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Comparison of the Effectiveness of Static, Animated, and Interactive Infographics on Students' Creative Thinking Skills in Biology Learning

Nur Alamsyah[1], Adnan[2*], Muhiddin Palennari[2]

[1]Biology Education Study Program, Postgraduate Program, Makassar State University, Makassar, Indonesia.
[2]Biology Study Program, Faculty of Mathematics and Natural Sciences, Makassar State University, Makassar, Indonesia.

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Corresponding Author:
Adnan
adnan@unm.ac.id

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Abstract: This study aims to compare the effectiveness of three types of infographics, namely static, animated, and interactive, on students' creative thinking skills in biology learning on the human circulatory system. The research method used was a quasi-experimental with a pretest-posttest control group design, involving 144 grade XI students at SMA Negeri 3 Takalar who were divided into four classes: three experimental classes and one control class. The instrument used was a creative thinking skills essay test developed based on Guilford indicators (fluency, flexibility, originality, and elaboration). Data analysis was carried out using the ANCOVA test and LSD follow-up test. The results showed a significant difference between classes ($F = 582.693$; $p < 0.05$). The average value of estimated marginal means showed that interactive infographics had the greatest influence (86.89), followed by static infographics (84.27), animation (81.53), and handouts (74.18). Learning using interactive infographics provides navigation autonomy and encourages higher cognitive engagement, making it more effective in developing students' creative thinking skills. This research emphasizes the importance of utilizing interactive media in biology learning to optimally develop creative thinking skills.

Keywords: Animated infographics; Creative thinking skills; Interactive infographics; Static infographics

Introduction

21st-century skills are a collection of essential competencies that individuals need to adapt to the challenges of the digital era. These competencies encompass various aspects, such as learning and innovation skills (e.g., communication and creativity), technological, media, and information skills, and preparedness for future life and careers (Cristea et al., 2024; Kain et al., 2024). One of the main skills in this category is creative thinking, which is part of the 4C competencies (Critical Thinking, Creative Thinking, Collaboration, and Communication) which are very much needed in the modern world of education or in the digital era (Makaramani, 2015; Adnan et al., 2021; Palennari et al., 2023).

Creative thinking is a product of divergent and convergent thinking (Nufus et al., 2024). Convergent thinking is based on one correct solution to a problem (Busnawir, 2018), whereas divergent thinking allows for the emergence of various solutions to one problem (Baer, 2015). Creativity is not limited to certain groups, such as gifted students, but can be developed in all students through appropriate learning approaches (Kuo et al., 2024). In addition, creative thinking also plays an important role in problem solving and decision making, and is a key indicator in high-level thinking processes (Tam et al., 2022). International surveys show that around 88% of people believe that creativity should be integrated into the Education curriculum (Reisman, 2016).

Guilford in Baer (2015) stated that creative thinking includes four main components of divergent thinking:

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fluency, flexibility, originality, and elaboration. This model later became the basis for developing the Torrance creative thinking test (Hébert et al., 2002). Fluency refers to the ability to generate many ideas or many answers, flexibility refers to the ability to create diverse ideas, originality refers to the ability to generate unique ideas, and elaboration refers to the ability to detail, develop, evaluate, and enrich ideas (Luthfia, 2024). Unfortunately, many students still have difficulty completing assignments that require creativity. Some studies even show that students tend to be less proficient in creative thinking (Adnan et al., 2014; Nufus et al., 2024), one of which is caused by learning that is still conventional and teacher-centered (Mulbar et al., 2021).

To address this, technological developments are providing new opportunities in education, particularly through the use of innovative visual media. Effective learning media are those that can clarify information delivery, focus students' attention, and help overcome limitations related to the senses, space, and time (Alamsyah et al., 2022). An innovative visual medium is infographics. Infographics are defined as visual representations of information that combine text, images, and data elements to convey a message in an engaging, clear, and memorable way (Smiciklas, 2012; Pack et al., 2023; Zhu et al., 2020). According to Lankow et al. (2012), infographics are classified into three types, namely static, animated, and interactive infographics. Static infographics present information in a visual format without moving elements (Afify, 2018; Ismaeel & Al Mulhim, 2021), whereas animated infographics integrate movement and audio to simplify complex concepts and appeal to the audience's emotions (Hamid et al., 2020). Meanwhile, interactive infographics give students full control over the information exploration process, allowing for greater personalization of learning (Dur, 2014; Krum, 2014).

