness. Furthermore, improving proficiency in interactive visualizations, automation, and coding customizations will sharpen learners' skills, while improving presentation and communication strategies will boost audience engagement.

In conclusion, the findings show that the visual perception learning model based on inclusive design improves data storytelling skills in digital visualization. While learners have made significant progress, targeted improvements in advanced analytics, storytelling refinement, and interactive visualizations will allow them to create more engaging, inclusive, and impactful data-driven narratives for a variety of audiences.

4) Limitations of the study and future work

Although this study presents a learning model based on inclusive design to improve data storytelling skills in digital visualization, some limitations may limit its effectiveness and applicability. One significant limitation is the sample group's composition, which consists primarily of learners with a background in digital or data visualization [32]. As a result, the findings may not be entirely applicable to a larger audience, such as general users, data analysts, or communication professionals. Furthermore, the experiments were carried out in controlled environments, such as laboratories or specific platforms, which may not fully capture the complexities and challenges of real-world applications. While this study uses a variety of metrics to evaluate data storytelling skills and visual perception, there are still limitations in assessing the ability to interpret data in highly complex scenarios [39]. Furthermore, technological constraints in the tools and platforms used in this study may limit accessibility for a wide range of learners, particularly those with disabilities such as vision impairments. These learners may require more adaptable and flexible solutions to ensure an inclusive learning environment.

For future research, a larger sample group of participants, such as data analysts, communication specialists, and general users, would provide a more complete understanding of the model's applicability. Furthermore, should focus on implementing and evaluating the learning model in real-world settings, such as educational curricula, corporate training programs, or professional data visualization projects, to determine its efficacy in a variety of contexts. Another critical direction is the development of advanced technologies and platforms that fully support inclusive design, including AI-powered adaptive learning systems that tailor the learning experience to individual needs. Further research should investigate the psychological and behavioral effects of data storytelling, as well as the factors that influence learning outcomes and practical application. Furthermore, combining the proposed model with modern educational approaches such as gamification, AI-based learning, or learner-centered designs may improve engagement and learning effectiveness [40]. These future directions would ensure that the learning model helps to develop data storytelling skills in a more effective, inclusive, and sustainable way.

7. CONCLUSION

This study presents a visual perception learning model based on inclusive design, which aims to improve data storytelling skills in digital visualization. The findings fill critical gaps in the existing literature by incorporating inclusive design principles into visual perception training, resulting in more effective, accessible, and contextually relevant data visualization practices.

The research makes an important contribution by bridging curriculum gaps that frequently overlook the intersection of visual perception, inclusive design, and data storytelling. Traditional approaches tend to focus on either technical visualization skills or storytelling techniques separately, whereas this model provides a comprehensive framework that connects these dimensions. As a result, it provides learners with cognitive and perceptual strategies for creating more engaging, inclusive, and meaningful data narratives for diverse audiences.

Notable strengths of this study include the development of a learning model that employs inclusive design to improve data storytelling abilities in a digital learning environment. The model effectively addresses learners' varying visual perception and physical abilities. The study's practical focus, which includes applying the model to real-world digital learning environments, allows for testing and evaluation in realistic settings. Furthermore, creating learning tools based on the model is extremely valuable for educational institutions and organizations looking to foster data storytelling skills through inclusive design principles.

However, the study does have some limitations. The sample size was small, so the results may not accurately reflect the diversity of learners, and they may not be universally applicable. Furthermore, the brief testing phase may not accurately reflect the long-term evolution of data storytelling abilities.

External factors, such as familiarity with technology or uncontrollable learning environments, could also have influenced the results. Future research should consider increasing the sample size and conducting longer-term evaluations to achieve more comprehensive and long-lasting results.

The results of this study show that the visual perception learning model based on inclusive design has the potential to improve data storytelling skills in the context of digital data visualization. While the results show a positive trend, there are still some areas that need to be addressed for the model to be effective in broader applications. Compared to previous research, such as learning models based on cognitive load theory or approaches focusing on data visualization literacy, the proposed model stands out by emphasizing inclusive design principles. This method ensures accessibility for a wide range of learners, allowing people with different backgrounds and perceptual abilities to develop data storytelling skills more effectively.

Nonetheless, several key aspects of the model require further investigation to be refined and optimized. To begin, broader testing should be conducted across different learner groups and learning environments to ensure its applicability in a variety of settings. Second, long-term studies are required to determine whether the skills learned through this model can be retained and effectively applied in real-world situations. Third, incorporating supplementary technologies like artificial intelligence (AI) or adaptive learning systems may improve the model's ability to cater to individual learner needs. Furthermore, to gain a better understanding of learners' interactions with data, evaluation methods should be expanded to include physiological analysis techniques such as eye-tracking or observational studies in real-world settings. Addressing these issues will help to refine the model, ensuring its robustness and effectiveness in a broader range of educational and professional settings.

