

Optimizing Drawing Ability Through Working Memory Effects: Methods for Novice and Expert Learners

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Abstract

This research aims to develop two model-drawing methods based on students' levels of competency, guided by a psychological approach to working memory. The study adopts a qualitative method with a case study design. Observations were carried out by analyzing six samples of model drawings produced by students in the Visual Arts Education program, Faculty of Art and Design. The drawings were categorized into two levels, expert and novice, based on students' performance in proportion, coloring, and detail. The findings show that (1) three students belong to the expert level, producing highly impressive model drawings whose proportions, coloring, and details are close to perfection; (2) three students fall into the novice level, with their proportions, coloring, and object forms still at a minimal or below-standard quality; and (3) one commonly used method is found to be unsuitable for all learners. Therefore, this research proposes two model-drawing methods according to students' competency levels: the Golden Ratio technique for expert-level students and a proportion-and-shape-based technique for novice learners.

Keywords: Model Drawing; Psychology; Expert Level; Novice Level; Proportion.

1. Introduction

Model drawing is the process of transferring a live object through direct observation. It is a process of translating visual forms from the external world into two-dimensional lines, typically drawn on paper or canvas. In its development, individuals' drawing abilities can generally be classified into two main categories: the expert level, characterized by drawings that approach perfection based on three aspects—size, proportion, and form; and the novice level, characterized by drawings that show inaccuracy across those same aspects (Tchalenko, 2009). Therefore, in art education, particularly in model-drawing courses, students require different instructional approaches according to their level of ability. This is essential in order to provide appropriate learning methods that align with students' competence levels.

In educational settings, instruction in model drawing is often delivered using a single method for students of varying ability levels (Andriani et al., 2018). This situation may disadvantage both expert-level and novice students. For instance, when expert students are taught using basic methods, the instructional content becomes redundant and ineffective. Conversely, when novice students are taught using highly complex methods, they tend to perform poorly. (Pollock et al., 2002) argue that when educators provide complex instructional methods, students who lack the relevant schemas in their memory will experience diminished performance. This occurs because, in psychological theory, human working memory is highly limited (Pollock et al., 2002, p. 83). As a result, students will not be able to draw effectively until their internal schemas are built through appropriate instructional methods.

Therefore, this study aims to develop a method that is more relevant to students' competency levels. Specifically, the research seeks to address these issues through three psychological principles related to human working memory: (1) the worked-example effect; (2) the redundancy effect; and (3) the expertise-reversal effect. These three principles are interrelated and offer several benefits, including: (1) enabling more comprehensive instructional design, thereby reducing extraneous load; and (2) supporting the development of intrinsic cognitive abilities according to learners' levels of expertise. This is crucial because using a single instructional method for students with different characteristics may ultimately disadvantage learners.

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1.1. Worked example effect

The worked example effect, widely recognized within psychology—particularly in studies on working memory—refers to the cognitive process involved when learners are introduced to new information (Chen et al., 2015, 2016; Kalyuga et al., 2001; Nievelstein et al., 2013; van Gog et al., 2015). Providing worked examples at the introductory stage of learning is highly beneficial. According to (Atkinson, 2000; Kalyuga et al., 2001), worked examples play a crucial role in developing cognitive abilities, especially for novice learners. The application of worked examples is well-suited to students whose skills are still at a foundational level (Buchner et al., 2022; Heitzmann et al., 2023; Kinnear et al., 2022; Maddock et al., 2022; Paas & van Merriënboer, 2020; Salmela-Aro et al., 2022; Solé-Llussà et al., 2022; van de Pol et al., 2019; Yeager & Dweck, 2020; Zhi et al., 2019), as seen in early instruction across disciplines such as music, chess, athletics, programming, mathematics, and likewise in model drawing.

The strategy of using worked examples is particularly suitable for students with basic abilities, as it enables them to plan and form mental schemas when observing examples directly. (Atkinson, 2000) notes that worked examples help students manage the heavy cognitive demands of learning new tasks. In addition, this method can increase learners' confidence by demonstrating that they can complete tasks successfully after studying the examples (Schunk, 2012). Therefore, the design of worked examples must remain simple and easy to understand when intended for beginner-level learners, so as to reduce extraneous cognitive load. (Clarke et al., 2006) further emphasize that worked example instruction is effective because it is purposely designed to reduce cognitive burden. As a result, implementing worked examples for novices requires straightforward instructional steps so that learners can grasp new content efficiently. The illustration below represents a commonly taught beginner method, where learners draw a face using a simple three-division guideline, beginning from a point located between the eyes.