In learning practice, infographics have been shown to improve conceptual understanding, visual literacy, memory, and encourage critical and creative thinking, particularly through the integration of visualization, audio, and interactive elements (Aldalalah, 2020; Alscher, 2021; Huh, 2016; Bhat & Alyahya, 2024; Matrix & Hodson, 2014). Effective visual representations also help students organize ideas logically, understand relationships between concepts, and form original thoughts (Hameed & Jabeen, 2022; Khongprakob & Kantathanawat, 2021).

However, although numerous studies have demonstrated the benefits of using infographics in learning, most studies are limited to just one or two types. Studies that comprehensively compare the effectiveness of static, animated, and interactive infographics on creative thinking skills are rare. Furthermore, in the context of biology learning in Indonesia, particularly on the circulatory system, there have been few quasi-experimental approaches that simultaneously evaluate all three types of infographics based on creative thinking indicators such as fluency, flexibility, originality, and elaboration, supported by adequate statistical analysis.

Based on this background and gap, this study aims to determine the differences in effectiveness of using three types of infographic media: static, animated, and interactive, on students' creative thinking skills in biology learning, specifically on the human circulatory system. This research is expected to contribute to the development of more effective, contextual, and data-driven visual media-based learning strategies to improve students' creative thinking skills in schools.

Method

Types of Research

This study used a quantitative approach with a quasi-experimental design. This design was chosen to determine the differences in the effects of three types of infographics—static, animated, and interactive—on students' creative thinking skills.

Research Design

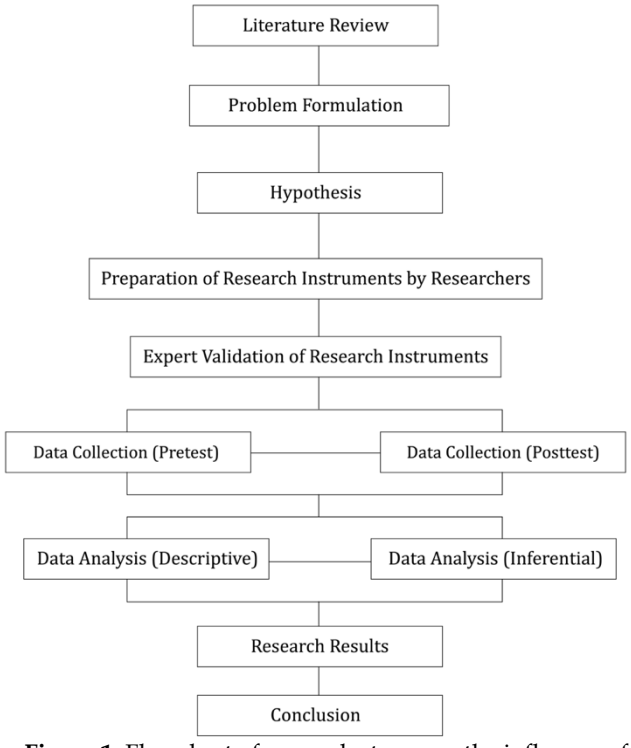

Figure 1. Flowchart of research stages on the influence of infographics on creative thinking skills

The design used was a pretest-posttest control group design, in which students were divided into four classes: three experimental classes and one control class.

Each experimental class received treatments in the form of static, animated, and interactive infographics. The control class used conventional media in the form of handouts. Creative thinking skills were measured before and after the treatment using the same instrument. The stages of research activities can be seen in Figure 1.

Population and Sample

The population in this study was all eleventh-grade students at SMA Negeri 3 Takalar in the odd semester of the 2024/2025 academic year. The sample size was 144 students. Each class consisted of 36 students and received different treatments according to the research design.