The study's relevance goes beyond academic discourse, as it aligns with global trends in digital transformation, data-driven decision-making, and inclusive digital communication. As industries rely more on data visualization to communicate complex information, the demand for professionals with both technical and storytelling skills grows. This study emphasizes the importance of educational models that prepare learners to navigate this changing landscape, ensuring that data storytelling remains impactful, accessible, and inclusive across multiple sectors.

Finally, it is critical to investigate how this model can evolve and be applied in various educational and professional settings. This will help to demonstrate its ability to improve the teaching and application of data storytelling skills in digital visualization.

REFERENCES:

[1] S. Douville, P.T. Grandjean Targos, N.D. Jones, C. Knight, and T. Azzam, "Data Visualization Expert Lessons Learned: Implications for Program Evaluators," *American Journal of Evaluation,* 2025. DOI: 10.1177/10982140241290744.

[2] H. Shao, R. Martinez-Maldonado, V. Echeverria, L. Yan, and D. Gasevic, "Data Storytelling in Data Visualisation: Does it Enhance the Efficiency and Effectiveness of Information Retrieval and Insights Comprehension?", *Proceedings of the CHI Conference on Human Factors in Computing Systems*, ACM, May 11, 2024, pp. 1–21. DOI: 10.1145/3613904.3643022.

[3] L.-D. Zhang, "Data Visualization and Visual Design - Creative Applications in Information Presentation and Communication," *Innovation on Design and Culture (IDC)*, Vol. 4, Issue 4, IIKII (Singapore), Dec. 30, 2024, pp. 17–23. DOI: 10.35745/idc2024v04.04.0003.

[4] X. Wang, R. Hu, and C. Xue, "Enhancing User Perception of Reliability in Computer Vision: Uncertainty Visualization for Probability Distributions," *Symmetry*, Vol. 16, MDPI (Switzerland), Aug. 3, 2024, pp. 986. DOI: 10.3390/sym16080986.

[5] S. Yin, H. Li, Y. Sun, M. Ibrar, and L. Teng, "Data Visualization Analysis Based on Explainable Artificial Intelligence: A Survey," *IJLAI Transactions on Science and Engineering*, Vol. 2, No. 2, Shenyang Normal University (China), 2024, pp. 13–20.

[6] K.J. Olowe, N.L. Edoh, S.J.C. Zouo, and J. Olamijuwon, "Conceptual Review on the Importance of Data Visualization Tools for Effective Research Communication," *International Journal of Engineering Research and Development*, Vol. 20, Issue 11, Nov. 2024, pp. 1259-1268.

[7] P. Sarkar, Y. D. Priya, P. B. Patel, P. Chatterjee Biswas, S. Arigela and S. Sallaram, "Data Visualization in Transforming Raw Data into Compelling Visual Narratives," *2024 International Conference on Trends in Quantum Computing and Emerging Business*

Technologies, Pune, India, 2024, pp. 1-6, doi: 10.1109/TQCEBT59414.2024.10545256.

[8] Z. Peng, (2025). Telling a Story with Graphs: How to Apply Narrative Visualization Strategies and Visualization Techniques in Journalistic Storytelling. In: Mutsvairo, B., Orgeret, K.S. (eds) *The Palgrave Handbook of Global Digital Journalism. Palgrave Macmillan, Cham.* https://doi.org/10.1007/978-3-031-59379-6_18

[9] G. Ferrari and P. Diana, "Data Visualization in Shaping the Institutional COVID-19 Narrative," *Society Register*, Vol. 8, No. 3, 2024, pp. 69-98. DOI: 10.14746/sr.2024.8.3.03.

[10] M. Berger and S. Liu, "The Visualization JUDGE: Can Multimodal Foundation Models Guide Visualization Design Through Visual Perception?," *2024 IEEE Evaluation and Beyond - Methodological Approaches for Visualization (BELIV)*, St Pete Beach, FL, USA, 2024, pp. 60-70, https://doi.ieeecomputersociety.org/10.1109/BELIV64461.2024.00012

[11] W.Y. Ouyang, "Data Visualization in Big Data Analysis: Applications and Future Trends," *Journal of Computer and Communications*, Vol. 12, Nov. 12, 2024, pp. 76-85. DOI: 10.4236/jcc.2024.1211005

[12] N. Mahyar, "Reimagining Data Visualization to Address Sustainability Goals," *arXiv preprint arXiv:2409.03611*, Sept. 5, 2024. https://doi.org/10.48550/arXiv.2409.03611

[13] S. Cao, Q. Chen, and N. Cao, "Visual Narrative for Data Journalism Based on User Experience," *Journal of Visualization*, Vol. 27, 2024, pp. 1195–1211. DOI: 10.1007/s12650-024-01005-w.

