

Character Design in Medical Learning Infographics: A Conceptual Framework

Reka Bentuk Watak dalam Infografik Pembelajaran Perubatan: Satu Kerangka Konseptual

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ABSTRACT - Artificial Intelligence (AI) has revolutionized the development of visual learning materials by enabling the creation of medical infographics at various levels of realism, ranging from cartoon-like to hyper-realistic, within the context of secondary education. This advancement also allows educators without a design background to produce visual learning materials. However, differences in levels of realism are said to potentially influence viewer comfort, a phenomenon referred to as the Uncanny Valley. Students' comfort levels, in turn, may affect their emotions, motivation, and learning achievement.

Using a quasi-experimental design, this study will compare the effectiveness of AI-generated infographics with traditionally designed infographics. It will evaluate the effects of three levels of character realism used in medical infographic design on students' emotions, motivation, and learning achievement. Furthermore, it will examine the role of students' emotions as a mediating variable between character realism and learning motivation.

Grounded in the theoretical frameworks of the Uncanny Valley and the Control-Value Theory of Achievement Emotions, the conceptual framework of this study is developed to address the research questions. The findings of this research are expected to contribute to the development of evidence-based guidelines for the effective use of AI-generated infographic visuals in secondary school science education.

INTRODUCTION

The rapid advancement of Artificial Intelligence (AI) technologies has significantly reshaped the development of instructional materials, particularly in the production of medical illustrations and educational infographics. Infographics, which integrate text, images, charts, and other visual elements, have been shown to be effective in simplifying complex information, thereby enhancing both comprehension and knowledge retention (Afify, 2018; Rahim et al., 2016). Within the context of science education, the incorporation of medical illustration characters as the primary visual element in infographics not only facilitates the transfer of knowledge but also has the capacity to elicit emotional responses that influence student motivation (Zibrek et al., 2018).

Control-Value Theory (CVT) asserts that emotions are fundamentally shaped by students' perceptions of control over, and the value they assign to, learning tasks (Pekrun, 2006). Emotions can be categorized along two dimensions: valence (positive vs. negative) and activation level (activating vs. deactivating). For example, enjoyment and interest are positive activating emotions that promote cognitive engagement, whereas boredom is a negative deactivating emotion that can weaken

motivation. In contrast, anxiety represents a negative activating emotion which, although it may heighten attentional focus, often disrupts learning performance (Pekrun & Linnenbrink-Garcia, 2012).

Recent research has further highlighted the mediating role of perceived control and value in linking environmental factors of the learning context to achievement-related emotions. Stillin et al. (2024) demonstrated that the integration of digital technologies in science and mathematics education enhanced students' enjoyment and pride when they appraised themselves as competent (control appraisal) and interested (value appraisal). Conversely, low perceptions of control were associated with heightened anxiety and boredom.

Empirical evidence demonstrates that emotions play a critical role not only in the short term but also in shaping long-term academic achievement. For instance, Pekrun et al. (2017) identified a reciprocal relationship between emotions and performance, whereby positive emotions foster higher levels of academic achievement, while strong performance, in turn, reinforces students' positive emotions. These findings indicate that emotions elicited through learning visuals, such as medical illustration characters, may exert enduring effects on students' academic development.

The level of visual realism in illustrations carries significant implications for students' emotional responses. The Uncanny Valley phenomenon suggests that visuals which closely approximate reality yet remain perceptibly imperfect can evoke feelings of discomfort or emotional unease (Mori, 2012; Kätsyri et al., 2015). In contrast, cartoon-like or overly simplified visuals may be perceived as lacking seriousness, thereby inducing boredom, whereas hyper-realistic visuals may provoke anxiety or stress, particularly when addressing sensitive medical topics. These observations are consistent with the findings of Pekrun and Linnenbrink-Garcia (2012), who reported that overly complex tasks often elicit anxiety, while tasks perceived as too simple tend to foster boredom.

