Discourse: Indonesian Journal of Social Studies and Education
Volume 3 Nomor 3 (2026), 01-21
DOI: https://doi.org/10.69875/djosse.v3i3.435

Visualizing the Past: The Effect of Canva-Based Infographics on Students' Chronological Thinking in History Learning

Siti Kurniyah[1], Badarudin[2], B. Fitri Rahmawati[3*]
[1,2,3]Universitas Hamzanwadi

ARTICLE INFO

Article history:
Received: April 11, 2026
Accepted: July 09, 2026

Kata Kunci:
Berpikir Kronologis; Infografis Berbasis Canva; Pembelajaran Sejarah; Visualisasi Temporal.

Keywords:
Chronological Thinking; Canva-Based Infographics; History Learning; Temporal Visualization.

ABSTRAK

Kemampuan berpikir kronologis diperlukan agar siswa dapat mengorganisasi urutan, periodisasi, dan hubungan temporal dalam peristiwa sejarah. Penelitian ini bertujuan menganalisis efektivitas infografis berbasis Canva terhadap kemampuan berpikir kronologis siswa dalam pembelajaran sejarah. Penelitian menggunakan pendekatan kuantitatif dengan metode kuasi-eksperimen dan desain nonequivalent control group pretest–posttest. Partisipan berjumlah 46 siswa kelas X MA NW Kotaraja, terdiri atas 22 siswa kelompok eksperimen dan 24 siswa kelompok kontrol. Kelompok eksperimen belajar menggunakan infografis berbasis Canva, sedangkan kelompok kontrol mengikuti pembelajaran reguler. Data dikumpulkan menggunakan tes yang mengukur kemampuan membandingkan periodisasi, menyusun struktur temporal dalam narasi, dan menafsirkan linimasa, kemudian dianalisis secara deskriptif melalui N-gain dan secara inferensial menggunakan independent-samples t-test. Rata-rata kelompok eksperimen meningkat dari 37,86 menjadi 67,23 dengan N-gain 0,47, sedangkan kelompok kontrol meningkat dari 45,54 menjadi 48,42 dengan N-gain 0,03. Perbedaan N-gain kedua kelompok signifikan, $t(44) = 7{,}062$, $p < 0{,}001$, dengan selisih rata-rata 44,14 poin persentase. Temuan ini menunjukkan bahwa penggunaan infografis berbasis Canva berkaitan dengan peningkatan kemampuan berpikir kronologis yang lebih tinggi daripada pembelajaran reguler. Secara pedagogis, infografis dapat digunakan untuk mengeksternalisasi struktur waktu dan membantu siswa mengorganisasi informasi sejarah, tetapi efektivitasnya bergantung pada akurasi isi, koherensi visual, dan aktivitas pemrosesan yang menyertainya.

ABSTRACT

Chronological thinking skills enable students to organize sequences, periodization, and temporal relationships in historical events. This study aimed to analyze the effectiveness of Canva-based infographics in developing students' chronological thinking skills in history learning. A quantitative approach was employed using a quasi-experimental method and a nonequivalent control group pretest-posttest design. The participants were 46 Grade 10 students at MA NW Kotaraja, comprising 22 students in the experimental group and 24 in the control group. The experimental group learned through Canva-based infographics, whereas the control group received regular instruction. Data were collected using a test that assessed students' ability to compare periodizations, construct temporal structures in narratives, and

*Corresponding author
E-mail addresses: fitrimukti@hamzanwadi.ac.id

interpret timelines. The data were analyzed descriptively using normalized gain (N-gain) and inferentially using an independent-samples t-test. The experimental group's mean score increased from 37.86 to 67.23, with an N-gain of 0.47, whereas the control group's mean score increased from 45.54 to 48.42, with an N-gain of 0.03. The difference in N-gain between the groups was significant, t(44) = 7.062, p < .001, with a mean difference of 44.14 percentage points. These findings indicate that the use of Canva-based infographics was associated with a greater improvement in chronological thinking skills than regular instruction. Pedagogically, infographics can externalize temporal structures and help students organize historical information; however, their effectiveness depends on content accuracy, visual coherence, and the processing activities that accompany their use.

INTRODUCTION

Digital transformation in education does not in itself produce more meaningful learning. A second-order meta-analysis indicates that using digital technology merely as a substitute for conventional media has no meaningful overall effect on learning outcomes; its benefits are stronger when technology facilitates more constructive and interactive learning activities supported by appropriate cognitive guidance (Sailer et al., 2024). Similarly, the effectiveness of technology in supporting deep learning is shaped by how its use is structured, the instructional guidance provided, and the types of learning activities involved, rather than simply by the presence of digital devices (Wu, 2024). Applications, devices, and visual learning materials therefore add value only when their representations serve specific pedagogical functions and help students perform cognitive operations relevant to the learning objectives. Visual or multiple representations do not invariably improve understanding; their success depends on representational design, the functions they perform, and the cognitive tasks students undertake when using them (Ainsworth, 2006).

In history education, learning objectives extend beyond mastering isolated names, dates, and facts. Historical reasoning requires students to organize information about the past in order to describe, compare, and explain historical phenomena through source use, contextualization, argumentation, and metahistorical concepts such as cause and consequence, change, and continuity (van Drie & van Boxtel, 2008). Understanding historical time also encompasses the ability to use temporal concepts, sequence events, place phenomena on a timeline, recognize the characteristics of a period, and compare changes across periods (Groot-Reuvekamp et al., 2014). Constructing historical explanations, meanwhile, requires students to connect various conditions, actions, and events causally rather than merely list facts in chronological order (Stoel et al., 2015). Thus, the educational value of a technology should be determined not primarily by the novelty of the application but by its capacity to facilitate the cognitive activities and epistemic practices characteristic of historical knowledge (Ainsworth, 2006; Sailer et al., 2024; van Drie & van Boxtel, 2008).

Chronological thinking is one of the foundational skills in historical thinking. A chronological framework is a central organizing principle in history because it enables events

and developments to be situated within a broader temporal context (van Drie & van Boxtel, 2008). Chronological thinking extends beyond recalling dates. It includes distinguishing among the past, present, and future; recognizing temporal structures in historical narratives; sequencing events; calculating calendar time; constructing and interpreting timelines; explaining change and continuity; and comparing alternative models of periodization (Lorenc & Mrozowski, 2013). Understanding historical time also involves mastering temporal vocabulary, placing objects, individuals, situations, and events in the appropriate periods, and comparing the characteristics of and changes across historical periods (Groot-Reuvekamp et al., 2014).