Research Variables

The independent variable is the type of infographic: static infographics, animated infographics, and interactive infographics. The dependent variable is students' creative thinking skills.

Research Instruments

The main instrument is a creative thinking skills test in the form of descriptive questions structured based on Guilford's four indicators of creative thinking: fluency, flexibility, originality, and elaboration. The test consists of four open-ended questions, each representing one indicator, and each question is scored on a 0–10-point scale. The maximum total score is 40, which is then converted to a 100-point scale. Content validity was tested by two education experts, who stated that the items were valid with minor modifications.

Infographic Development and Validation

The infographics used in this study were developed by the researcher herself in accordance with the principles of instructional design and the needs of the human circulatory system material in the 11th grade curriculum. The infographics were developed in three forms: static infographics (still visual image format), animated infographics (using motion and audio elements), and interactive infographics (interactive PowerPoint, allowing navigation control by students).

Before being used in the treatment, all media underwent a validation phase by two learning media experts and one biology material expert. Validation was conducted using an assessment instrument covering aspects of content suitability, visual appearance, interactivity (specifically for interactive media), and pedagogical suitability. The validation results indicated that all three media were deemed suitable with minor revisions. The average validation score was in the very valid category.

Experimental Procedures and Data Collection

The research implementation procedure began with a pretest administered to all students in the experimental and control classes to measure their initial creative thinking skills. The pretest was administered to three experimental classes and one control class to ensure homogeneity between classes. Next, the learning process was carried out according to plan, covering the circulatory system, which consists of blood components, blood clotting mechanisms, blood types, the structure and function of the heart, types of blood vessels, and the blood circulation process. Each class received treatment during four specific material meetings using different media according to the class. After all the material was taught, a posttest was administered to all classes as a final evaluation. The pretest and posttest data were then analyzed statistically using a one-way ANCOVA (Analysis of Covariance) test to determine the effect of the use of infographics on creative thinking skills. The ANCOVA test was used to control for the influence of the initial score (pretest) and determine the effectiveness of the treatment (infographics). Next, a further LSD (Least Significant Difference) test was conducted to compare the effect of each type of infographic in pairs and identify significant differences between classes.

Result and Discussion

Creative Thinking Skills Pretest Results

Pretest analysis showed that students' initial creative thinking skills were in the adequate category across all classes. The average scores for each indicator can be seen in Table 1.

Table 1. Analysis of creative thinking skills for each indicator on pretest scores

Media/Indicators	Fluency	Flexibility	Originality	Elaboration
Static Infographics	42.78	46.39	41.11	38.33
Animated Infographics	46.94	46.11	47.50	49.72
Interactive infographics	38.61	39.44	41.67	48.89
Handout	49.72	31.94	38.33	38.61
Average	44.51	40.97	42.15	43.89
Category	Enough	Enough	Enough	Enough

Creative Thinking Skills Posttest Results

Posttest results showed an increase in creative thinking skills in all classes. Average scores increased to the good to excellent category. The average scores for each indicator can be seen in Table 2.

Table 2. Analysis of creative thinking skills for each indicator on posttest scores

Media/Indicators	Fluency	Flexibility	Originality	Elaboration
Static Infographics	87.50	85.28	76.67	89.44
Animated Infographics	89.17	85.56	80.00	86.11
Interactive infographics	87.78	84.44	78.89	84.17
Handout	75.00	65.83	67.22	76.11
Average	84.86	80.28	75.70	83.96
Category	Very Good	Very Good	Good	Very Good

Normality Test

The results of the Kolmogorov–Smirnov normality test in Table 3 show that the data are normally distributed ($p > 0.05$).

Table 3. Normality test of pretest and posttest scores in each class

Media		Kolmogorov-Smirnov	Information
Static Infographics	Pretest	0.119	Normal
Animated Infographics		0.198	Normal
Interactive Infographics		0.176	Normal
Handout (Control)		0.190	Normal
Static Infographics	Posttest	0.200	Normal
Animated Infographics		0.200	Normal
Interactive infographics		0.101	Normal
Handout (Control)		0.189	Normal

Homogeneity Test

The results of the Levene test in Table 4 show that the variance between classes is homogeneous ($p > 0.05$), so the data meets the assumptions for the ANCOVA test.