Building on this, Symes et al. (2025) identified that students can be categorized into distinct emotional profiles Positive, Negative, and Mixed based on their perceived control, value appraisals, and emotions such as enjoyment, anxiety, and boredom. This indicates that the level of realism in illustrations may shape students' emotional profiles; for example, overly complex hyper-realistic visuals may diminish perceptions of control and trigger anxiety (Negative profile), whereas semi-realistic visuals are more likely to sustain interest and reinforce stronger perceptions of control (Positive profile). Accordingly, the degree of realism in medical illustrations must be carefully calibrated to sustain student attention while minimizing negative emotional reactions.

Moreover, the degree of realism in medical illustrations embedded within infographics has the potential to influence students' comfort and their acceptance of the learning medium, a factor critical to the effective delivery of information. Pekrun et al. (2019) demonstrated that consistent emotional experiences, in conjunction with academic self-concept, can contribute to the formation of students' identities within specific fields. Similarly, Marsh et al. (2002) and Hazari et al. (2010) noted that science identity is shaped by a combination of emotional factors, interest, and perceived control over tasks. These insights suggest that the design of realistic medical illustrations must be carefully calibrated to ensure that students feel comfortable with the medium, thereby fostering acceptance and enhancing learning effectiveness, while also shaping the ways in which students come to identify themselves with the field of science.

Empirical evidence within the context of science education further underscores the importance of emotions. Gupta et al. (2018) and Jaber et al. (2021), for instance, found that students' emotional responses evolve alongside their deepening understanding of scientific concepts. These findings highlight that effective visual, including AI-generated illustrations designed with an appropriate level of realism, not only elicit emotional engagement but also have the capacity to reinforce scientific understanding. Consequently, in the design of medical infographics for secondary school students, the degree of illustration realism must be carefully calibrated to optimize motivation, mitigate negative emotions, and support the development of academic identity within the field of science.

INFOGRAPHIC IN EDUCATION

Infographics, defined as the integration of text, images, charts, and other visual elements, have emerged as an effective medium for simplifying complex information and facilitating knowledge transfer within educational contexts. By engaging both visual and verbal cognitive channels simultaneously, infographics accelerate comprehension and enhance memory retention, rendering them particularly effective for teaching abstract or information-dense topics (Afify, 2018; Rahim et al., 2016). In the digital era, this dual-channel approach corresponds with the growing emphasis on visual literacy, a critical competency for both students and educators.

The use of infographics has extended across multiple domains. In health education, for example, infographic campaigns during the COVID-19 pandemic were shown to enhance public understanding and retention of preventive measures such as mask-wearing and physical distancing (Egan et al., 2021). Likewise, within clinical and pharmaceutical contexts, infographics have been demonstrated to improve communication between healthcare providers and patients, thereby strengthening decision-making processes and facilitating knowledge transfer (Damman et al., 2018; Tidd et al., 2022). Despite these benefits, the systematic integration of infographics into classroom instruction particularly within science and medical education remains limited. Existing research is often fragmented, tending to focus on specific applications rather than providing a comprehensive framework for educational practice (Naparini & Saad, 2017; Dunlap & Lowenthal, 2016).

This study investigates how the design principles of infographics, particularly the degree of character realism, influence students' emotional responses during the learning process. Emotions elicited by characters embedded within infographics are anticipated to shape learners' motivation, interest, and acceptance of the medium, thereby affecting the overall effectiveness of learning among secondary school students. The analysis is further extended to examine students' acceptance of character design, as such acceptance constitutes a critical determinant of both the effectiveness and the perceived appropriateness of new learning materials, especially among adolescents (Martha & Santoso, 2019; Liu & Elms, 2019).

EMOTION AND ACCEPTANCE

Within the learning context, emotions are understood as internal responses experienced by students when engaging with instructional materials, and they can be broadly classified as positive or negative (Pekrun, 2006). While prior research has explored the relationship between emotions and learning, much of this work has disproportionately emphasized test anxiety, with comparatively less attention given to other emotions that likewise shape academic achievement (Pekrun et al., 2011).