Teachers must also recognize that students have varying levels of prior knowledge; some are beginners, while others are already experts. Learners are considered experts when they have formed strong internal schemas derived from extensive previous experience. While worked examples are highly effective for novices, they become inappropriate for expert learners who have already mastered the preliminary steps. (Kalyuga et al., 2001) explain that worked examples become ineffective for advanced learners because these individuals already possess the schemas needed to understand the material. Hence, instructional design must carefully consider individual differences in skill level. To optimize their learning process, advanced learners must engage with instructional tasks that match their experience, enabling them to strengthen problem-solving skills (Kalyuga et al., 2001).

Nevertheless, worked examples can also present weaknesses when misapplied. One drawback emerges when learners' attention becomes split due to complex or poorly designed examples. For novice learners, instructional schemas must remain simple (Sweller & Cooper, 1985). When worked examples are designed with unnecessary complexity, the effectiveness of the method diminishes. (Sweller, 1998, p. 19) further notes that designing worked examples is not always easy, as overly complicated examples can render the method ineffective. In such cases, students will struggle to understand and benefit from the instructional material.

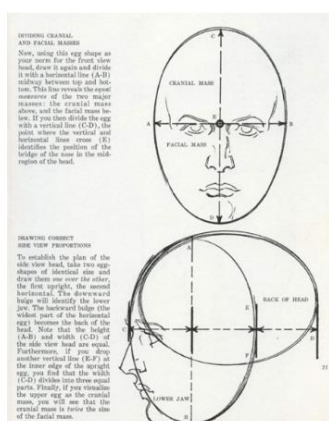


Figure 1. Example of redundant information in a drawing book. (Hogarth, B., 1989)

1.2. Redundancy effect

The redundancy effect refers to the theory that explains how instructional methods may become ineffective when information provided is excessive or unnecessary. When multiple media or forms of information are presented simultaneously, the content may become redundant, causing the learning process to be less efficient for students. (Kalyuga et al., 2001; Sweller, 1998) and (Sweller, 1998) state that appropriate instructional strategies help students better understand the material being taught.

For novice learners, instructional materials should contain simplified text accompanied by clear visual emphasis, whereas for expert learners, the focus should shift toward visual information with minimal or reduced text (Azman & Johari, 2022; Baceviciute et al., 2022; Chiu et al., 2020; Hahnel et al., 2019; Li et al., 2020; Shadiev & Sun, 2020). Therefore, in model-drawing instruction, it is more effective to prioritize high-quality, relevant information rather than providing excessive textual explanation. Simplifying instructional content remains one of the most effective strategies for supporting learners (Sweller, 1998).

1.3. Expertise Reversal Effect

The expertise reversal effect is conceptually similar to the redundancy effect. In practice, this principle relates to the differences between learners who are already experienced and those who remain at the novice level. When learners have prior knowledge of a particular topic, additional instructional information becomes unnecessary and unhelpful (Sweller et al., 2011). To achieve more targeted learning outcomes, instructional strategies must be designed with multiple approaches that align with students' varying levels of ability (Armougum et al., 2019; Bates & Moore, 2022; Belfiore et al., 2022; Ben Chikha et al., 2023; Emhardt et al., 2023; Glückler et al., 2023; Patel, n.d.; Porter et al., 2022; Ross et al., 2019; J. van Merriënboer, 2023). When learners already possess knowledge related to the subject, the use of detailed text-based explanations becomes ineffective. This situation is known as memory overload, in which excessive and unnecessary information leads learners to lose focus on instruction (J. J. G. van Merriënboer & Sweller, 2005).

For more experienced learners, instructors should implement faded worked examples or remove worked examples altogether. This means that instruction should no longer focus on step-by-step examples but instead emphasize problem-solving tasks (Sweller et al., 2011). Through this approach, learners concentrate on improving their weaknesses and enhancing their overall skill development. Therefore, in model-drawing instruction, worked examples should serve as the primary instructional tool for novice learners, while advanced learners should focus on expanding their capabilities and addressing specific areas that require refinement.

2. Research Method

This study employs a qualitative research method. The selection of this approach is based on the need to analyze and interpret meaningful aspects relevant to the research objectives (Cohen, 2017). The primary focus of the study is to examine the final skill levels of learners who have been taught using a single instructional method, namely the proportion method. Based on these findings, the study aims to recommend instructional methods that correspond to learners' varying competency levels, supported by evidence drawn from the students' artworks.

The research design adopted in this study is a case study, which is considered highly relevant in visual analysis (Yuwono, 2019). The objectives of this study are: (1) to identify students' drawing ability levels in the context of model drawing, and (2) to develop instructional methods that align more effectively with learners' levels of expertise. This design is grounded in psychological theories of working memory (Kalyuga et al., 2001), the model-drawing principles presented in (Hampton, 2009), and the application of the Golden Ratio technique popularized by Leonardo da Vinci.

The participants in this study were students who had completed the Model Drawing course, specifically third-semester students from the 2021 cohort in the Visual Arts Education Program at the Faculty of Art and Design, Universitas Negeri Makassar. Six samples of students' model drawings were selected randomly to obtain more accurate and representative data. The names of the participants were anonymized and replaced with codes such as A1, A2, A3, and so forth. The researcher conducted observations directly on the students' artwork.