On this basis, chronological thinking skills can be operationalized through activities such as identifying and comparing models of periodization, recognizing the duration of a development, constructing temporal structures in narratives, and creating and interpreting historical data presented as timelines (Fardi, 2022; Lorenc & Mrozowski, 2013). Such operationalization is important because chronology in history education is often reduced to knowledge of dates and event sequences. In fact, chronology serves as a frame of reference that helps students understand when an event occurred, what preceded and followed it, how long a process lasted, and how different events and developments unfolded sequentially, simultaneously, or in relation to one another (Fardi, 2022; van Drie & van Boxtel, 2008). Without such a temporal framework, collections of events lose their context and become difficult to use in understanding change, continuity, and causal relationships in history (Lorenc & Mrozowski, 2013).

Awareness of historical time has both procedural and conceptual dimensions. Human understanding of historical time does not develop entirely intuitively. Concepts such as chronology, periodization, historical distance, long duration, change, continuity, and the relationship among the past, present, and future need to be deliberately developed through history education (Wilschut, 2019). This development requires temporal language, narratives, timelines, dating systems, and representations of periodization that help students organize and make sense of human experience over time (Fardi, 2022; Groot-Reuvekamp et al., 2014). In a broader sense, historical consciousness concerns how people understand the relationship among the past, present, and future in order to situate themselves in time and make meaning of historical experience (Popa, 2022).

Within a historical thinking framework, time, change, and continuity are components of disciplinary practice that help students interpret developments in the past. Historical thinking, however, is not limited to temporal skills. It also encompasses the use of evidence from sources, analysis of cause and consequence, determination of historical significance, historical perspective taking, and consideration of the ethical dimension of history (Seixas, 2015). Similarly, (van Drie & van Boxtel, 2008) describe historical reasoning as a complex activity involving the formulation of historical questions, the use of sources,

contextualization, argumentation, and the application of substantive and metahistorical concepts.

Chronological thinking is therefore an essential foundation, but it does not constitute the whole of historical thinking. Students may know the sequence of events or place events on a timeline without necessarily being able to explain causal relationships, evaluate evidence, construct arguments, or understand the perspectives of historical actors. Accordingly, when a research instrument measures only temporal sequencing, periodization, duration, and timeline interpretation, the findings should be framed as improvements in chronological thinking or understanding of historical time, rather than in historical thinking as a whole. This limitation of the claim is consistent with the principle of construct validity, according to which interpretations of assessment results must be supported by evidence appropriate to the construct and the actual scope of the skills measured (Kane, 2013).

Difficulties in organizing time were also evident in history learning at MA NW Kotaraja. Based on preliminary observations and interviews conducted for this study, some students had difficulty sequencing events, distinguishing between events that occurred close together in time, identifying the stages of a development, and reading historical information presented in timeline form. In the observed classes, history instruction still relied heavily on teachers' oral explanations and textbooks as the primary representations of the material (preliminary observation and interview data, January 12, 2026).

These findings do not imply that lectures and textbooks are invariably ineffective. A more plausible issue is a mismatch between the skill to be developed-temporal organization-and the form of representation that dominates instruction. The effectiveness of a representation is determined not only by its format but also by the pedagogical function it performs and the cognitive tasks students undertake when interacting with it (Ainsworth, 2006). The issue, therefore, is not simply the use of text, but the extent to which textual structure helps students recognize and organize temporal relationships. A meta-analysis indicates that instruction in text structure improves comprehension of expository texts, particularly because it helps readers recognize the organizational relationships among the ideas presented (Hebert et al., 2016).

When a complex series of events is presented primarily in lengthy paragraphs without explicit temporal structuring, students must identify temporal markers, connect dispersed information, sequence events, and independently construct a coherent mental representation. Research on text comprehension indicates that less cohesive texts make it more difficult for readers to integrate information into a mental model, particularly for readers with more limited working-memory capacity (Schurer et al., 2020). This may increase processing demands because new information must be maintained and processed within working memory, which is limited in both capacity and duration (Sweller et al., 2019). By contrast, an appropriate visual representation can provide an initial framework that helps

readers organize information and construct a mental model while reading (Eitel et al., 2013). In history education, timelines or chronological infographics may therefore externalize sequences and temporal relationships that students would otherwise have to construct independently from verbal descriptions.

Chronological infographics have the potential to bridge the gap between the demands of temporal organization and the predominantly verbal presentation of historical content. Instructionally, an infographic is a visual representation that integrates concise text with graphic elements-such as symbols, images, color, space, and layout-to summarize complex information and highlight relationships among elements (Dunlap & Lowenthal, 2016; Traboco et al., 2022). Its learning benefits, however, do not arise merely from the presence of visual elements, but from the alignment among the information displayed, its spatial organization, and the cognitive processes students need to perform (Mccrudden & Rapp, 2015).

In history education, the relevant format is therefore not merely a decorative poster, but a temporal visualization or timeline that uses year markers, period blocks, relational arrows, comparisons of time spans, and event hierarchies. Research on learning historical time suggests that timelines can serve as frameworks that help students understand relationships among events, phenomena, and historical periods (Groot-Reuvekamp et al., 2014). Spatial organization makes several points and spans of time simultaneously available within a single visual field, enabling comparison, while placing brief annotations close to the elements they explain reduces the need for students to search for and combine separated information (Eitel et al., 2013; Schroeder & Cenkci, 2018). Information dispersed across several paragraphs can thus be represented as a more integrated temporal framework.

This explanation is consistent with the Cognitive Theory of Multimedia Learning (CTML). The theory rests on three assumptions: people have distinct but interacting channels for processing verbal/auditory and pictorial/visual information; each channel has limited capacity; and learning requires active processing. Meaningful learning occurs when students select relevant words and images, organize them into coherent verbal and visual representations, and then integrate these representations with each other and with prior knowledge stored in long-term memory (Mayer, 2024; Mayer & Moreno, 2010).

Consequently, adding images or visual elements does not automatically improve learning. Decorative images and interesting but irrelevant information, often termed seductive details, can divert attention from the core material and reduce learning outcomes (Sundararajan & Adesope, 2020). Excessive or redundant text can likewise increase processing demands, particularly when students must process narration and written text that convey identical information (Adesope & Nesbit, 2012). Placing related text and images far apart also forces students to search for and mentally connect the information, increasing the risk of split attention (Schroeder & Cenkci, 2018).

Conversely, infographics are more likely to support learning when their design eliminates irrelevant information, positions text near the visual elements it explains, and uses visual cues to emphasize important structures and relationships. Meta-analytic evidence indicates that visual signaling-through color, connecting lines, labels, or typographic emphasis, for example-can direct students' attention to correspondences between text and images (Richter et al., 2016). Eye-tracking research also shows that color supports learning when used functionally to help students locate and connect corresponding information (Ozcelik et al., 2009). The instructional value of an infographic therefore lies not in the quantity of its visual elements but in its capacity to direct cognitive processing toward structures relevant to the learning objectives.

