ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

Research Progress on the Integration of Science and Art——Exploration of Generative Learning Strategies with Drawing as the Core

Yang Song[1,a,*], Wenbin Jiang[2,b], Linlin Chen[1,c], Xizhi Wang[1,d]

[1]*School of Management, Liaoning University of International Business and Economics, Dalian, 116052, Liaoning, China*
[2]*Department of Anatomy, School of Basic Medicine, Dalian Medical University, Dalian, 116044, Liaoning, China*
[a]*51883909@qq.com*, [b]*1282205797@qq.com*, [c]*chenlinlin4321@126.com*, [d]*184831999@qq.com*
[*]*Corresponding author*

Abstract: *Generative learning theory emphasizes learners' active participation in the construction of meaning rather than passive knowledge acceptance. Based on generative learning theory, this paper systematically reviews the application progress of drawing as a generative learning strategy in the education of medical science, biology, physical education, and other disciplines, as well as in the visualization of scientific research outcomes. The analysis indicates that by concretizing abstract scientific concepts, drawing plays a distinct role in knowledge construction, skill development, and interdisciplinary integration, enabling learners to actively construct knowledge for in-depth understanding, and further assisting them in clarifying the inherent links among different knowledge elements to build a structured knowledge framework. Additionally, the paper addresses practical challenges, including unbalanced cognitive load, ambiguous evaluation criteria, and inadequate interdisciplinary competencies of teachers, and outlines prospects for future development in technology integration, standard establishment, and teacher training. It provides theoretical support and practical pathways for advancing the in-depth integration of science and art.*

Keywords: *Drawing; Generative Learning; Teaching Application; Interdisciplinary Connections*

1. Practical Significance of Integrating Science and Art

Although science and art constitute distinct domains, they share inherent and profound connections [1]. Their in-depth integration in contemporary education and research is forging a new paradigm amid the advancement of generative learning theory. Generative learning emphasizes that learners achieve in-depth internalization and transfer of knowledge through active construction, transformation, and integration of information [2]. Meanwhile, drawing, as a key form of artistic expression, has emerged as an irreplaceable component in this process [3, 4]. It can concretize abstract scientific concepts, facilitate learners' comprehension and retention of knowledge, and also plays a pivotal role in presenting scientific research outcomes [5, 6].

Driven by the British Industrial Revolution in the 19th century, an information transmission mode dominated by images with text as a supplement gradually emerged. The importance of text matching became increasingly apparent, and the evolution of illustration art began to affect culture [7]. This in-depth integration of images and text not only reshapes the form of information dissemination but also implies the possibility of integration between art and practical knowledge. Although some scholars characterize science and art as a dichotomy of "two cultures" [1], educational and scientific research practices are gradually breaking this barrier. This is because drawing, as the most important form of art, has gradually become an effective strategy for learning scientific knowledge and conducting scientific research. Despite their distinct nature, the close connection between science and art can be traced back to Leonardo da Vinci's anatomical drawings during the Renaissance, and this concept of interdisciplinary integration has persisted to the present day [8].

With the advancement of modern educational research, education is undergoing a paradigm shift from passive knowledge reception to active knowledge generation. This transformation not only reshapes the pathways of knowledge transmission but also advances learning scenarios from single-

ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

discipline cognition to interdisciplinary integration. Despite widespread recognition of disciplinary integration and its emphasis by numerous professional organizations, empirical research supporting its superiority over traditional curricula remains insufficient [9]. In recent years, with the development of visualization technology, the generative value of drawing in science education has been re-examined. Learners establish a cognitive structure of observation, drawing, and reconstruction, and the integration of drawing and science has become a research focus among scholars [10]. As a visualization tool to concretize abstract concepts, drawing enables learners to achieve in-depth understanding through active knowledge construction during the drawing process, which is precisely consistent with the concept of generative learning, thus highlighting the value of drawing [11]. Therefore, drawing is not only an artistic expression but also an effective tool to stimulate students' thinking and a widely used method to communicate scientific ideas. In disciplines centered on morphology and systematic knowledge such as medical science and biology, it is a key means for knowledge processing and dissemination [1,12-16].