More specifically, the study applies two basic facial-drawing techniques tailored to students' competency levels, which are classified as novice and expert. This classification is based on Kalyuga's psychological framework of

working memory. To analyze expert-level performance, the Golden Ratio theory was used (Britz, n.d.; Manolo Esteban Bravo Encalada et al., 2023; Marilyn Dayana Argudo Velasteguí et al., 2023; Moridani et al., 2023; Peng et al., 2022). Meanwhile, novice-level learners were analyzed using (Hampton, 2009) fundamental perspective method for constructing facial features as outlined in his model-drawing work.

3. Results and Discussions

1.4. Results

1.4.1. Model-Drawing Ability of Visual Arts Education Students (2021 Cohort), Faculty of Art and Design, UNM

This study began with a literature review focusing on psychological research related to human cognition and working memory. The purpose of this review was to obtain information on learners' levels of ability, which would later be used to determine more appropriate instructional methods. The findings of this research indicate two distinct learner characteristics: students who demonstrate expert-level abilities and those who fall into the novice category. Expert-level learners are characterized by highly detailed and proportional drawings, although not yet perfect—likely due to instructional methods that rely on only a single approach. Meanwhile, novice-level learners are identified by drawings that are significantly disproportionate, accompanied by less accurate shading techniques.

Based on observations of the students' artwork, the researcher identified two instructional methods that are more suitable for their respective ability levels. For expert-level students, it is recommended that they refine their proportional skills to achieve more accurate and harmonious drawings. This can be accomplished using techniques inspired by Leonardo da Vinci. On the other hand, novice-level students should be required to use a model-drawing book as a reference, with instructional materials presented using minimal text and visually uncluttered examples. Clear and guided model-drawing resources are essential for beginners; therefore, instructional approaches for novice learners should start with mastering only the fundamental proportions.

1.4.2. Expert-Level Student Ability

Among the six drawing samples collected, three students demonstrated skills that fall into the expert-level category. These students were anonymized as A1, A2, and A3. Below is the model-drawing example produced by A1, an expert-level student. The student's drawing shows a high degree of detail; small features such as the shadows around the eyes and the curvature of the hair are rendered with remarkable precision. However, in terms of proportion and overall balance, the drawing still has room for further improvement.



Figure 2. Model drawings by students A1, A2, and A3, respectively, categorized as expert level (Personal Documentation, 2024).

The second expert-level drawing is a portrait of an elderly woman created by student A2. Although the drawing is unfinished, the level of detail, accuracy, and shading is highly impressive. Technically, A2 has mastered model

drawing to an almost perfect degree. However, the weakness in this work lies in the imbalance between the left and right sides of the face, particularly in the nose and mouth area. As a result, the portrait appears wider and less harmonious.

Next is the model drawing by student A3, who depicted the Hollywood actor Keanu Reeves. This drawing displays an exceptional level of detail and likeness, placing it firmly within the expert category. However, a noticeable error appears in the overall facial proportion, which is slightly elongated, especially around the nose. Through the observation of A3's work, the researcher identified distinct variations in drawing quality depending on the instructional method provided. When the teaching method did not align with the student's skill level, the resulting drawing quality decreased significantly. This indicates that appropriate instructional methods greatly influence A3's performance, enabling the student to achieve expert-level outcomes when the method matches their learning needs.

1.4.3. Novice-Level Student Ability

Of the six model-drawing samples collected, three students demonstrated abilities that fall into the novice category. Their model-drawing skills show very basic levels of sketching, proportional accuracy, and black-and-white shading. These students were anonymized as A4, A5, A6, and A7. Below is the model drawing produced by A4, whose work reflects a beginner level of ability, particularly in black-and-white shading, proportion, and, most notably, the facial structure, which appears flat and lacks depth.



Figure 3. Model drawings by students A4, A5, and A6, respectively, categorized as novice level (Personal Documentation, 2024).

The next drawing, produced by student A5, depicts the renowned South Sulawesi painting maestro A. Kahar Wahid. The student's ability is categorized at the novice level. This is evident from the inaccurate proportions, which cause the portrait to appear dissimilar to the original subject. The shading in the drawing is also quite rough and appears unfinished. The work would improve significantly if the anatomical structure of the face were rendered more accurately, thereby achieving better proportional balance.

Similarly, the third drawing, created by student A6 and portraying an elderly woman, clearly demonstrates novice-level ability. The use of instructional methods that were not aligned with the learner's skill level contributed to ineffective learning outcomes. Therefore, to support the development of this student's drawing ability, instructional methods must be chosen based on the learner's competency level. For novice learners, the use of reference books or guided model-drawing materials is highly important and can help them progress toward the expected level of skill.