Table 4. Homogeneity test of pretest and posttest scores

Data	Levene Statistic	Sig.	Information
Pretest	1.573	0.199	Homogeneous
Posttest	0.021	0.996	Homogeneous

Hypothesis Test

The results of the ANCOVA test in Table 5 show that there are significant differences in creative thinking skills based on the type of media used with a value of $F = 582.693$ and $p < 0.05$.

Table 5. ANCOVA test of the effect of infographics on creative thinking skills

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Media	3167.268	3	1055.756	582.693	0.000

The results of the LSD test in Table 6 show that all class pairs have significant differences ($p < 0.05$).

Table 6. LSD test of the effect of infographics on creative thinking skills

Media	Mean Difference	Sig.	Information
Static infographics and animated infographics	2.746*	0.000	Significant
Static infographics and interactive infographics	2.617*	0.000	Significant
Animated infographics and interactive infographics	5.362*	0.000	Significant
Static infographics and handouts	10.090*	0.000	Significant
Animated infographics and handouts	7.344*	0.000	Significant
Interactive infographics and handouts	12.707*	0.000	Significant

The estimated marginal means in Table 7 show a difference in influence between the three infographics in the experimental class and the handouts in the control class. Interactive infographics had the greatest impact on improving creative thinking skills, followed by static infographics, animations, and finally, handouts.

Table 7. Estimated marginal means values in the LSD test

Media	Mean
Interactive Infographics	86.89[a]
Static Infographics	84.27[b]
Animated Infographics	81.53[c]
Handout	74.18[d]

The Effectiveness of Interactive Infographics on Creative Thinking Skills

Interactive infographics demonstrate the highest positive impact on the development of creative thinking skills. Their key characteristic lies in the user's ability to independently control the sequence, focus, and depth of information exploration. This capability creates a personalized and active learning experience, which strongly supports divergent thinking. According to Aldalalah (2020) and Abdulmoneim (2021), students who use interactive infographics can organize ideas in a

hierarchical thinking structure, connect concepts, and formulate new ideas through in-depth processing of meaning. The ability to think in multiple directions and create connections between information is key to developing creativity. Ismaeel & Al Mulhim (2021) emphasize that interactive infographics encourage complex cognitive activities as students interact with the content, explore specific sections, and adapt the information to their learning needs. The integration of illustrations, animation, audio, and text in interactive designs also supports multimodal learning, strengthening comprehension and creative thinking (Grasia et al., 2023). This makes interactive infographics superior to static and animated infographics.

Additionally, interactive infographics encourage students to become producers of meaning, not just consumers of content, allowing for more creative interpretations and solutions (Ali & Diab, 2023). Autonomy in choosing how to learn also contributes to the emergence of innovative thinking. Hamid et al. (2024) stated that interactive learning materials can increase information retention by more than 30% compared to other visual media. In this context, retention plays a crucial role in creativity because it allows students to remember, rework, and develop new ideas (Palennari, 2016). Thus, interactive infographics not only serve as a tool for presenting information, but also as a medium for in-depth intellectual exploration, which is able to optimize students' creative thinking potential.

The Effectiveness of Static Infographics on Creative Thinking Skills

Static infographics have been shown to have a positive impact on creative thinking skills, although not as significant as interactive infographics. This medium relies primarily on visuals in the form of images and illustrations, which facilitate students' imagination and original ideas (Hameed & Jabeen, 2022). Visualization in static infographics provides space for students to observe and interpret information in depth. Shemy (2022) explains that students can interact with static infographics by adjusting the visual display, such as zooming in on certain sections or scrolling in various directions, allowing them to extract relationships between elements and construct meaning independently. In this process, creative thinking skills can be honed through visual analysis and synthesis. Furthermore, images in static infographics are processed by the human brain more quickly than text, keeping students engaged in learning (Alrajhi, 2020; Alamsyah et al., 2025), allowing them to quickly connect information and discover new ideas. However, this medium remains passive because it doesn't provide students with navigational freedom or full control over the flow of the material.