2. Teaching Application of Drawing as a Generative Learning Strategy

2.1 Drawing Practice in Medical Education

Anatomy, as a basic discipline in medical education, is the most representative field for the application of drawing. Anatomical drawing helps students establish a three-dimensional cognition of human body structures, with effects superior to simple textual descriptions or image observation [15-17]. For example, when drawing complex organs such as the skull and heart, students need to actively integrate information including morphological features and spatial relationships. In the process of sorting out materials and drawing pictures, students can promote free recall through the synergistic effect of processing, presentation, and image inspection and processing, which makes this strategy more effective than writing in free recall tasks [5]. The innovation of the haptico-visual observation and drawing (HVOD) method further verifies the generative value of drawing. Some scholars have found through experiments that students combining haptic exploration with synchronous drawing can construct more accurate three-dimensional mental models and perform better in anatomical structure memory tests [10]. To further increase students' interest in learning anatomy and improve their participation, educators have adopted competitions as a stimulus. As a derivative form of teaching, anatomical drawing competitions encourage participants to combine scientific accuracy with artistic expressiveness, thereby stimulating creativity [18]. This competition-driven learning model not only strengthens knowledge mastery but also cultivates medical students' humanistic literacy [13]. With the advancement of science and technology, the form of medical drawing continues to innovate. New visualization technologies have promoted the development of anatomy, facilitated the learning of medical knowledge, and demonstrated practical value in medical education, surgical preparation, and doctor-patient communication [19].

2.2 Drawing Strategies in Biology Teaching

In the field of biology, drawing is used to strengthen the understanding of microstructures and dynamic processes. Drawing can visualize abstract biological knowledge. Through methods such as drawing while explaining, classroom activities, replacing experimental reports, and extended exercises, it effectively stimulates students' learning interest and improves their comprehensive abilities in observation, analysis, and expression [20]. Some scholars designed a drawing course for students studying biology. This teaching experiment integrates the two courses, significantly improving students' observation ability and demonstrating the correlation between art and science [1]. Students participating in the drawing course showed significant improvement in drawing skills, which helped them observe better in biology classes, and this improvement in observation ability is long-lasting [1].

2.3 Application of Drawing in Physical Education Teaching

As an interdisciplinary subject of sports and arts, sports drawing plays an important role in the field of physical education teaching. Research on physical education teaching in colleges and universities mainly focuses on teaching models and techniques. Although most colleges and universities still adopt basic skill teaching and positioning decomposition models, they can still achieve the goal of improving and consolidating teaching effects [21]. Physical education drawing plays a significant role in teaching, training, and competitions. It can cooperate with explanations to improve teaching efficiency, make up for the transience of demonstration actions and limitations of teaching conditions, facilitate teachers in

ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

preparing lesson plans, and provide intuitive support for innovation in action design [22].

3. Integrated Application of Drawing in Scientific Research Activities

3.1 Visualization of Scientific Research Results

Drawing is a core medium for disseminating scientific research results. To address the insufficient mapping skills and standard awareness of college students in scientific papers, some universities have set up scientific paper drawing courses to systematically train students, aiming to improve the quality of students' papers and their scientific research capabilities [23]. Currently, scientific paper drawing courses have realized integrated teaching of software skills, scientific expression, and aesthetic literacy, highlighting the design concept of integrating appreciation, transmission, and creation of beauty. These courses can improve medical students' aesthetic literacy, learning enthusiasm, and scientific research interest, and promote their scientific research capabilities [25]. Scientific research drawing has been widely applied in various fields. For example, in micro-research such as cell signaling pathways and embryonic development, the complex mechanism can be simplified into understandable visual logic by drawing schematic diagrams, which helps readers clearly understand scientific research ideas and content [25]. The application demand for scientific research drawing is particularly prominent in the medical field. Medical visualization is currently developing and popularizing. To be closely linked to clinical practice, surgical illustrations must meet both scientificity (e.g., accurate anatomical structures) and narrativity (e.g., coherent surgical steps). Their production process is essentially the visual translation of scientific research thinking [26].