Meta-analytic evidence reinforces the importance of signaling in multimedia materials. The signaling principle holds that students learn more effectively when verbal or visual cues direct attention to important information, clarify the organization of the material, and highlight relationships between verbal and visual representations (Alpizar et al., 2020; Schneider et al., 2017). Signals may include consistent color, connecting lines, arrows, labels, headings, typographic emphasis, contrast, and spatial grouping. Their purpose is not decorative; rather, they support the selection of information, the organization of material, and the integration of relationships among elements (Koning et al., 2009).

Meta-analytic evidence indicates that signaling has positive effects on retention and transfer, although effect sizes vary according to the characteristics of the material and the learners (Schneider et al., 2017). More specifically, a meta-analysis of text-picture relations found small-to-moderate positive effects on comprehension and transfer, with benefits tending to be more pronounced among learners with low prior knowledge (Richter et al., 2016). Eye-tracking research further indicates that using color to code relationships can accelerate the search for corresponding information and support retention and transfer (Ozcelik et al., 2009).

In history education, this principle can be applied to timelines by using consistent colors to designate periods, lines to indicate continuity in a development, and arrows and labels to distinguish temporal sequence from causal relationships. Spatial positioning and coding systems should remain consistent from the beginning to the end of a timeline so that students do not have to relearn the meaning of each marker. This application is consistent with the use of timelines as frameworks for organizing historical time (Groot-Reuvekamp et al., 2014). Signaling is therefore more substantive than merely making a display attractive because it relates directly to how attention is directed, information is selected, and temporal relationships are organized.

Canva is a visual design platform that provides a wide range of templates, images, icons, graphic elements, typefaces, videos, animations, and drag-and-drop editing tools. These features make it technically easier for teachers to produce presentations, posters,

worksheets, and infographics without mastering professional design software (Canva, 2026). This technical accessibility is important because producing effective infographics requires deliberate decisions concerning layout, color, typography, context, and communicative purpose (Traboco et al., 2022).

Nevertheless, Canva cannot be treated as a variable that produces learning by itself. The same platform can be used to create concise, well-structured learning materials, but it can also produce designs crowded with decoration, excessive text, and irrelevant visual elements. Multimedia learning theory emphasizes that learning outcomes depend on selecting, organizing, and integrating relevant information, rather than on the number of visual features or the sophistication of the platform used (Mayer, 2024). This study therefore positions Canva as a production tool, while the pedagogical treatment consists of presenting historical information through concise, structured chronological infographics designed to support temporal organization.

Distinguishing between the platform and the instructional design is necessary to avoid technological determinism-the tendency to regard technology as the primary driver of change and the direct cause of improved learning outcomes. The literature cautions that educational technology research often overstates the influence of technological tools while giving insufficient attention to methods, objectives, learner characteristics, and contexts of use (Oliver, 2011). In the media-method debate, (Clark, 1983) argued that improvements attributed to media often actually derive from instructional methods or the novelty of a treatment. (Kozma, 1994) subsequently refined this position by explaining that media effects must be understood through the interaction among the representational capabilities of the medium, instructional methods, tasks, and learners' cognitive processes. Contemporary perspectives similarly view technology, pedagogy, objectives, values, and context as mutually constitutive; learning outcomes therefore cannot be inferred solely from the name of the platform used (Fawns, 2022).

Previous research demonstrates the potential-although not entirely consistent-of visual representations in history learning. Prangsma et al. compared three representational construction activities: textual representations, visual-textual representations, and visual-textual representations integrated into a timeline. Their final sample comprised 85 pre-vocational secondary school students aged 12-13 who worked in pairs on four history tasks. Students who constructed visual-textual representations integrated into a timeline achieved higher immediate test scores than those who constructed textual representations alone, particularly on items assessing the placement and sequencing of events in time (Prangsma et al., 2008). These findings suggest that a timeline can serve not merely as an illustration but as an external framework for organizing the phenomena, concepts, and temporal and causal relationships that constitute a chronological-conceptual frame of reference. However,

the difference did not persist on the retention test, meaning that the study provides stronger support for short-term benefits than for durable learning.

Broader evidence comes from the Timewise intervention. In a quasi-experimental study involving 788 Grade 2 and Grade 5 students and 16 teachers, timelines were used consistently as a basis for connecting events, period characteristics, temporal sequences, and change and continuity. The intervention group demonstrated a better understanding of historical time than the comparison group (Groot-Reuvekamp et al., 2014; Wilson et al., 2023). This study is important because it shows that the benefits of timelines arise not only from their appearance but also from their consistent use in learning activities that explicitly target an understanding of historical time.

In the Indonesian context, (Dara & Setiawati, 2017) reported that students who learned with timeline media achieved higher chronological thinking outcomes than those who learned with PowerPoint. These findings should nevertheless be treated as supporting evidence because the study used a nonequivalent control group design and reported several inconsistencies in its statistical analysis. A developmental study by (Ofianto et al., 2022) likewise found that a Focusky-based digital timeline was judged feasible and practical and was accompanied by improved chronological thinking skills; however, its developmental design did not provide causal evidence as strong as that of a controlled experiment.

More closely aligned with the focus on digital infographics, (Susanto et al., 2025) involved 48 Grade 11 vocational high school students in a posttest-only control group design. The study reported a significant difference in chronological thinking skills between students who learned through digital infographics and the comparison group, with higher achievement in the experimental group. Although relevant, the absence of a baseline measure and the lack of clarity concerning individual randomization limit confidence that the final difference was attributable entirely to the infographics. Overall, previous studies support the potential of timelines and digital infographics as tools for temporal organization, but their benefits depend on representational design, student activity, consistency of use, and the alignment of the instrument with the construct of chronological thinking.

Recent research on spatial representations in history education offers additional support while also revealing their conceptual limitations. (Lucero et al., 2024) found that students who collaboratively completed partially filled concept maps engaged more extensively in causal explanation, argumentation, the use of historical and metahistorical concepts, and the integration of ideas than students who collaboratively wrote summaries. These findings indicate that spatial representations accompanied by a completion task can provide a framework for identifying and discussing conceptual relationships that are less readily visible in linear text. A concept map, however, is not equivalent to a timeline infographic, so these results cannot be treated as direct evidence of the effectiveness of temporal infographics. The benefits of visual representations also appear to be shaped by

the accompanying activity. Meta-analytic evidence suggests that constructing concept maps yields greater relative benefits than merely studying preconstructed maps, although both forms of use can support learning (Schroeder & Cenkci, 2018). Students who only view an infographic may therefore engage in less generative processing than those asked to interpret, complete, explain, or construct one (Fiorella, 2023).