Therefore, although static infographics are more effective than animated infographics in supporting creativity, their effectiveness is still lower than interactive infographics. As stated by Tversky et al. (2002), that static images can be superior to animation for complex material because they provide control over focus and pace of learning, but are still not as effective as interactive media in creating deep cognitive engagement. Khongprakob & Kantathanawat (2021) assert that static infographics are cognitively lighter or easier to process than animations, but lack the student-driven navigation necessary for deep learning.

The Effectiveness of Animated Infographics on Creative Thinking Skills

Animated infographics have been shown to have a positive impact on creative thinking skills, although not as significant as static and interactive infographics. Audio-visual-based animated infographics can contribute to the development of students' thinking skills. This medium combines visual movement and sound to strengthen understanding and encourage mental activation. Tawil & Dahlan (2021) emphasized that audiovisual aids can provide significant benefits in the learning process because they facilitate multisensory engagement. Mariam et al. (2024) added that animation can help students develop their thinking skills, particularly in forming and generating diverse ideas through dynamic visual representations. Similarly, Hasanah et al. (2023) stated that animated videos are designed to organize students' learning experiences, enabling them to generate diverse and contextual ideas.

However, in the context of this study, animated infographics demonstrated lower effectiveness compared to static and interactive infographics. This may be due to the nature of animation, which presents information linearly and quickly, without giving students the opportunity to control the speed or order of the display. Koning et al. (2011) stated that students may fail to pay attention to important parts of an animation if it is not accompanied by explicit guidance, ultimately reducing the effectiveness of comprehension. This is in line with Taufiq et al. (2024), who stated that excessive visual variations such as animation can also reduce student focus. In this case, passive and non-interactive animated infographics do not guarantee the deep cognitive engagement necessary to foster creativity.

Conclusion

Based on the results of data analysis and discussion, it can be concluded that infographic learning media has a significant influence on improving students' creative

thinking skills in biology learning. Among the three types of infographics used, interactive infographics provide the greatest influence, followed by static infographics and animated infographics. Interactive infographics are able to encourage higher cognitive engagement through self-navigation features, interactivity, and user control over information, which effectively develop aspects of fluency, flexibility, originality, and elaboration in creative thinking. These findings confirm that the higher the level of student interactivity and engagement in the learning process, the greater the potential for developing higher-order thinking skills. Therefore, teachers and media developers are advised to integrate interactive visual learning media into science instruction as a strategic effort to optimally foster students' creative thinking skills. However, this study has several limitations. It was conducted at only one educational level and focused on one topic, the human circulatory system. Furthermore, the infographics used were developed in conventional digital formats, such as interactive infographics that were still PowerPoint-based and did not utilize advanced interactivity features. Therefore, further research is recommended to involve various educational levels and more diverse materials, as well as develop infographics with more dynamic digital formats and platforms to support personalized learning and strengthen higher-order thinking skills more comprehensively.

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Author Contributions
All authors have contributed to this study and agree to the methods, results, and discussion and conclusions of this study.

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All authors declare that there are no conflicts of interest.

References

Abdulmoneim, M. (2021). The Effect of Interactive Infographic on Developing Some Technological Skills for Students at Technical Secondary schools. *International Journal of Advanced Humanities Research*, *1*(1), 46–53. https://doi.org/10.21608/ijahr.2020.256309

Adnan, A., Abimanyu, S., Bundu, P., & Arsyad, N. (2014). Enhance Cognitive Learning of Junior High-School Students Through the Implementation of Constructivist Models of Learning Biology-Based ICT (ICT-Based MPBK). *International Journal of Academic Research Part B*, *6*(6), 55-62. https://doi.org/10.7813/2075-4124.2014/6-6/B.8

Adnan, A., Mulbar, U., Sugiarti, S., & Bahri, A. (2021). Scientific Literacy Skills of Students: Problem of Biology Teaching in Junior High School in South Sulawesi, Indonesia. *International Journal of Instruction*, *14*(3), 847-860. https://doi.org/10.29333/iji.2021.14349a