3.2 Interdisciplinary Collaboration Mechanisms

Based on the above discussion, the establishment of medical art courses marks the professional development of interdisciplinary integration. Practice at Chengdu College of University of Electronic Science and Technology shows that medical illustrators with systematic training can better balance scientific research needs and artistic expression [26]. The innovation of digital tools has accelerated the integration process. In recent years, science and technology have endowed teaching with more opportunities and challenges, leading to new ideas and attempts in the application of drawing in teaching. The evolution of drawing tools has promoted the reform of teaching methods, and electronic drawing has been considered by many researchers. Some reports propose exploring paths for computer-aided drawing in physical education teaching, such as trying to develop special drawing software, adopting authoritative textbooks, and carrying out computer drawing teaching to improve the pertinence and timeliness of teaching [22]. Some scholars also suggest that electronic drawing (e.g., Procreate and other drawing software) can not only enhance artistic beauty but also allow students to modify in real-time and reduce the difficulty of learning drawing [14]. While affirming the benefits of drawing for anatomy teaching, tablet drawing technology has been tried to be introduced into teaching to replace paper-based drawing [27]. However, how to apply it effectively remains to be studied, and it may become an efficient tool for anatomy learning. Some scholars advocate replacing manual drawing with electronic drawing in biology teaching, then exploring the teaching methods and advantages of electronic drawing to enhance teaching effectiveness [28]. Nowadays, with the emergence of various drawing software such as Adobe illustrator and 3Ds Max, scientific research and teaching quality have been significantly improved with the support of these technologies [25,26].

4. Challenges and Prospects of Integrating Science and Art

4.1 Core Issues in Practice

4.1.1 Unbalanced Cognitive Load

Although generative learning can effectively reduce external cognitive load theory (CLT) and increase related cognitive load through designing appropriate tasks, thereby promoting in-depth processing of learners [29]. However, some studies have shown that when generative teaching and drawing strategies are applied simultaneously, learners' working memory resources are excessively consumed, which leads to the decline of test scores [30]. This is mainly reflected in the significant impact of drawing forms on learning effects. A study comparing three drawing modes found that there was no statistical difference in test scores between the copy drawing (copying existing diagrams) group

ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

and the teaching-only group; supplementary drawing (partially structured diagrams) could still maintain cognitive balance due to retaining partial framework support; while the scores of the generative drawing (constructing complete diagrams from scratch) group were significantly lower [30]. This indicates that generative drawing and generative teaching can increase cognitive load simultaneously, while low generative drawing tasks will not additionally increase such load. Therefore, at the basic stage, it is necessary to reduce the cognitive threshold of drawing tasks by providing basic templates and key element prompts appropriately to avoid the imbalance between processing and cognitive load.

4.1.2 Vague Evaluation Criteria

Although the scientific accuracy of drawing can be verified through objective standards (e.g., proportions of anatomical structures, physiological processes), the evaluation of artistic expressiveness lacks quantitative indicators. Factors such as harmony of color matching, hierarchy of information presentation, and fluency of visual narrative are more subjective and difficult to measure uniformly. Although some scholars have proposed a medical aesthetic education evaluation system, attempting to conduct dual scoring based on color harmony and information hierarchy, its credibility still needs long-term verification [24]. Science and art have achieved significant results in integration, but science focuses more on the rigor of knowledge, while art focuses more on visual guidance. The essential difference between these two evaluation criteria may restrict the promotion of the evaluation system.