1.4.4. Instructional Design for Expert-Level Model Drawing

Two student drawings were selected for observation using the Golden Ratio proportion method at the expert level (Figure 5). The results show that both drawings are nearly perfect; however, applying the Golden Ratio method can further refine the students' abilities and elevate their work toward a more optimal level. The illustration below demonstrates the facial-drawing method based on the Golden Ratio theory. The facial regions—particularly the eyes and nose—are critical areas in model drawing, as the likeness between the subject and the drawing is largely determined by the accuracy of these features.

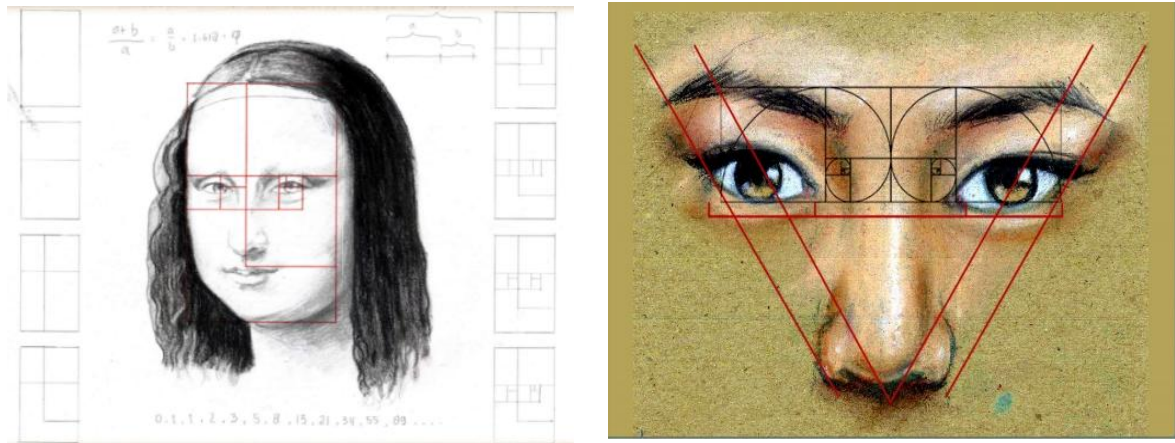


Figure 4. The Golden Ratio applied to the proportions of the Mona Lisa painting (Personal Documentation, 2024).

In Figure 5, the drawing on the right shows proportional inaccuracies in the height of the nose and chin. In model drawing, even a one-millimeter difference can significantly alter the character of a face. Meanwhile, the drawing on the left in Figure 5 illustrates additional proportional inconsistencies. By applying the Golden Ratio method, these weaknesses can be clearly identified. When used during the facial sketching process, this method can help improve accuracy and ultimately enhance the overall quality of the model drawing.

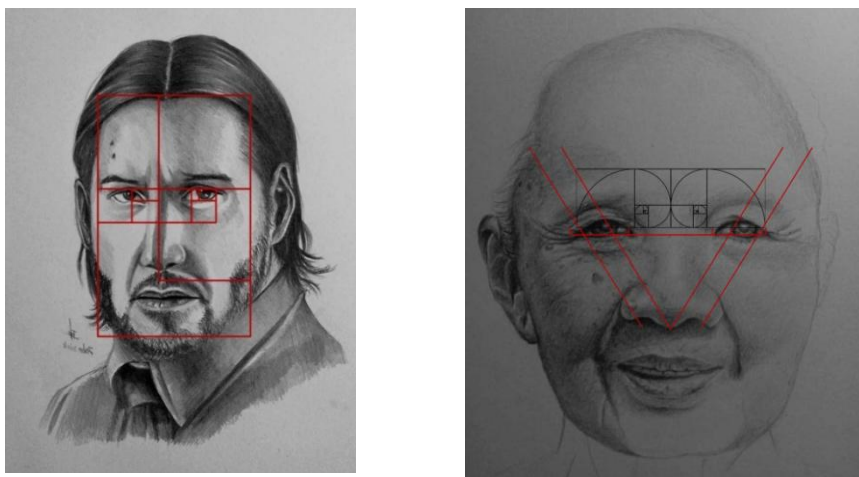


Figure 5. Facial proportion analysis using the Golden Ratio inspired by the Mona Lisa (Personal Documentation, 2024).

The image above represents a method that can be used for expert-level instruction. In this approach, learners receive information in the form of visual guidelines—such as red lines—rather than textual explanations. This method also provides expert-level students with a different level of challenge, enabling them to further refine and advance their drawing abilities.

1.4.5. Instructional Design for Novice-Level Model Drawing

In model-drawing instruction for the 2021 cohort of Visual Arts Education students, they were taught using a commonly applied yet inaccurate method (Figure 13). This method is unsuitable because it divides the face into three equal sections for all characters, assuming that every face shares the same structure. It is important to note that each facial character has its own unique features, and the proportions of male and female faces, in particular, differ significantly.