Afify, M. K. (2018). The Effect of the Difference between Infographic Designing Types (Static vs Animated) on Developing Visual Learning Designing Skills and Recognition of Its Elements and Principles. *International Journal of Emerging Technologies in Learning*, *13*(9), 204–223. https://doi.org/10.3991/ijet.v13i09.8541

Alamsyah, N., Adnan, A., & Palennari, M. (2025) The Effect of Different Types of Infographics on Students' Learning Motivation in Learning Biology. *BIO INOVED: Jurnal Biologi-Inovasi Pendidikan*, *7*(1), 116-124. https://doi.org/10.20527/bino.v7i1.21589

Alamsyah, N., Taufiq, A. U., & Rivai, A. T. O. (2022). Development of Website-Based E-Poster Learning Media on the Digestive System Material of Class XI MA Madani Alauddin Pao-Pao Students. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *4*(3), 351-359. https://doi.org/10.20527/bino.v4i3.14322

Aldalalah, O. M. A. (2020). The Effectiveness of Infographic via Interactive Smart Board on enhancing Creative Thinking: A Cognitive Load Perspective. *International Journal of Instruction*, *14*(1), 345–364. https://doi.org/10.29333/IJI.2021.14120A

Ali, S., & Diab, O. (2023). The Impact of Interactive Infographic in Enhancing the Quality of Education in Physiotherapy Field. *Journal of Design Sciences and Applied Arts*, *4*(2), 222–234. https://doi.org/10.21608/jdsaa.2023.193476.1256

Alrajhi, A. S. (2020). Static Infographics Effects on the Receptive Knowledge of Idiomatic Expressions. *Indonesian Journal of Applied Linguistics*, *10*(2), 315–326. https://doi.org/10.17509/ijal.v10i2.28596

Alscher, D. (2021). *Design Thinking vs. Visual Thinking: What Are They and How Do They Work Together?* Written. Retrieved from https://visme.co/blog/design-thinking/

Baer, J. (2015). *Domain of Specificity of Creativity*. Elsevier Inc.

Bhat, S. A., & Alyahya, S. (2024). Infographics in Educational Settings: A Literature Review. *IEEE Access*, *12*, 1633–1649. https://doi.org/10.1109/ACCESS.2023.3348083

Busnawir, B. (2018). *Pengukuran Kemampuan Berpikir Kreatif Matematika: Tinjauan Melalui Pembelajaran Berbasis Problem Solving dan Gaya Belajar*. Indramayu: CV Adanu Abimata.

Cristea, T. S., Snijders, C., Matzat, U., & Kleingeld, A. (2024). Do 21st-Century Skills Make You Less Lonely? The Relation between 21st-Century Skills, Social Media Usage, and Students' Loneliness During the COVID-19 Pandemic. *Heliyon*, *10*(3), 1-13. https://doi.org/10.1016/j.heliyon.2024.e25899

Dur, B. I. U. (2014). Interactive Infographics on the Internet. *Online Journal of Art and Design*, *2*(4), 1-15. Retrieved from https://www.researchgate.net/publication/303738492_Interactive_Infographics_on_the_Internet

Grasia, E., Faslah, R., & Adha, M. A. (2023). Development of Genially-Based Interactive Infographics in Public Relations and Protocol Subjects. *Jurnal Pendidikan Ekonomi, Perkantoran, dan Akuntansi*, *4*(3), 73–82. https://doi.org/10.21009/jpepa.0403.08

Hameed, A., & Jabeen, I. (2022). Prompting Cognition for Creativity in EFL Context: An Experimental Study on Use of Infographics for Teaching Writing Skill. *Journal of Language and Linguistic Studies*, *18*(1), 724–737. https://doi.org/10.52462/jlls.215

Hamid, M. F. A., Halim, Z. A., & Sahrir, M. S. (2020). An Insight on Needs Analysis Towards the Development of Animated Infographic Module in Arabic Grammar Learning. *Journal of Language and Linguistic Studies*, *16*(3), 1387–1401. https://doi.org/10.17263/jlls.803813