Positive emotions such as enjoyment, interest, and excitement have been shown to enhance motivation, effort, and the adoption of more effective learning strategies. For instance, studies indicate that students who experience enjoyment during static learning processes stimulated by the realism and expressions of characters or illustrations in infographics are more likely to achieve stronger academic performance (Putwain et al., 2020). This finding is further supported by research linking positive emotions elicited by the visual design of characters in infographics to increased motivation, sustained effort, and the use of deeper cognitive strategies (Camacho-Morles et al., 2021; Obergriesser & Stoeger, 2020). Early studies on visual aids also demonstrate that visual design can influence students' emotional responses toward characters or illustrations in infographics, thereby shaping their acceptance of the learning material (Mayer & Estrella, 2014; Zibrek et al., 2018).

Conversely, negative emotions such as anxiety and discomfort can diminish motivation and interfere with the learning process. In certain circumstances, students may adopt avoidance strategies when negative emotions dominate, thereby influencing their level of acceptance toward the learning material (Putwain et al., 2013). Nevertheless, studies also indicate that negative emotions such as frustration can be transformed into positive emotions such as pride when learning is effectively facilitated (Bellocchi & Ritchie, 2015).

In the context of science learning, the transition of students' emotions from negative to positive has also been reported to occur alongside epistemological shifts as they evaluate the utility of scientific models (Gupta et al., 2018). In addition, the expression of emotions by both teachers and students can enhance

interaction and foster the formation of learning communities within science inquiry (Jaber et al., 2021). This implies that medical infographics designed with appropriate visual realism and character expressions also hold the potential to elicit positive emotions that encourage student interaction. The emotional expressions generated through such visual experiences not only support individual understanding but also strengthen classroom social dynamics by building a more collaborative learning community.

Findings by Stilin et al. (2024) indicate that cognitive–affective pathways can be either positive (high control and value → enjoyment, engagement → better learning outcomes) or negative (low control and value → anxiety, boredom → lower achievement). Furthermore, Symes et al. (2025) demonstrated that students classified within the Positive emotional profile achieved higher mathematics scores compared to those in the Mixed or Negative profiles. Thus, the emotions elicited by the level of realism in infographics have the potential to influence not only motivation but also academic achievement directly.

Ultimately, students' emotions and motivation during static learning, elicited by the realism and expression of characters/illustrations in infographics, not only influence the learning experience directly but also function as mediators between learning goals and academic achievement (Daniels et al., 2009; Pekrun & Linnenbrink-Garcia, 2012). Thus, evaluating the effects of visual realism in characters within medical infographics on students' emotions and motivation can address this critical gap, particularly in the context of AI-assisted static education (Zibrek et al., 2018).

THEORETICAL FRAMEWORK

This study is grounded in two primary theoretical frameworks, namely the Control-Value Theory of Achievement Emotions (CVT) and the Uncanny Valley phenomenon. Both frameworks explain how the level of realism in characters within medical infographics can influence emotions, motivation, and acceptance among secondary school students in the context of science learning.

Control-Value Theory (Pekrun, 2006; Pekrun et al., 2007; Turnquest et al., 2023) emphasizes that achievement-related emotions play a crucial role in the learning experience. According to this theory, students' emotions are shaped by the interaction between their perceived control over a task and the value they assign to it. Positive emotions such as interest, enjoyment, and curiosity can enhance motivation and engagement, whereas negative emotions such as anxiety, stress, or boredom have the potential to hinder learning (Ramlie et al., 2022; Turnquest et al., 2023).

In the context of infographic use, effective visual design not only serves to convey information but also plays a role in eliciting positive emotions that foster student engagement in the learning process. Turnquest et al. (2023) demonstrated that students' achievement emotions can predict their academic success, underscoring the relevance of control and value in learning contexts. This framework remains significant as it continues to be applied in contemporary research; for example, Stilin et al. (2024) found that perceptions of control and value mediate the relationship between digital technology use and achievement emotions in science and mathematics learning, while Symes et al. (2025) confirmed the core predictions of CVT by showing that enjoyment arises from high control and high value, boredom from low value, and anxiety from low control but high value.