[14] N. Errey, J. Liang, T.W. Leong, and D. Zowghi, "Evaluating Narrative Visualization: A Survey of Practitioners," International Journal of Data Science and Analytics, Vol. 18, 2024, pp. 19-34. DOI: 10.1007/s41060-023-00394-9

[15] A. Jaglarz, "Color as a Key Factor in Creating Sustainable Living Spaces for Seniors," Sustainability, Vol. 16, 2024, pp. 10251. DOI: 10.3390/su162310251

[16] R.M. Romeh, D.M. Elhawary, T.M. Maghraby, A.E. Elhag, and A.G. Hassabo, "Psychology of the Color of Advertising in Marketing and Consumer Psychology," *Journal of Textiles, Coloration and Polymer Science*, Vol. 21, No. 2, 2024, pp. 427-434. DOI: 10.21608/jtcps.2024.259025.1272.

[17] M. Nazari and B. Matusiak, "Daylighting Simulation and Visualisation: Navigating Challenges in Accuracy and Validation," *Energy & Buildings*, Vol. 312, 2024, pp. 114188. DOI: 10.1016/j.enbuild.2024.114188

[18] Z. Liu, "Evaluating Digitalized Visualization Interfaces: Integrating Visual Design Elements and Analytic Hierarchy Process," *International Journal of Human–Computer Interaction*, 2024, pp. 1–30. DOI: 10.1080/10447318.2024.2365454.

[19] P.R.C. Gopal, N.P. Rana, T.V. Krishna, and M. Ramkumar, "Impact of Big Data Analytics on Supply Chain Performance: An Analysis of Influencing Factors," *Annals of Operations Research*, Vol. 333, 2024, pp. 769–797. DOI: 10.1007/s10479-022-04749-6

[20] F. Rocha Lourenço, R. Oliveira, and O. Tymoshchuk, "Challenges and Gaps in Promoting Inclusive Spaces: A Study Based on Interviews," in *Design, User Experience, and Usability. HCII 2024*, A. Marcus, E. Rosenzweig, and M.M. Soares (Eds.), *Lecture Notes in Computer Science*, Vol. 14714, Springer, Cham, 2024. DOI: 10.1007/978-3-031-61356-2_8.

[21] E. Behar Villegas, Z. Goh, and G.S. Horowitt, "Designing a Good Story for Better Policies: Entrepreneurship at the Crossroads of AI-Powered Visual Storytelling and Sensemaking," *Human Technology*, Vol. 20, No. 3, 2024, pp. 420–445. DOI: 10.14254/1795-6889.2024.20-3.1.

[22] O. Topuzov, O. Malykhin, N. Aristova, M. Zahorulko, and I. Lipchevska, "Visualizing Educational Information: Primary School Teachers' Views," *Society, Integration, Education - Proceedings of the International Scientific Conference*, Vol. 1, May 24, 2024, pp. 573-584. DOI: 10.17770/sie2024vol1.7885.

[23] B. Pinna and D. Porcheddu, "Visual Information Beyond Gestalt Principles: Unification vs. Differentiation, Similarity vs. Dissimilarity," *Arkete – Rivista di Filosofia*, Vol. VI, 2023, pp. 77-104. Available: https://arkete.it.

[24] M. Saqr and S. López-Pernas (Eds.), *Learning Analytics Methods and Tutorials: A Practical Guide Using R*, Springer, Cham, 2024. DOI: 10.1007/978-3-031-54464-4

[25] R. Li, Y. Cao, H. Tang, and G. Kaiser, "Teachers' Scaffolding Behavior and Visual Perception During Cooperative Learning," *International Journal of Science and Mathematics Education*, Vol. 22, 2024, pp. 333–352. DOI: 10.1007/s10763-023-10379-6

[26] G.W. Choi and J. Seo, "Accessibility, Usability, and Universal Design for Learning: Discussion of Three Key LX/UX Elements for Inclusive Learning Design," *TechTrends*, Vol. 68, 2024, pp. 936–945. DOI: 10.1007/s11528-024-00987-6

[27] F. Golbabaei, J. Dwyer, R. Gomez, A. Peterson, K. Cocks, and A. Paz, "Enabling Mobility and Inclusion: Designing Accessible Autonomous Vehicles for People with Disabilities," *Cities*, Vol. 154, 2024, pp. 105333. DOI: 10.1016/j.cities.2024.105333.