Hamid, M. F. A., Sahrir, M. S., Amiruddin, A. Z., Yahaya, M. F., & Sha'ari, S. H. (2024). Evaluating Student Acceptance of Interactive Infographics Module for Arabic Grammar Learning Using the Technology Acceptance Model (TAM). *International Journal of Learning, Teaching and Educational Research*, *23*(9), 121–140. https://doi.org/10.26803/ijlter.23.9.7

Hasanah, N., Cholily, M., & Syaifuddin, M. (2023). The Effect of Problem-Based Learning Assisted by Video Animation on Students' Self-Efficacy and Creative Thinking Ability. *Kreano, Jurnal Matematika Kreatif-Inovatif*, *14*(1), 61-74. https://doi.org/10.15294/kreano.v14i1.41374

Hébert, T. P., Cramond, B., Neumeister, K. L. S., Millar, G., & Silvian, A. F. (2002). *E. Paul Torrance: His Life, Accomplishments, and Legacy*. The National Research Center on the Gifted and Talented (NRC/GT). Connecticut: The University of Connecticut.

Huh, K. (2016). Visual Thinking Strategies and Creativity in English Education. *Indian Journal of Science and Technology*, *9*(1), 1-6. https://doi.org/10.17485/ijst/2016/v9is1/109885

Ismaeel, D., & Al Mulhim, E. (2021). The Influence of Interactive and Static Infographics on the Academic Achievement of Reflective and Impulsive Students. *Australasian Journal of Educational Technology*, *37*(1), 147–162. https://doi.org/10.14742/ajet.6138

Kain, C., Koschmieder, C., Matischek-Jauk, M., & Bergner, S. (2024). Mapping the Landscape: A Scoping Review of 21st Century Skills Literature in Secondary Education. *Teaching and Teacher Education*, *151*, 1-27 https://doi.org/10.1016/j.tate.2024.104739

Khongprakob, N., & Kantathanawat, T. (2021). Design and Visual Thinking Model for Thai Undergraduate Student Online Creative Thinking and Creative Products Promotion. *Turkish Journal of Computer and Mathematics Education (TURCOMAT)*, *12*(14), 5147–5155. https://doi.org/10.17762/turcomat.v12i14.11537

Koning, B. B. D., Tabbers, H. K., Rikers, R. M., & Paas, F. (2011). Attention Guidance in Learning from a Complex Animation: Seeing Is Understanding? *Learning and Instruction*, *21*(1), 113–124. https://doi.org/10.1016/j.learninstruc.2009.02.010

Krum, R. (2014). *Cool Infographic: Effective Communication with Data Visualization and Design*. Wiley and Sons, Inc.

Kuo, H. C., Chang, C. Y., Wang, J. P., Wu, E. L., & Li, P. L. (2024). Creating My Own Story: Improving Children's Creative Thinking and Composition Creativity Through a Three-Staged Individual-Group-Individual Story Writing Framework. *Cognitive Development*, *72*, 1-16. https://doi.org/10.1016/j.cogdev.2024.101513

Lankow. J., Ritchie, J., & Crooks, R. (2012). *Infographics: The Power of Storytelling*. Wiley and Sons, Inc.

Luthfia, S. (2024). The Enhancement of Creative Thinking Skill Using Creative Problem Solving Learning Model. *International Journal of Education and Teaching Zone*, *3*(1), 107–118. https://doi.org/10.57092/ijetz.v3i1.197

Makaramani, R. (2015). 21st Century Learning Design for a Telecollaboration Project. *Procedia - Social and Behavioral Sciences*, *191*, 622–627. https://doi.org/10.1016/j.sbspro.2015.04.567

Mariam, D., Harmawati, H., & Sa'diah, T. L. (2024). Effect of Animated Video Media on Creative Thinking in Elementary School IPAS (Natural and Social Sciences) Learning. *Journal of Education Method and Learning Strategy*, *2*(03), 1071–1085. https://doi.org/10.59653/jemls.v2i03.1128

Matrix, S., & Hodson, J. (2014) Teaching with Infographics: Practicing New Digital Competencies and Visual Literacies. *Journal of Pedagogic Development*, *3*(2), 17-27. Retrieved from http://www.beds.ac.uk/jpd/volume-4-issue-2/teaching-with-infographics