In the context of science learning, recent studies have also emphasized the importance of affective dimensions in supporting student achievement. Park (2023) demonstrated that teacher empathy and praise play a vital role in transforming students' negative emotions into positive ones, for example, from frustration to pride. This emotional transformation enhances student engagement in inquiry-based activities, thereby strengthening learning effectiveness. These findings underscore that achievement emotions are not static but can be mediated through affective support from teachers who are sensitive to students' emotional experiences. This is consistent with the findings of Stilin et al. (2024), which showed that students with high control and value reported more positive emotions such as enjoyment and pride, whereas students with low control were more likely to experience anxiety or boredom.

Meanwhile, the Uncanny Valley phenomenon (Mori et al., 2012) explains human reactions to the degree of realism in visual representations. This theory posits that when a representation approaches reality but remains imperfect, individuals may experience discomfort, awkwardness, or emotional unease. Previous studies have shown that digital characters or avatars designed to be highly realistic but not

entirely human-like can evoke feelings of “strangeness” and reduce user acceptance (Tinwell et al., 2011; McDonnell et al., 2012). Zibrek et al. (2019) further emphasized that although high realism can enhance perceptions of credibility, it may also generate discomfort when such perceptions fail to meet human expectations.

In the context of learning, the level of realism in characters within infographics can be a critical factor influencing students’ emotional responses to the presented visuals. The implication is that the degree of realism in medical illustrations may position students within different emotional profiles, as described by Symes et al. (2025) whether Positive (high control and value), Mixed, or Negative (low control and value). For instance, semi-realistic illustrations may represent the most balanced approach, as they maintain scientific credibility without eliciting feelings of unease, thereby fostering a positive emotional profile.

Although previous studies have underscored the importance of visualization in learning, there remains a gap that has not been fully explored, particularly concerning emotional dimensions and the level of visual realism. For instance, Afify (2018) and Rahim et al. (2016) emphasized the effectiveness of infographics in enhancing understanding and reducing cognitive load; however, their focus was directed more toward cognitive aspects than students’ emotional responses. In the context of emotions, Pekrun (2006), Pekrun et al. (2007), and Turnquest et al. (2023) demonstrated that positive emotions foster motivation, whereas negative emotions hinder learning; yet few studies have linked this theory to visual forms such as medical illustrations. Furthermore, while the Uncanny Valley phenomenon (Mori et al., 2012) has been substantiated in studies of avatars and digital characters (Zibrek et al., 2019; Tinwell et al., 2011; McDonnell et al., 2012), there is still limited empirical evidence assessing how different levels of realism, cartoon, semi-realistic, or hyper-realistic in educational illustrations, particularly in medical infographics, affect the emotions and motivation of secondary school students.

Research related to students’ emotions in the science classroom also highlights the importance of teachers’ attention to the affective dimension. For example, Bellocchi and Ritchie (2015) found that the emotions displayed by students during scientific inquiry provided indicators of their level of conceptual understanding. In this context, Park (2023) also emphasized that teachers’ empathy and praise for the learning process can sustain student engagement and foster activating positive emotions. Conversely, negative emotional support from teachers may trigger deactivating negative emotions, which ultimately lead to withdrawal from learning activities. These findings strengthen the argument that students’ emotions in the classroom are not solely the result of cognitive experiences but also depend on the affective support provided by teachers.

The reliance of previous studies on animation or multimedia (Mutlu-Bayraktar, 2024) also indicates that static visuals, which are more commonly used in textbooks and formal learning materials, have not yet been thoroughly explored. This gap underscores the importance of the present study in integrating the framework of Control-Value Theory and the Uncanny Valley to understand the effects of levels of illustration realism on emotional experience, motivation, and learning potential in the context of secondary science education.

Accordingly, this study integrates both theories as a conceptual foundation to examine how levels of character realism in medical infographics shape students’ emotional experiences, foster motivation, and enhance learning effectiveness. This approach not only advances the understanding of the role of visuals in science education but also addresses a critical research gap regarding the impact of emotions and the Uncanny Valley phenomenon on static instructional materials. Findings from Turnquest et al. (2023) underscore the importance of linking achievement emotions to learning outcomes, further reinforcing the applicability of Control-Value Theory in secondary education contexts.