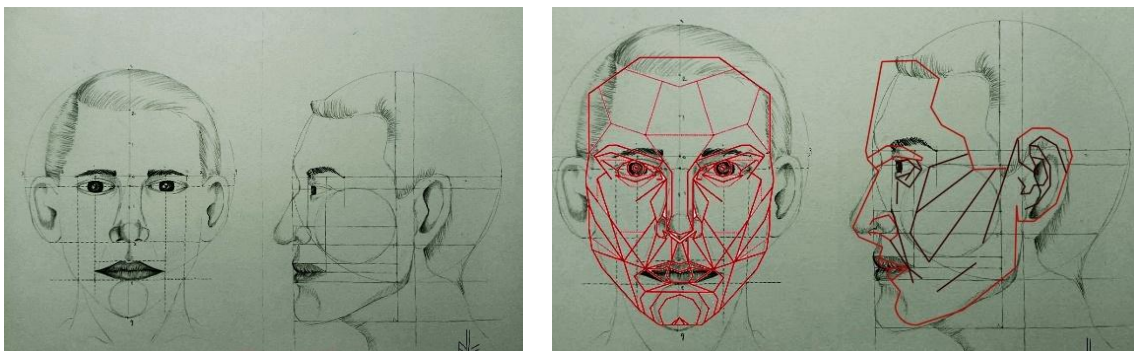


Figure 6. Comparison between the commonly taught facial-drawing method (left) and its weaknesses (right) (Personal Documentation, 2024).

Therefore, the recommended model-drawing method for novice-level learners is to begin by studying proportion and basic forms, as illustrated in Figure 15. The advantage of Hampton’s method is that students focus more on understanding form, shadow, and proportion through comparative observation of the model’s facial structure, rather than relying on the commonly used three-part numerical division method.

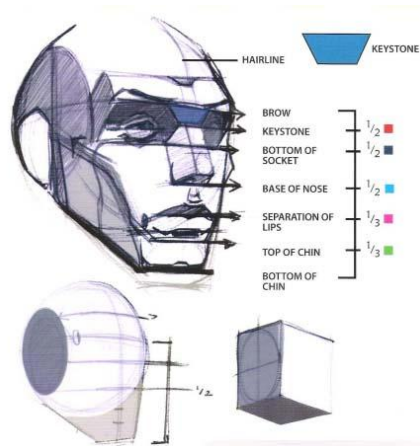


Figure 7. Basic facial-drawing technique for novice learners (Hampton, M., 2009).

1.5. Discussion

The findings of this model-drawing study reveal two distinct learner characteristics, consistent with the framework proposed by (Kalyuga et al., 2001; Sweller et al., 2011). The results show that students fall into two sharply different ability levels: expert and novice. From a psychological perspective, particularly regarding human working memory, expert learners are those who possess prior learning experience, enabling them to achieve higher levels of drawing performance. Conversely, novice learners have minimal experience and rarely practice their drawing skills, resulting in model drawings that remain at a beginner level. This study therefore outlines two learner groups and proposes two instructional methods suited to each level.

First, three of the six students (A1, A2, and A3) demonstrated expert-level model drawing. Their drawings exhibit strong proportional accuracy and detailed resemblance to the subjects. However, their work still holds potential for further refinement. Thus, instructional methods appropriate for beginner learners are no longer relevant for these students. Worked examples, which are highly effective for novices, become unsuitable for expert learners. This aligns with (Kalyuga et al., 2001; Sweller et al., 2011), who explain that worked examples lose effectiveness once learners possess sufficient schemas related to the material.

Second, three students (A4, A5, and A6) were categorized as novice-level learners. These students exhibited difficulties in understanding form and shading. For this level, worked examples are recommended to support the development of their motor and cognitive skills in model drawing. This is in line with (Atkinson, 2000; Sweller et al., 2011), who state that worked examples provide substantial cognitive support for novice learners and enhance early-stage skill acquisition.

Third, once students such as A1, A2, and A3 recognize the instructional methods and skill requirements in the model-drawing course, they should be introduced to expert-level techniques, such as Leonardo da Vinci's Golden Ratio method. According to (Sweller et al., 2011), when learners already possess the necessary knowledge, additional instructional text becomes redundant and ineffective. Therefore, expert-level students should receive instruction that relies less on textual explanation and more on visually guided information, which they can easily interpret due to pre-existing schemas in their memory (Kalyuga et al., 2001).

Fourth, novice-level learners must use appropriate drawing methods tailored to their ability level. However, they should not rely on simplified methods that are inaccurate or imprecise. (Sweller, 1998; Sweller & Cooper, 1985) emphasize that beginner instruction must use simple, clear methods—but simple does not mean incorrect. As demonstrated in this study, the commonly used method lacks accuracy and does not account for differences in gender-based facial proportions. Therefore, a more suitable simplified method is (Hampton, 2009) technique and other similar approaches that emphasize dimension, form, and proportion.