Three gaps underpin this study. First, many Canva-related studies assess motivation, creativity, product feasibility, or general learning outcomes, whereas the relationship between infographic design and specific cognitive operations in historical thinking remains underexamined. Second, research directly assessing chronological thinking at the Islamic senior secondary school level remains limited. Third, educational technology studies often attribute changes in outcomes to the name of an application without explaining the representational mechanisms that may be operating. This study shifts the focus from whether Canva is engaging to a more disciplinary question: Is temporal visualization through Canva-based infographics associated with the development of students' ability to organize historical time?

This study aimed to analyze the effectiveness of Canva-based infographics in developing Grade 10 students' chronological thinking skills in history learning. Effectiveness was examined through changes in pretest-posttest scores, N-gain, and differences in final outcomes between the experimental and control groups. Because the design involved pre-existing classes, the analysis also paid particular attention to differences in baseline ability. The working hypothesis was that students who learned through Canva-based infographics would demonstrate greater development in chronological thinking skills than those who received conventional instruction.

METHOD

This This study employed a quantitative approach using a quasi-experimental method and a nonequivalent control group pretest-posttest design. This design was selected because the participants came from administratively established classes, and the researchers neither randomized individual students nor randomly allocated classes to the study conditions. In quasi-experimental designs, groups are formed or selected on nonrandom criteria, although the researcher still manipulates the independent variable to examine the effect of an intervention on a particular outcome (Denny et al., 2023; Shadish et al., 2002). Both groups completed a pretest before the intervention and a posttest after it. The experimental group received history instruction using Canva-based infographics, whereas

the control group received the regular history instruction typically provided by the teacher. The design can be represented as follows:

Group	Pretest	Treatment	Posttest
Experimental	(O_1)	(X_1)	(O_2)
Control	(O_3)	(X_0)	(O_4)

Notes:

O_1 and O_3: initial measurement or pretest;

O_2 and O_4: final measurement or posttest;

X_1: instruction using Canva-based infographics;

X_0: regular instruction in the control group.

The study was conducted at MA NW Kotaraja, East Lombok Regency, during the first semester of the 2026/2027 academic year. The participants were 46 Grade 10 students: 22 students from Class X-1 in the experimental group and 24 students from Class X-2 in the control group. The primary instrument was a chronological thinking skills test administered before and after instruction. The test indicators included the ability to identify and compare models of historical periodization, construct temporal structures in historical narratives, and interpret historical data presented as timelines. Data collection involved mapping baseline conditions, administering the pretest, implementing the instruction, observing the learning process, and administering the posttest. The data were analyzed using an independent-samples t-test (Lakens, 2013) with SPSS 25.0.

RESULT

Profile of Students' Chronological Thinking Skills

A descriptive analysis of the chronological thinking skills of Grade 10 students at MA NW Kotaraja is presented in Table 1.

Table 1. Profile of students' chronological thinking skills

Group	Mean pretest score	Mean posttest score	Mean N-gain
Experimental (n = 22)	37.86 (SD = 5.514)	67.23 (SD = 14.925)	0.47
Control (n = 24)	45.54 (SD = 9.203)	48.42 (SD = 8.444)	0.03

Table 1 shows that the experimental group's mean pretest score was 37.86 (SD = 5.514), whereas the control group was 45.54 (SD = 9.203). The control group's baseline mean was therefore 7.68 points higher. After instruction, the experimental group's mean posttest score reached 67.23 (SD = 14.925), whereas the control group reached 48.42 (SD = 8.444). The

experimental group's mean increased by approximately 29.37 points from pretest to posttest, while the control group's increased by approximately 2.88 points. The wider range of posttest scores in the experimental group was also reflected in its larger standard deviation. This indicates that students did not respond uniformly to the treatment; some may have benefited more than others. The N-gain analysis showed a mean gain of 0.47 in the experimental group and 0.03 in the control group. Under the classification used in this study, the experimental group's gain was moderate, whereas the control group was low.

Effect of Canva-Based Infographics on Students' Chronological Thinking Skills

The test of the effect of Canva-based infographics on students' chronological thinking skills is presented in Table 2.

Table 2. Results of the independent-samples t-test

t	df	Sig. (two-tailed)	Mean difference
7.062	44	< .001	44.140

Table 2 shows a significant difference in mean N-gain between the experimental and control groups, $t(44) = 7.062$, $p < .001$. The result indicates that students who learned through Canva-based infographics demonstrated a significantly greater improvement in chronological thinking skills than those in the control group. The mean difference further shows that the experimental group's average N-gain was 44.140 percentage points higher than that of the control group.

DISCUSSION

The findings indicate that Canva-based infographics can improve students' chronological thinking skills. Chronological thinking is not limited to recalling dates; it encompasses placing events within a temporal framework, establishing sequences, recognizing patterns of duration and succession, and understanding periodization. A chronological framework provides a basis for organizing historical knowledge and explaining change and continuity across events (van Drie & van Boxtel, 2008). In linear narrative texts, temporal information may appear in separate sections, requiring readers to identify temporal markers, maintain access to earlier information, and integrate it into a mental model of the event sequence. Research on text processing indicates that readers monitor the consistency of temporal sequences and update their situation models when they encounter temporal shifts; these processes can impose additional processing demands and affect the accessibility of previously read information (Rinck, 2003; Speer & Zacks, 2005).

Timeline infographics can externalize some of these temporal relationships by organizing information spatially. Consistent horizontal or vertical positions can encode sequence; blocks or fields of color can distinguish periods or categories; and lines and arrows can represent relationships, directions of development, or continuity. When a proportional

chronological scale is used, the distance and length of visual elements can also represent intervals and event durations (Brehmer et al., 2016; Tversky, 2011). Such external representations do not replace students' historical reasoning. Rather, they provide cognitive scaffolding and reduce the need to continually search for or retain temporal information in working memory, allowing cognitive resources to be directed more fully toward organizing, integrating, and interpreting historical patterns (Ainsworth, 2006; Mayer, 2024; Risko & Gilbert, 2016). These benefits, however, depend on the clarity of the scale, consistency of the visual coding, relevance of graphic elements, and students' ability to connect verbal and visual representations.

The findings of this study partially align with those of (Prangsma et al., 2008). In their study of 85 students aged 12-13, participants worked in pairs to construct textual representations, visual-textual representations, or visual-textual representations integrated into a timeline. The group that constructed visual-textual representations within a timeline achieved higher posttest scores than the textual-representation group, particularly on items assessing temporal relationships. However, this difference did not persist on the retention test, and no significant difference was found between the timeline group and the visual-textual group without a timeline. The study therefore provides limited support for the proposition that integrating verbal and visual information within a temporal structure can facilitate the formation of a chronological-conceptual framework, particularly in the short term.