[28] M. Monova-Zheleva and Y. Zhelev, "Inclusive Design for Digital Learning: The UDL Framework," *Proceedings of the International Scientific Conference: Multidisciplinary Innovations for Social Change – Educational Transformations and Entrepreneurship*, Burgas Free University, 2024, pp. 573-582.

[29] Y. Méhat, S. Sagot, E. Ostrosi, and D. Deuff, "A Multi-Process System for Investigating Inclusive Design in User Interfaces for Low-Income Countries," *Algorithms*, Vol. 17, No. 6, 2024, pp. 232. DOI: 10.3390/a17060232

[30] H. Shao, R. Martinez-Maldonado, V. Echeverria, L. Yan, and D. Gašević, "Data Storytelling in Data Visualisation: Does it Enhance the Efficiency and Effectiveness of Information Retrieval and Insights Comprehension?", *Proceedings of the CHI Conference on Human Factors in Computing Systems (CHI '24)*, ACM, May 11-16, 2024, pp. 1-21. DOI: 10.1145/3613904.3643022

[31] M.A.M. Tamimi, "Effects of Digital Story-telling on Motivation, Critical Thinking, and Academic Achievement in Secondary School English Learners," *Research in Social Sciences and Technology*, Vol. 9, No. 1, 2024, pp. 305-328. DOI: 10.46303/ressat.2024.18.

[32] M.N.A. Hamid, N. Khairudin, A.A. Razak, and Q.H.A. Alshorman, "Pecha Kucha: The Use of Visual Technology for Storytelling to Improve Students' Presentation Skills in Marketing Course," *Journal of Advanced Research in Applied Sciences and Engineering Technology*, Vol. 47, No. 1, 2025, pp. 67-80. DOI: 10.37934/araset.47.1.6780.

[33] S. Fitri and M. Lubis, "An Evaluation on Online Learning by Data Visualization: A Case Study from Information Technology Education Program," *Humaniora*, Vol. 25, No. 2, Aug. 2024, pp. 67-80. DOI: 10.23917/humaniora.v25i2.23687.

[34] B. Alwuqaysi, A. Abdul-Rahman, and R. Borgo, "Correlational Data Visualizations with Colored Bar Charts," *Proceedings of the WSCG 2024 Conference*, University of West Bohemia, Czech Republic, 2024. Available: http://wscg.zcu.cz/WSCG2024/2024-CSRN-3401.pdf.

[35] J. Schoenherr, A.R. Strohmaier, and S. Schukajlow, "Learning with Visualizations Helps: A Meta-Analysis of Visualization Interventions in Mathematics Education," *Educational Research Review*, Vol. 45, 2024, pp. 100639. DOI: 10.1016/j.edurev.2024.100639.

[36] H.-Y. Chang, Y.-J. Chang, and M.-J. Tsai, "Strategies and Difficulties During Students' Construction of Data Visualizations," *International Journal of STEM Education*, Vol. 11, 2024. DOI: 10.1186/s40594-024-00463-w

[37] N.F.A. Shahidan, A.F. Ibrahim, and M.N.F. Jamaluddin, "Data Visualization of Student Academic Performance Analysis," *Applied Mathematics and Computational Intelligence*, Vol. 13, No. 4, 2024, pp. 49-61. Universiti Teknologi MARA (UiTM) Perlis Branch.

[38] B. Lee, K. Marriott, D. Szafir, and G. Weber, "Inclusive Data Visualization," *Dagstuhl Reports*, Vol. 13, Issue 6, pp. 81–105, 2023. DOI: 10.4230/DagRep.13.6.81

[39] L. Yan, V. Echeverria, Y. Jin, G. Fernandez-Nieto, L. Zhao, X. Li, R. Alfredo, Z. Swiecki, D. Gašević, and R. Martinez-Maldonado, "Evidence-Based Multimodal Learning Analytics for Feedback and Reflection in Collaborative Learning," *British Journal of Educational Technology*, Vol. 55, 2024, pp. 1900–1925. DOI: 10.1111/bjet.13498

[40] N. Li, L. Li, X. Chen, and I.A. Wong, "Digital Destination Storytelling: Narrative Persuasion Effects Induced by Story Satisfaction in a VR Context," *Journal of Hospitality and Tourism Management*, Vol. 58, 2024, pp. 184-196. DOI: 10.1016/j.jhtm.2023.12.007