4. Conclusion

This study identifies two distinct levels of student ability in model drawing, namely the expert level and the novice level. The six samples analyzed in this research consisted of three students who demonstrated expert-level abilities, indicated by detailed drawings that closely resembled the original subjects, and three students whose drawings were categorized as novice level, characterized by disproportional forms and foundational skill limitations.

The researcher also found that the commonly used drawing method among students was not aligned with the structural requirements of model drawing. As a result, expert-level learners were unable to reach their full potential, while novice learners struggled to develop their basic skills effectively. Therefore, this study proposes two differentiated instructional methods: the use of the Golden Ratio technique for expert-level students, which aligns well with their advanced abilities, and the use of reference-based model-drawing methods—such as those presented in Hampton's book—for novice learners. These recommendations aim to address the diverse learner characteristics present in the classroom.

In teaching model drawing, educators must carefully consider the unique characteristics of each learner, as students require instructional approaches tailored to their specific needs. Based on the findings of this study, two general learner profiles were identified: expert-level and novice-level students. Thus, it is strongly recommended that instructional methods in model drawing be differentiated according to learners' cognitive schemas and prior drawing experience. Since this research focuses primarily on psychological aspects of learning, future studies may expand upon these findings by exploring creativity in model drawing, offering new perspectives that may further enrich the field.

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References

- Andriani, S., Murdowo, D., & Firmansyah, R. (2018). ANALISIS DESAIN INTERIOR KANTOR CALL CENTER TELKOMSEL DI GEDUNG INFOMEDIA NUSANTARA, BANDUNG DENGAN PENDEKATAN PSIKOLOGI RUANG. *Idealog: Ide dan Dialog Desain Indonesia*, 3(1), 61. <https://doi.org/10.25124/idealog.v3i1.1783>
- Armougum, A., Orriols, E., Gaston-Bellegarde, A., Marle, C. J.-L., & Piolino, P. (2019). Virtual reality: A new method to investigate cognitive load during navigation. *Journal of Environmental Psychology*, 65, 101338. <https://doi.org/10.1016/j.jenvp.2019.101338>
- Atkinson, R. K. (2000). *Learning from Examples: Instructional Principles from the Worked Examples Research*.
- Azman, A. N., & Johari, M. (2022). Investigating the Effectiveness of Videos Designed Using Cognitive Load Theory on Biology Students' Academic Achievement. *Jurnal Pendidikan IPA Indonesia*, 11(3), 461–468. <https://doi.org/10.15294/jpii.v11i3.37324>
- Baceviciute, S., Lucas, G., Terkildsen, T., & Makransky, G. (2022). Investigating the redundancy principle in immersive virtual reality environments: An eye-tracking and EEG study. *Journal of Computer Assisted Learning*, 38(1), 120–136. <https://doi.org/10.1111/jcal.12595>
- Bates, D., & Moore, J. (2022). High-fidelity simulation for graduate athletic training students and impact on students' learning experience. *Research and Practice in Technology Enhanced Learning*, 18, 015. <https://doi.org/10.58459/rptel.2023.18015>
- Belfiore, E. B., Zasso, F., & Santos, F. N. (2022). Canadian fellowship experience: The different challenges and emotions faced by an International Medical Graduate and mitigation strategies. *Canadian Medical Education Journal*. <https://doi.org/10.36834/cmej.74696>
- Ben Chikha, H., Zoudji, B., & Khacharem, A. (2023). Using pointing gestures to convey tactical information: Investigating the roles of expertise and complexity. *Psychological Research*. <https://doi.org/10.1007/s00426-023-01806-y>
- Britz, T. (n.d.). *The beauty of the Golden Ratio*.
- Buchner, J., Buntins, K., & Kerres, M. (2022). The impact of augmented reality on cognitive load and performance: A systematic review. *Journal of Computer Assisted Learning*, 38(1), 285–303. <https://doi.org/10.1111/jcal.12617>
- Chen, O., Kalyuga, S., & Sweller, J. (2015). The worked example effect, the generation effect, and element interactivity. *Journal of Educational Psychology*, 107(3), 689–704. <https://doi.org/10.1037/edu0000018>
- Chen, O., Kalyuga, S., & Sweller, J. (2016). Relations between the worked example and generation effects on immediate and delayed tests. *Learning and Instruction*, 45, 20–30. <https://doi.org/10.1016/j.learninstruc.2016.06.007>
- Chiu, T. K. F., Jong, M. S., & Mok, I. A. C. (2020). Does learner expertise matter when designing emotional multimedia for learners of primary school mathematics? *Educational Technology Research and Development*, 68(5), 2305–2320. <https://doi.org/10.1007/s11423-020-09775-4>
- Clarke, N. A., Stow, S., Ruebling, C., & Kayona, F. (2006). Developing Standards-Based Curricula and Assessments: Lessons from the Field. *The Clearing House*, 79(6), 258–261.
- Cohen, L. (2017). *Research Methods in Education* (8th ed.). Routledge. <https://doi.org/10.4324/9781315456539>