The similarity between that study and the present research lies in the use of verbal and visual information organized within a temporal structure. The difference is that students in (Prangsma et al., 2008) collaboratively constructed and integrated the representations, whereas students in the present study primarily used teacher-provided infographics as instructional media. This distinction is important because constructing a representation is a generative activity that requires students to select relevant information, organize it into a coherent structure, and integrate it with prior knowledge (Fiorella & Mayer, 2016). Within the ICAP framework, generating or completing one's own representation is a constructive activity, whereas merely observing a provided representation tends to involve a lower level of engagement unless it is accompanied by an information-processing task (Chi & Wylie, 2014).

Nevertheless, student-generated representations are not necessarily more effective than provided visuals. The benefits of generative activities are shaped by representational quality, students' spatial ability, the complexity of the material, and the support provided during construction (Fiorella & Zhang, 2018; Zhang & Fiorella, 2019). Eye-tracking research suggests that drawing one's own representation can encourage rereading of important information and more frequent shifts of attention between the text and the drawing space, but the activity still requires guidance to avoid adding unproductive processing demands

(Hellenbrand et al., 2019). Future research should therefore compare the effectiveness of teacher-provided infographics with infographics that students construct, complete, or revise, while controlling for design quality, prior knowledge, learning time, and the level of scaffolding.

The Cognitive Theory of Multimedia Learning can help explain the findings of this study. According to the theory, meaningful learning occurs when students select relevant information, organize it into coherent mental representations, and integrate it with their existing knowledge (Mayer, 2024). In historical infographics, text can explicitly state events, concepts, and temporal relationships, while layout, lines, positioning, images, and symbols can externalize those relationships spatially. When text is placed close to the visual element to which it refers, students need not continually search for correspondences between the two sources of information. This condition can reduce split attention and facilitate the integration of verbal and visual information (Holsanova et al., 2009; Schroeder & Cenkci, 2018). A review of 29 systematic reviews encompassing 1,189 studies likewise found spatial and temporal contiguity to be among the multimedia design principles with strong meta-analytic support (Noetel et al., 2022).

This effect can be strengthened through signalling, or the use of cues that highlight the organization or essential information in the material. In chronological infographics, signals may include bold dates, meaningful colour changes, directional arrows, period labels, connecting lines, or the placement of events in particular positions. A meta-analysis by (Schneider et al., 2017), encompassing 103 studies and 12,201 participants, found that signalling had positive effects on retention ($g = 0.53$) and transfer ($g = 0.33$), while also increasing attention to relevant information. Visual cues are helpful, however, only when their meaning is clear and their use is consistent. Colour, for example, should designate the same categories, periods, or statuses rather than merely create aesthetic variation. Similarly, size, position, and arrows should direct attention to relationships that form part of the learning objective. When too many elements are emphasized, signalling becomes less effective because students can no longer distinguish central from supplementary information.

Multimedia principles do not, however, imply that more visual elements invariably produce better learning. Template-based design platforms such as Canva make it easy to add icons, illustrations, colours, shapes, animations, and decorative effects, but this convenience can also increase the risk of seductive details-elements that attract attention but are irrelevant to the learning objectives. A meta-analysis by (Sundararajan & Adesope, 2020) indicates that adding interesting but irrelevant details tends to reduce learning outcomes. This finding is reinforced by a recent multilevel meta-analysis of 177 effect sizes from 50 studies, which found a small negative overall effect on learning outcomes ($g = -0.16$), including comprehension, recall, and transfer. This effect operated primarily by

increasing extraneous cognitive load (Cheng et al., 2026). Visual appeal should therefore support the communication of meaning rather than become an end in itself.

In this context, an effective historical infographic need not use a prescribed number of colors, but it should apply a limited, legible, and consistent visual code; place labels near the elements they explain; maintain sufficient contrast; and divide verbal information into units aligned with the temporal structure. If a single infographic presents chronological sequence, causal relationships, change, and comparison simultaneously, each type of relationship should be distinguished through clear visual codes and a legend. This is important because lines and arrows may be interpreted as indicating sequence, movement, temporal relationships, or causality; using them without differentiation can therefore create ambiguity (Tversky, 2011). In historical reasoning, an earlier event does not automatically cause the event that follows; a causal relationship requires an explanation of the mechanisms, conditions, and interconnections among factors (van Drie & van Boxtel, 2008). Timelines should therefore encode temporal sequence, while causal relationships should be represented by different line styles, arrows, colors, or labels and explained in a legend.

Within this framework, the improvement in chronological thinking observed in this study may be interpreted as resulting from a presentation of temporal information that was more integrated, directed, and easy to trace. Because this study did not directly measure students' visual attention, information-integration processes, or cognitive load, however, this mechanism should be treated as a theoretically plausible explanation rather than as an empirically demonstrated mechanism within the present study.

One of the most direct contributions of infographics is that they provide an external structure for organizing historical time. Within a single visual field, students can identify temporal positions, sequences, transition points, durations, and simultaneous relationships among conditions or events. This benefit should nevertheless be understood as a representational affordance rather than an automatic consequence of infographic use. Its effectiveness continues to depend on content accuracy, the legibility of temporal markers, consistency of symbols, and the learning activities accompanying the visualization. (Prangsma et al., 2008), for example, found that the collaborative construction of visual-textual representations integrated with timelines produced better short-term understanding than the construction of textual representations. Other research nevertheless indicates that adding visuals does not always improve immediate or retention-test performance when the represented relationships are insufficiently clear or do not support a single, unambiguous interpretation.

In teaching periodization, visual blocks or bands can help students compare divisions based on political, economic, social, and cultural change. Periodization, however, should not be presented as a natural division inherent in the past. Period boundaries result from historians' selection of turning points and criteria of change considered significant. Because

change in different domains can proceed at different rates, a political period boundary does not necessarily coincide with a boundary of economic or cultural change. The notion of plural and layered historical temporalities also reveals the limitations of periodization that is excessively linear and homogeneous (Jordheim, 2012). Infographics can therefore use parallel bands, overlapping boundaries, or color gradients to show that periodization is interpretive and may vary according to the focus of analysis. The criteria used to define each period should also be stated explicitly.