4.1.3 Insufficient Teacher Competence

Taking medical science as an example, most teachers do not simultaneously possess drawing ability. Their anatomy teaching generally relies on atlases, making it difficult to transform scientific content into visual expressions that are both accurate and aesthetically pleasing. Art teachers, on the other hand, may make scientific errors in drawing due to insufficient understanding of scientific principles. Therefore, there is a shortage of teachers proficient in using blackboard drawing for teaching, especially young teachers with weak drawing skills, which restricts the popularization and promotion of drawing teaching methods [14].

4.2 Future Development Directions

4.2.1 Technology Integration

Intelligence is currently an important topic, and drawing tools will become more intelligent and diversified. Artificial intelligence (AI) painting technology has shown great potential in the field of medical visualization, capable of quickly generating high-quality medical illustrations, including anatomical structures and pathological manifestations. Although this technology, which can automatically generate images through text descriptions, improves work efficiency, it is expected that future technologies will enable AI-generated images to be more accurate. In teaching, can we further explore the model of using AI drawing to assist teaching, provide students with personalized drawing guidance, and generate targeted graphic examples according to their learning status? In scientific research, AI drawing may further improve the efficiency and quality of visualization of scientific research results, and even help researchers discover new research ideas and relationships. In addition, it is expected to conduct in-depth research on the differences in demand for drawing strategies among different disciplines and learning stages, so as to more accurately apply drawing strategies to promote generative learning and drive the development of science education and scientific research.

4.2.2 Standard Construction

To further strengthen the integration of science and art, it is necessary to establish interdisciplinary evaluation standards for drawing ability, which can be considered from three aspects: science, art, and effectiveness, to improve the credibility of evaluation. For example, the textbook “Anatomy Learning through Zero-Based Drawing” developed by Dalian Medical University has made useful explorations in this regard. It transforms abstract artistic expression into operable scientific processes, providing a practical sample for standardization [13].

4.2.3 Teacher Training

Teachers need to continuously learn and practice to improve their ability in blackboard drawing for teaching, focusing on enhancing their ability to visually transform abstract scientific content, and ultimately achieving the dual goals of improving comprehensive quality and establishing teaching authority. Firstly, teachers can learn from interdisciplinary classic cases (such as medical illustrations)

ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

and apply them in practice. Secondly, they can learn and master symbolic expression to reduce the teaching difficulty for teachers without drawing foundation. Thirdly, teachers can be organized to participate in scientific research drawing projects, learning how to transform raw data into teaching images through cooperation with researchers. Fourthly, interdisciplinary collaborative lesson preparation can be carried out to jointly design teaching of scientific content and visual schemes with art teachers. This improvement in ability will be directly reflected in classroom teaching, simplifying the difficulty of knowledge understanding and winning students' recognition with professional literacy, thereby promoting the effective implementation of teaching strategies integrating science and art.

5. Conclusion

As a core medium for integrating science and art, the generative value of drawing has been fully verified in fields such as medical science, biology, and physical education. In educational scenarios, from the construction of 3D cognition in anatomical drawing to the visualization of micro-processes in biology, drawing promotes the transformation of knowledge from passive acceptance to active construction through the synergistic activity of hands, brain, and eyes. In the field of scientific research, as a key tool for result visualization, it realizes the intuitive expression and interdisciplinary dissemination of complex mechanisms. Although technological innovation and interdisciplinary collaboration provide new paths for integration, challenges such as unbalanced cognitive load, vague evaluation criteria, and insufficient interdisciplinary competence of teachers still exist in practice. In the future, it is necessary to further promote the integration of intelligent drawing tools with discipline teaching, establish evaluation standards balancing science and art, and strengthen the cultivation of teachers' visualization transformation ability. Drawing will continue to serve as a key link connecting scientific rigor and artistic expressiveness, playing a deeper role in precision education, scientific research dissemination, and other fields, and promoting the development of interdisciplinary learning and innovative practice.