- Emhardt, S. N., Kok, E., van Gog, T., Brandt-Gruwel, S., van Marlen, T., & Jarodzka, H. (2023). Visualizing a Task Performer's Gaze to Foster Observers' Performance and Learning—A Systematic Literature Review on Eye Movement Modeling Examples. *Educational Psychology Review*, 35(1), 23. <https://doi.org/10.1007/s10648-023-09731-7>
- Glückler, J., Winch, C., & Punstein, A. M. (Eds.). (2023). *Professions and Proficiency* (Vol. 18). Springer International Publishing. <https://doi.org/10.1007/978-3-031-24910-5>
- Hahnel, C., Schoor, C., Kroehne, U., Goldhammer, F., Mahlow, N., & Artelt, C. (2019). The role of cognitive load in university students' comprehension of multiple documents. *Zeitschrift Für Pädagogische Psychologie*, 33(2), 105–118. <https://doi.org/10.1024/1010-0652/a000238>
- Hampton, M. (2009). *Figure Drawing design and invention*.
- Heitzmann, N., Stadler, M., Richters, C., Radkowsch, A., Schmidmaier, R., Weidenbusch, M., & Fischer, M. R. (2023). Learners' adjustment strategies following impasses in simulations—Effects of prior knowledge. *Learning and Instruction*, 83, 101632. <https://doi.org/10.1016/j.learninstruc.2022.101632>
- Kalyuga, S., Chandler, P., Tuovinen, J., & Sweller, J. (2001). When problem solving is superior to studying worked examples. *Journal of Educational Psychology*, 93(3), 579.
- Kinnear, G., Wood, A. K., & Gratwick, R. (2022). Designing and evaluating an online course to support transition to university mathematics. *International Journal of Mathematical Education in Science and Technology*, 53(1), 11–34. <https://doi.org/10.1080/0020739X.2021.1962554>
- Li, Y., Wang, X., Thomsen, J. B., Nahabedian, M. Y., Ishii, N., Rozen, W. M., Long, X., & Ho, Y.-S. (2020). Research trends and performances of breast reconstruction: A bibliometric analysis. *Annals of Translational Medicine*, 8(22), 1529–1529. <https://doi.org/10.21037/atm-20-3476>
- Maddock, A., McCusker, P., Blair, C., & Roulston, A. (2022). The Mindfulness-Based Social Work and Self-Care Programme: A Mixed Methods Evaluation Study. *The British Journal of Social Work*, 52(5), 2760–2777. <https://doi.org/10.1093/bjsw/bcab203>
- Manolo Esteban Bravo Encalada, Diego Alejandro Lima Dominguez, Pablo Andrés Astudillo Pacheco, & Manuel Estuardo Bravo Calderón. (2023). Comparison between golden rectangle and ideal facial height proposed by the Silva Cephalometric Method (MCS) through digital analysis (NemoStudio 2022) in a university population. *World Journal of Advanced Research and Reviews*, 17(3), 464–470. <https://doi.org/10.30574/wjarr.2023.17.3.0141>
- Marilyn Dayana Argudo Velasteguí, Jeny Maricela Bermeo Cabrera, & Valeria Alexandra Juella Bravo. (2023). Correlation of the golden proportion between the intercanine distance and the vertical measurement of the middle third of the face in fourth year students of the faculty of dentistry of the University of Cuenca, 2023. *World Journal of Advanced Research and Reviews*, 17(1), 578–588. <https://doi.org/10.30574/wjarr.2023.17.1.0121>
- Moridani, M. K., Behbahani, S., & Nejati, F. (2023). *Designing an Expert System for Ranking Facial Attractiveness Based on Deep Learning and Fuzzy Inference System* [Preprint]. In Review. <https://doi.org/10.21203/rs.3.rs-2380160/v3>
- Nievelstein, F., van Gog, T., van Dijck, G., & Boshuizen, H. P. A. (2013). The worked example and expertise reversal effect in less structured tasks: Learning to reason about legal cases. *Contemporary Educational Psychology*, 38(2), 118–125. <https://doi.org/10.1016/j.cedpsych.2012.12.004>
- Paas, F., & van Merriënboer, J. J. G. (2020). Cognitive-Load Theory: Methods to Manage Working Memory Load in the Learning of Complex Tasks. *Current Directions in Psychological Science*, 29(4), 394–398. <https://doi.org/10.1177/0963721420922183>
- Patel, S. (n.d.). *The effects of difficulty and prior expertise levels in educational video games*.
- Peng, R., Inoue, K., & Hara, K. (2022). Generating Face Images Based on Golden Ratios for Facial Beauty. *Journal of the Institute of Industrial Applications Engineers*, 10(1), 11–18. <https://doi.org/10.12792/JIAE.10.11>
- Pollock, E., Chandler, P., & Sweller, J. (2002). Assimilating complex information. *Learning and Instruction*, 12(1), 61–86. [https://doi.org/10.1016/S0959-4752\(01\)00016-0](https://doi.org/10.1016/S0959-4752(01)00016-0)