Historical time consciousness differs from the understanding of everyday time, which is formed primarily through direct experience (Wilschut, 2019). Spans of decades or centuries, historical distance, the simultaneity of events in different places, long-term change, and alternative possible trajectories require modes of thinking that are not always intuitive. Within this framework, using infographics as a bridge between spatial organization and concepts of historical time is a plausible pedagogical interpretation. Positions, paths, layers, and visual distances can help externalize temporal relationships that are difficult to observe in linear text. Timeline design must, however, distinguish chronological scale from sequential scale. On a proportional chronological scale, visual distance can represent the length of a time interval. On a sequential scale, by contrast, distance indicates order only and need not correspond to duration. Scale, representation, and layout are central dimensions in timeline design (Brehmer et al., 2016). If one-year and one-hundred-year spans are assigned equal distances without explanation, the visualization may lead to erroneous interpretations of duration. Teachers should therefore indicate whether a timeline is drawn 'to scale' or 'not to scale.' If the scale is compressed or interrupted, this change should also be marked visually.

This discussion must also distinguish chronology from causality. Temporal proximity or sequence indicates only that a causal relationship may be temporally possible; neither demonstrates that the earlier event caused the subsequent one. A timeline can help test the temporal plausibility of an explanation-for example, by ruling out a factor that emerged only after the outcome-but causal explanation still requires evidence of how a factor produced or enabled change. Historical causal reasoning must also consider actors' actions and intentions, structural conditions, context, triggers, unintended consequences, and alternative possible developments (Seixas, 2015; Stoel et al., 2015; van Drie & van Boxtel, 2008). Lines or arrows in an infographic should therefore not be used simultaneously to mean 'occurred after' and 'was caused by' without clear visual differentiation and explanation.

Cause and consequence constitute one of the central concepts in historical thinking, alongside the use of evidence, change and continuity, historical perspectives, significance, and the ethical dimension (Seixas, 2015). (van Drie & van Boxtel, 2008) meanwhile, describe historical reasoning as an activity encompassing the formulation of questions, the use of sources, contextualization, argumentation, and the application of substantive and

metahistorical concepts. Both frameworks indicate that the ability to establish chronological sequence is an essential foundation, but does not yet constitute complete historical reasoning.

The findings of (Lucero et al., 2024) provide more specific support for the importance of generative activity. In a study involving 20 secondary school students, collaboratively completing semi-structured concept maps led to greater engagement in causal explanation and argumentation than collaboratively writing summaries. These findings do not directly demonstrate the effectiveness of Canva infographics because the representation, number of participants, and type of activity differed. They do suggest, however, that infographics may be more productive when students do not merely view a finished product but also complete, revise, compare, or construct the relationships within it. Future research could therefore compare teacher-provided infographics with infographics constructed or completed by students.

Distinguishing chronology from causality is important to prevent fluency in reading a visual from being equated with depth of understanding. Students may be able to reproduce an event sequence without explaining why change occurred, assessing the strength of evidence, comparing causal factors, or recognizing interpretive uncertainty. External representations can support learning, but their benefits are not always realized because students must still understand the function of each representation and translate relationships among representations (Ainsworth, 2006). Consistent with this point, (Prangsma et al., 2008) found that combining text and visuals did not in itself improve history-learning outcomes.

Chronological infographics are therefore best positioned as orientation maps and scaffolding tools rather than as complete historical explanations. Once students have mastered the temporal structure, instruction should proceed to source analysis, comparison of interpretations, discussion, and argumentative tasks. A document-based approach, for example, requires students to use background knowledge to examine and reconcile multiple sources rather than merely accept a single preassembled narrative (Reisman, 2012). Follow-up questions can address the reasons for change, the evidence supporting a relationship, differences between long-term factors and immediate triggers, the relative weight of each cause, and the ways in which historical actors' perspectives shaped their actions. In such a sequence, infographics serve as an entry point to more complex historical reasoning.

CONCLUSION

The use of Canva-based infographics was associated with greater development of chronological thinking skills among Grade 10 students at MA NW Kotaraja. The experimental group's mean score increased from 37.86 to 67.23, with an N-gain of 0.47, whereas the control group's mean score changed from 45.54 to 48.42, with an N-gain of 0.03. The

between-group difference in N-gain was significant at $p < .001$, and the Cohen's d estimate calculated from the summary statistics indicated a large standardized difference.

The pedagogical value of the intervention lies primarily in temporal visualization: time markers, hierarchy, period grouping, and reading paths help students organize sequences and interpret timelines. Canva is a tool that facilitates production rather than an automatic cause of learning. Effectiveness is determined by historical accuracy, visual coherence, signaling principles, and activities that require students to process the representation actively.

REFERENCES

Adesope, O. O., & Nesbit, J. C. (2012). Verbal Redundancy in Multimedia Learning Environments : A Meta-Analysis. Journal of Educational Psychology, 104(1), 250–263. https://doi.org/10.1037/a0026147

Ainsworth, S. (2006). DeFT : A conceptual framework for considering learning with multiple representations. Learning and Instruction, 16, 183–198. https://doi.org/10.1016/j.learninstruc.2006.03.001

Alpizar, D., Adesope, O. O., & Wong, R. M. (2020). A meta - analysis of signaling principle in multimedia learning environments. Educational Technology Research and Development, 68(5), 2095–2119. https://doi.org/10.1007/s11423-020-09748-7

Brehmer, M., Lee, B., Bach, B., Riche, N. H., & Munzner, T. (2016). Timelines Revisited : A Design Space and Considerations for Expressive Storytelling. IEEE Transactions on Visualization and Computer Graphics, 23(9), 2151–2164. https://doi.org/10.1109/TVCG.2016.2614803

Canva. (2026). Tentang Canva Pendidikan. Canva for Education. https://www.canva.com/help/about-canva-for-education/

Cheng, C., Wu, Y., Wang, R., & Wang, Z. (2026). Seductive Details, Cognitive Load, and Learning Outcomes: A Multi-level Meta-analysis and MASEM. Educational Psychology Review, 38(1), 28. https://doi.org/10.1007/s10648-025-10099-z

Chi, M. T. H., & Wylie, R. (2014). The ICAP Framework : Linking Cognitive Engagement to Active Learning Outcomes The ICAP Framework : Linking Cognitive Engagement to Active Learning Outcomes. Educational Psychologist, 49(4), 219–243. https://doi.org/10.1080/00461520.2014.965823

Clark, R. E. (1983). Reconsidering Research on Learning from Media. Review of Educational Research, 53(4), 445–459. https://doi.org/10.3102/00346543053004445

Dara, M. C., & Setiawati, E. (2017). Pengaruh Penggunaan Media Timeline terhadap Kemampuan Berpikir Kronologis Pembelajaran Sejarah di SMAN 2 Metro. Jurnal HISTORIA, 5(1), 55–76.