CONCEPTUAL FRAMEWORK

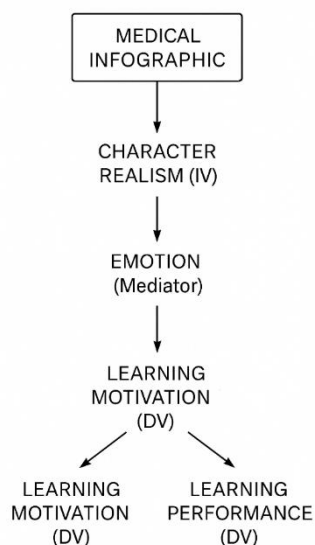


Fig 1: Conceptual Framework

This study proposes a conceptual framework as a guide for addressing the constructed research questions based on the earlier discussions. In this framework, character realism in medical infographics will act as the independent variable, while student learning motivation and learning performance will serve as the dependent variables. Emotion both positive and negative functions as the mediating variable, linking the visual characteristics of the infographic to students' motivational and cognitive outcomes.

RQ: Does the use of medical infographic character designs with different levels of realism have a significant impact on students' emotions, motivation, and learning performance?

Student emotions are significantly influenced by the level of realism embedded in the medical infographic character design. The emotional responses generated by these visuals may be positive (such as enjoyment, curiosity, or interest) or negative (such as anxiety, boredom, or frustration), and these responses will determine how students engage with the learning material. Positive emotions are expected to enhance students' motivation, encouraging them to invest more effort and maintain focus during the learning process. Conversely, negative emotions may lower motivation, leading to disengagement and reduced willingness to continue learning.

In particular, the chosen level of character realism in the medical infographic must be appropriate to elicit beneficial emotions that support learning outcomes. To be effective as a learning tool, the infographic must not only succeed in conveying educational content accurately but also evoke positive emotional engagement that motivates students and improves performance. Positive emotional experiences are likely to foster stronger motivation, which, in turn, enhances both immediate learning outcomes (such as recall and comprehension) and long-term retention.

Therefore, this framework highlights the importance of identifying the emotional effects both positive and negative of character realism in medical infographics. The goal is to assist educators and visual designers in selecting the most effective levels of realism that can create positive emotional engagement, strengthen student motivation, and ultimately improve learning performance in medical and science-related education.

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CONFLICT OF INTEREST

It should disclose any financial or non-financial interests such as political, personal, or professional relationships that may be interpreted as having influenced the manuscript. The phrase "The authors declare no conflicts of interest" should be included if there is no conflict of interest.

AVAILABILITY OF DATA AND MATERIALS

1. Data available within the article or its supplementary materials.
2. Data is openly available in a public repository, with a permanent identifier (such as a DOI).

AUTHORS' CONTRIBUTION

All authors contributed to the design of the research and the write-up. The data cleaning and tabulation were undertaken by University Teknologi MARA. All authors have read and approved the final manuscript.

Credit author statement: **Ahmad Khairul Azizi bin Ahmad**: Writing, Research Design and Findings. **Dr. Mohd khairulnizam bin Ramlie**: Research Supervision.

DECLARATION OF GENERATIVE AI

During the preparation of this work, the author(s) used ChatGPT to enhance the clarity of the writing. After using the ChatGPT, the author(s) reviewed and edited the content as needed and take(s) full responsibility for the content of the publication.

ETHIC STATEMENTS

Ethical approval statements will usually include:

- 1) Whether or not the study included human or animal subjects. In all cases, the ethical approval status of the work should be stated in the ethical approval statement.
- 2) The committee which approved the study.
- 3) The compliance documents. What policies, declarations, acts, etc.
- 4) Persistent identifier: reference or approval number. Include the registration ID/reference number if applicable.

If not applicable, please write 'Not applicable' in this section.

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