- Porter, A., Graham, S., Myles, F., & Holmes, B. (2022). Creativity, challenge and culture in the languages classroom: A response to the Ofsted Curriculum Research Review. *The Language Learning Journal*, 50(2), 208–217. <https://doi.org/10.1080/09571736.2022.2046358>
- Ross, K., Sarkar, P., Rodenburg, D., Ruberto, A., Hungler, P., Szulewski, A., Howes, D., & Etemad, A. (2019). Toward Dynamically Adaptive Simulation: Multimodal Classification of User Expertise Using Wearable Devices. *Sensors*, 19(19), 4270. <https://doi.org/10.3390/s19194270>
- Salmela-Aro, K., Upadaya, K., Ronkainen, I., & Hietajärvi, L. (2022). Study Burnout and Engagement During COVID-19 Among University Students: The Role of Demands, Resources, and Psychological Needs. *Journal of Happiness Studies*, 23(6), 2685–2702. <https://doi.org/10.1007/s10902-022-00518-1>
- Shunk, D. H. (2012). *Learning theories: An educational perspective* (6th ed). Pearson.
- Shadiev, R., & Sun, A. (2020). Using texts generated by STR and CAT to facilitate student comprehension of lecture content in a foreign language. *Journal of Computing in Higher Education*, 32(3), 561–581. <https://doi.org/10.1007/s12528-019-09246-7>
- Solé-Llussà, A., Aguilar, D., & Ibáñez, M. (2022). Video-worked examples to support the development of elementary students' science process skills: A case study in an inquiry activity on electrical circuits. *Research in Science & Technological Education*, 40(2), 251–271. <https://doi.org/10.1080/02635143.2020.1786361>
- Sweller, J. (1998). *Cognitive Architecture and Instructional Design*.
- Sweller, J., Ayres, P., & Kalyuga, S. (2011). *Cognitive Load Theory*. Springer New York. <https://doi.org/10.1007/978-1-4419-8126-4>
- Sweller, J., & Cooper, G. A. (1985). The Use of Worked Examples as a Substitute for Problem Solving in Learning Algebra. *Cognition and Instruction*, 2(1), 59–89. https://doi.org/10.1207/s1532690xci0201_3
- Tchalenko, J. (2009). Segmentation and accuracy in copying and drawing: Experts and beginners. *Vision Research*, 49(8), 791–800. <https://doi.org/10.1016/j.visres.2009.02.012>
- van de Pol, J., Mercer, N., & Volman, M. (2019). Scaffolding Student Understanding in Small-Group Work: Students' Uptake of Teacher Support in Subsequent Small-Group Interaction. *Journal of the Learning Sciences*, 28(2), 206–239. <https://doi.org/10.1080/10508406.2018.1522258>
- van Gog, T., Kester, L., Dirx, K., Hoogerheide, V., Boerboom, J., & Verhoeijen, P. P. J. L. (2015). Testing After Worked Example Study Does Not Enhance Delayed Problem-Solving Performance Compared to Restudy. *Educational Psychology Review*, 27(2), 265–289. <https://doi.org/10.1007/s10648-015-9297-3>
- van Merriënboer, J. (2023). *Learning in Simulated and Real Environments*: Maastricht University. <https://doi.org/10.26481/spe.20230330jm>
- van Merriënboer, J. J. G., & Sweller, J. (2005). Cognitive Load Theory and Complex Learning: Recent Developments and Future Directions. *Educational Psychology Review*, 17(2), 147–177. <https://doi.org/10.1007/s10648-005-3951-0>
- Yeager, D. S., & Dweck, C. S. (2020). What can be learned from growth mindset controversies? *American Psychologist*, 75(9), 1269–1284. <https://doi.org/10.1037/amp0000794>
- Yuwono, A. A. (2019). KAJIAN ELEMEN VISUAL ARSITEKTUR TERKAIT PERSEPSI ANAK USIA DINI TERHADAP BANGUNAN. *Idealog: Ide dan Dialog Desain Indonesia*, 4(1), 1. <https://doi.org/10.25124/idealog.v4i1.1557>
- Zhi, R., Price, T. W., Marwan, S., Milliken, A., Barnes, T., & Chi, M. (2019). Exploring the Impact of Worked Examples in a Novice Programming Environment. *Proceedings of the 50th ACM Technical Symposium on Computer Science Education*, 98–104. <https://doi.org/10.1145/3287324.3287385>