Denny, M., Denieffe, S., & O'Sullivan, K. (2023). Non-equivalent Control Group Pretest–Posttest Design in Social and Behavioral Research. In A. L. Nichols & J. Edlund (Eds.), The Cambridge Handbook of Research Methods and Statistics for the Social and Behavioral Sciences: Volume 1: Building a Program of Research (pp. 314–332). Cambridge University Press. https://doi.org/10.1017/9781009010054.016

Dunlap, J. C., & Lowenthal, P. R. (2016). Getting graphic about infographics : design lessons learned from popular infographics. Journal of Visual Literacy, 35(1), 42–59. https://doi.org/10.1080/1051144X.2016.1205832

Eitel, A., Scheiter, K., Schüler, A., Nyström, M., & Holmqvist, K. (2013). How a picture facilitates the process of learning from text : Evidence for scaffolding. Learning and Instruction, 28, 48–63. https://doi.org/10.1016/j.learninstruc.2013.05.002

Fardi, K. (2022). The concept of historical time in early childhood education : theoretical , methodological approaches and practice. History Education Research Journal, 19(1), 1–11. https://doi.org/https://doi.org/10.14324/HERJ.19.1.11

Fawns, T. (2022). An Entangled Pedagogy : Looking Beyond the Pedagogy — Technology Dichotomy. Postdigital Science and Education, 4, 711–728. https://doi.org/10.1007/s42438-022-00302-7

Fiorella, L. (2023). Making Sense of Generative Learning. Educational Psychology Review, 35, 50. https://doi.org/10.1007/s10648-023-09769-7

Fiorella, L., & Mayer, R. E. (2016). Eight Ways to Promote Generative Learning. Educational Psychology Review, 28, 717–741. https://doi.org/10.1007/s10648-015-9348-9

Fiorella, L., & Zhang, Q. (2018). Drawing Boundary Conditions for Learning by Drawing. Educational Psychology Review, 30(3), 1115–1137. https://doi.org/https://doi.org/10.1007/s10648-018-9444-8

Groot-Reuvekamp, M. J. De, Boxtel, C. Van, Ros, A., & Harnett, P. (2014). The understanding of historical time in the primary history curriculum in England and the Netherlands The understanding of historical time in the primary. Journal of Curriculum Studies, 46(4), 487–514. https://doi.org/10.1080/00220272.2013.869837

Hebert, M., Bohaty, J. J., Nelson, J. R., & Brown, J. (2016). The Effects of Text Structure Instruction on Expository Reading Comprehension : A Meta-Analysis. Journal of Educational Psychology, 108(5), 609–629. https://doi.org/http://dx.doi.org/10.1037/edu0000082

Hellenbrand, J., Mayer, R. E., Opfermann, M., Schmeck, A., & Leutner, D. (2019). How Generative Drawing Affects the Learning Process: An Eye-Tracking Analysis. Applied Cognitive Psychology, 33(6), 1147–1164. https://doi.org/10.1002/acp.3559

Holsanova, J., Holmberg, N., & Holmqvist, K. (2009). Reading Information Graphics : The Role of Spatial Contiguity and Dual Attentional Guidance. Applied Cognitive Psychology, 23(9), 1215–1226. https://doi.org/10.1002/acp

Ilham, M., Mashuri, S., Hamzah, E. I., & Agustan, A. (2025). LIVING QUR'AN PERSPEKTIF PENDIDIKAN ISLAM: BELAJAR DARI TRADISI KEAGAMAAN ETNIS SASAK TRANSMIGRASI DI DESA KARYA MUKTI DONGGALA SULAWESI TENGAH. TA'LIM : Jurnal Studi Pendidikan Islam, 8(2), 258–275. https://doi.org/10.52166/talim.v8i2.10503

Jordheim, H. (2012). AGAINST Periodization: Koselleck's Theory of Multiple Temporalities. History and Theory, 51(May), 151–171.

Kane, M. T. (2013). Validating the Interpretations and Uses of Test Scores. Journal of Educational Measurement, 50(1), 1–73. https://doi.org/https://doi.org/10.1111/jedm.12000

Koning, B. B. de, Tabbers, H. K., Rikers, R. M. J. P., & Paas, F. (2009). Towards a Framework for Attention Cueing in Instructional Animations : Guidelines for Research and Design. Educational Psychology Review, 21, 113–140. https://doi.org/10.1007/s10648-009-9098-7

Kozma, R. B. (1994). Will Media Influence Learning ? Reframing the Debate. Ducational Technology Research and Development, 42(2), 7–19. https://doi.org/https://doi.org/10.1007/BF02299087

Lakens, D. (2013). Calculating and reporting effect sizes to facilitate cumulative science : a practical primer for t -tests and ANOVAs. Frontiers in Psychology, 4, 1–12. https://doi.org/10.3389/fpsyg.2013.00863

Lorenc, J., & Mrozowski, K. (2013). How is chronological thinking tested? Edukacja An Interdisciplinary Approach, 1, 84–97.

Lucero, M., Montanero, M., & Boxtel, C. Van. (2024). Semiempty collaborative concept mapping in history education: students' engagement in historical reasoning and coconstruction. Instructional Science, 52, 557–581.

Mayer, R. E. (2024). The past, present, and future of the cognitive theory of multimedia learning. Educational Psychology Review, 36(1), 8.

Mayer, R. E., & Moreno, R. (2010). Nine Ways to Reduce Cognitive Load in Multimedia Learning Nine Ways to Reduce Cognitive Load in Multimedia Learning. Educational Psychologist, 38(1), 43–52. https://doi.org/http://dx.doi.org/10.1207/S15326985EP3801_6

Mccrudden, M. T., & Rapp, D. N. (2015). How Visual Displays Affect Cognitive Processing. Educational Psychology Review, 29(3), 623–639. https://doi.org/10.1007/s10648-015-9342-2

Noetel, Michael, Griffith, Shantell, Delaney, Oscar, Harris, Nicola Rose, Sanders, Taren, Parker, Philip, del Pozo Cruz, Borja, & Lonsdale, Chris. (2022). Multimedia Design for Learning: An Overview of Reviews With Meta-Meta-Analysis. Review of Educational Research, 92(3), 413–454. https://doi.org/10.3102/00346543211052329

Ofianto, O., Aman, A., Sariyatun, S., Bunar, B., Zahra, T. Z. N., & Marni, M. E. P. (2022). Media Timeline Development with the Focusky Application to Improve Chronological Thinking Skills. International Journal of Learning, Teaching and Educational Research, 21(4), 114–133.