Mulbar, U., Alimuddin, A., Rahmadani, R., Adnan, A., & Hasanah, R. (2021). The Influence of Discovery Learning with Scientific Approach on Students' Creative Thinking Ability. *Journal of Physics:*

Conference Series, *1899*(1), 1-8. https://doi.org/10.1088/1742-6596/1899/1/012134

Nufus, H., Muhandaz, R., Hasanuddin, H., Nurdin, E., Ariawan, R., Fineldi, R. J., Hayati, I. R., & Situmorang, D. D. B. (2024). Analyzing the Students' Mathematical Creative Thinking Ability in Terms of Self-Regulated Learning: How Do We Find What We Are Looking For?. *Heliyon*, *10*(3), 1-14. https://doi.org/10.1016/j.heliyon.2024.e24871

Pack, A. P., Zuleta, A., Daugerdas, E., Huang, W., Batio, S., Svoboda, S., Zeitler, E. P., Kumar, N., Watt, S., Fernandez-Arias, M. I., Bader, M., Assaf, A. R., & Bailey, S. C. (2023). Developing, Optimizing, and Evaluating Patient Infographics for Diagnosing Cardiac Amyloidosis. *PEC Innovation*, *3*, 1-6. https://doi.org/10.1016/j.pecinn.2023.100212

Palennari, M. (2016). Exploring the Correlation between Metacognition and Cognitive Retention of Students Using Various Biology Teaching Strategies. *Journal of Baltic Science Education*, *15(*5), 617–629. https://doi.org/10.33225/jbse/16.15.617

Palennari, M., Rachmawaty, R., Saparuddin, S., Saleh, A. R., & Jamaluddin, A. B. (2023). Pelatihan Pembelajaran Inovatif Abad 21 bagi Guru SMP Negeri 2 Galesong Utara. *Jurnal IPMAS*, *3*(2), 66–74. https://doi.org/10.54065/ipmas.3.2.2023.272

Reisman, F. K. (2016). *Creativity in Arts, Science and Technology*. KIE Conference Publication.

Shemy, N. S. (2022). Digital Infographics Design (Static vs Dynamic): Its Effects on Developing Thinking and Cognitive Load Reduction. *International Journal of Learning, Teaching and Educational Research*, *21*(5), 104–125. https://doi.org/10.26803/ijlter.21.5.6

Smiciklas, M. (2012). *The Power of Infographics Using Pictures to Communicate and Connect with Your Audiences*. Pearson Education, Inc.

Tam, C., Chan, A.K., Cheng, E. C., Rogers, J., & Tan, X. (2022). *Teaching Creative Thinking Skills in the Higher Education Classroom: A Guidebook for Educators.* Departemen of Cultural and Creative Arts, The Educations University of Hongkong.

Taufiq, A.U., Hamansah, H., Sari, N. H., & Alamsyah, N. (2024). Development of E-Books Integrated with the Qur'an to Support Learning in the Nutrition and Health Course within the Biology Education Program at the University. *BIO-INOVED: Jurnal Biologi-Inovasi Pendidikan*, *6*(2), 227-235. http://dx.doi.org/10.20527/bino.v6i2.18624

Tawil, M., & Dahlan, A. (2021). Application of Interactive Audio Visual Media to Improve Students' Creative Thinking Skill. *Journal of Physics: Conference Series*, *1752*(1), 1-7. https://doi.org/10.1088/1742-6596/1752/1/012076

Tversky, B., Morrison, J. B., & Bétrancourt, M. (2002). Animation: Can It Facilitate? *International Journal of Human-Computer Studies. International Journal of Man-Machine Studies*, *57*(4), 247–262. https://doi.org/10.1006/IJHC.2002.1017

Zhu, S., Sun, G., Jiang, Q., Zha, M., & Liang, R. (2020). A Survey on Automatic Infographics and Visualization Recommendations. *Visual Informatics*, *4*(3), 24–40. https://doi.org/10.1016/j.visinf.2020.07.002