Oliver, M. (2011). Technological determinism in educational technology research: some alternative ways of thinking about the relationship between learning and technology. Journal of Computer Assisted Learning, 27(5), 373–384. https://doi.org/10.1111/j.1365-2729.2011.00406.x

Ozcelik, E., Karakus, T., Kursun, E., & Cagiltay, K. (2009). An eye-tracking study of how color coding affects multimedia learning. Computers & Education, 53(2), 445–453. https://doi.org/10.1016/j.compedu.2009.03.002

Popa, N. (2022). Operationalizing Historical Consciousness : A Review and Synthesis of the Literature on Meaning Making in Historical Learning. Review of Educational Research, 92(2), 171–208. https://doi.org/10.3102/00346543211052333

Prangsma, M. E., Boxtel, C. A. M. Van, & Kanselaar, G. (2008). Developing a "big picture": Effects of collaborative construction of multimodal representations in history. Instructional Science, 36(2), 117–136. https://doi.org/10.1007/s11251-007-9026-5

Rahmah, H., Takunas, R., & Hamzah, E. I. (2024). PENGUATAN PENDIDIKAN KARAKTER DALAM PEMBELAJARAN SEJARAH KEBUDAYAAN ISLAM DI MI ALKHAIRAAT POMBEWE KACAMATAN SIGI BIROMARU KABUPATEN SIGI. DISCOURSE: Indonesian Journal of Social Studies and Education, 2(1), 43–55. https://doi.org/10.69875/djosse.v2i1.153

Reisman, A. (2012). Reading Like a Historian: A Document-Based History Curriculum Intervention in Urban High Schools. Cognition and Instruction, 30(1), 86–112. https://doi.org/10.1080/07370008.2011.634081

Richter, J., Scheiter, K., & Eitel, A. (2016). Signaling text-picture relations in multimedia learning : A comprehensive meta-analysis. Educational Research Review, 17, 19–36. https://doi.org/10.1016/j.edurev.2015.12.003

Rinck, M. (2003). Processing of temporal information : Evidence from eye movements. Memory & Cognition, 31(1), 77–86.

Risko, E. F., & Gilbert, S. J. (2016). Cognitive Of floading. Trends in Cognitive Sciences, 20(9), 676–688. https://doi.org/10.1016/j.tics.2016.07.002

Sailer, M., Maier, R., Berger, S., Kastorff, T., & Stegmann, K. (2024). Learning activities in technology-enhanced learning : A systematic review of meta-analyses and second-order meta-analysis in higher education. Learning and Individual Differences, 112(April), 102446. https://doi.org/10.1016/j.lindif.2024.102446

Schneider, S., Beege, M., Nebel, S., Rey, G. D., & Schneider, S. (2017). A Meta-Analysis of How Signaling Affects Learning with Media. Educational Research Review, 23, 1–24. https://doi.org/10.1016/j.edurev.2017.11.001

Schroeder, N. L., & Cenkci, A. T. (2018). Spatial Contiguity and Spatial Split-Attention Effects in Multimedia Learning Environments : a Meta-Analysis. Educational Psychology Review, 30(3), 679–701. https://doi.org/https://doi.org/10.1007/s10648-018-9435-9

Schurer, T., Opitz, B., & Schubert, T. (2020). Working Memory Capacity but Not Prior Knowledge Impact on Readers ' Attention and Text Comprehension. Frontiers in Education, 5(6), 1–12. https://doi.org/10.3389/feduc.2020.00026

Seixas, P. (2015). A Model of Historical Thinking. Educational Philosophy and Theory, 1857(December), 1–13. https://doi.org/10.1080/00131857.2015.1101363

Shadish, W. R., Cook, T. D., & Campbell, D. T. (2002). Experimental and Quasi-experimental Designs for Generalized Causal Inference. Houghton Mifflin. https://books.google.co.id/books?id=o7jaAAAAMAAJ

Speer, N. K., & Zacks, J. V. M. (2005). Temporal changes as event boundaries : Processing and memory consequences of narrative time shifts. Journal of Memory and Language, 53, 125–140. https://doi.org/10.1016/j.jml.2005.02.009

Stoel, G. L., Drie, J. P. van, & Boxtel, C. A. M. van. (2015). Teaching towards historical expertise . Developing a pedagogy for fostering causal reasoning in history. Journal of Curriculum Studies, 47(1), 49–76. https://doi.org/10.1080/00220272.2014.968212

Sundararajan, N., & Adesope, O. (2020). Keep it Coherent : A Meta-Analysis of the Seductive Details Effect. Educational Psychology Review, 32(3), 707–734. https://doi.org/https://doi.org/10.1007/s10648-020-09522-4

Susanto, H., Amiruddin, K., Fathurrahman, Sriwati, Siswandari, & Akmal, H. (2025). Contributive Analysis Of The Use Of Digital Infographic Media On The Chronological Thinking Ability Of SMK Students. Jurnal Wahana Pendidikan, 12(2), 275–284. https://doi.org/https://doi.org/10.25157/jwp.v12i2.18464

Sweller, J., Merriënboer, J. J. G., & Paas, F. (2019). Cognitive Architecture and Instructional Design : 20 Years Later. Educational Psychology Review, 31(2), 261–292. https://doi.org/10.1007/s10648-019-09465-5

Traboco, L., Pandian, H., Nikiphorou, E., & Gupta, L. (2022). Designing Infographics : Visual Representations for Enhancing Education , Communication , and Scientific Research. Journal of Korean Medical Science, 37(27), 1–7. https://doi.org/https://doi.org/10.3346/jkms.2022.37.e214

Tversky, B. (2011). Visualizing Thought. Topics in Cognitive Science, 3, 499–535. https://doi.org/10.1111/j.1756-8765.2010.01113.x

van Drie, J., & van Boxtel, C. (2008). Historical Reasoning: Towards a Framework for Analyzing Students' Reasoning about the Past. Educational Psychology Review, 20(2), 87–110. https://doi.org/10.1007/s10648-007-9056-1

Wilschut, A. (2019). Historical consciousness of time and its societal uses. Journal of Curriculum Studies, 51(6), 831–849. https://doi.org/10.1080/00220272.2019.1652939

Wilson, K., Dudley, D., Dutton, J., Preval-mann, R., & Paulsen, E. (2023). A systematic review of pedagogical interventions on the learning of historical literacy in schools. History Education Research Journal, 20(1), 1–27. https://doi.org/https://doi.org/10.14324/HERJ.20.1.09

Wu, X. (2024). Exploring the effects of digital technology on deep learning: a meta-analysis. In Education and Information Technologies (Vol. 29, Issue 1). Springer US. https://doi.org/10.1007/s10639-023-12307-1

Zhang, Q., & Fiorella, L. (2019). Role of Generated and Provided Visuals in Supporting Learning from Scientific Text. Contemporary Educational Psychology, 59, 101808. https://doi.org/10.1016/j.cedpsych.2019.101808