Acknowledgements

This work was supported by University-level scientific research project of Liaoning University of International Business and Economics: Research on the Digital Application of Drawing Practice in Smart and Healthy Pension from the Perspective of Combination of Medical Care and Nursing Care. Project Approval No.: 2024XJLXYB009.

References

[1] E. Alkaslassy, & O'Day, T., Linking art and science with a drawing class. Bioscene, 2002(28), 7-14.
[2] M. C. Wittrock, Learning as a generative process1. Educational Psychologist, 2009(11), 87-95.
[3] L. Fiorella, R. E. Mayer, Eight Ways to Promote Generative Learning. Educational Psychology Review, 2015(28), 717-741.
[4] W. A. Bainbridge, R. Chamberlain, J. Wammes, J. E. Fan, Drawing as a means to characterize memory and cognition. Memory & Cognition, 2025(53), 1-5.
[5] H. P. Xie, Y. Q. Wang, S. E. Deng, & Z. K. Zhou, Drawing to Remember: The Generative Drawing Effect on Memory. Psychological Exploration, 2023(43), 16-25.
[6] C. Leopold, D. Leutner, Science text comprehension: Drawing, main idea selection, and summarizing as learning strategies. Learning and Instruction, 2012(22), 16-26.
[7] Y. W. Zhang, Media Change: The Evolution of Illustration Art from the Perspective of the British Industrial Revolution. Art Market, 2021(06), 73-75.
[8] K. D. Keele, Leonardo da Vinci's influence on Renaissance anatomy. Medical history, 1964(8), 360-370.
[9] C. M. Czerniak, W. B. Weber Jr, A. Sandmann, J. Ahern, A literature review of science and mathematics integration. School Science and Mathematics, 1999(99), 421-430.
[10] S. Reid, L. Shapiro, G. Louw, How haptics and drawing enhance the learning of anatomy. Anatomical sciences education, 2019(12), 164-172.
[11] P. V. Meter, C. M. Firetto, Cognitive model of drawing construction: Learning through the construction of drawings, 2013, 247-280.
[12] L. Fiorella, S. Kuhlmann, Creating Drawings Enhances Learning by Teaching. Journal of Educational Psychology, 2019(112), 4:811.

ISSN 2618-1568 Vol. 7, Issue 6: 70-75, DOI: 10.25236/FAR.2025.070611

[13] S. Z. Sun et al., Anatomical Drawing Practice: An Effective Approach to Enhancing Medical Students' Comprehensive Abilities. China Medical Education Technology, 2021(35), 274-277.
[14] X. Y. Zhai et al., Application of Drawing Practice in Human Anatomy Teaching. Chinese Medicine Modern Distance Education of China, 2023(21), 26-28.
[15] A. Amin, 'Drawing'to learn Anatomy: Exploring the theoretical underpinning and conditions favouring drawing based learning. JPMA. The Journal of the Pakistan Medical Association, 2020(70), 2017-2022.
[16] D. Kumar, R. Rajprasath, Drawing skills in anatomy education and the millennial learner: A cognitive and metacognitive viewpoint. Research and Development in Medical Education, 2019(8), 58-60.
[17] Ji Piyou, Liang Shaohua, Zhao Dongmei, Yu Zhenhai, Wang Zhiqiang. The Significance and Challenges of Drawing in Anatomy Teaching and Learning. Heilongjiang Science and Technology Information, 2015, 82-82.
[18] S. B. Yu et al., The role of anatomical drawing competition in cultivating the comprehensive quality of medical students. Acta Anatomica Sinica, 2019(50), 847-849.
[19] H. Y. Jing, Y. Lu, B. W. Jing, W. J. Zhang, Progress in the application of medical illustrations and their new visualization modes in anatomical teaching and clinical practice. Chinese Journal of Anatomy and Clinics, 2020(25), 4.
[20] H. Wang, The role of drawing training in stimulating learning interest in biology courses. China Training, 2016, 204.
[21] R. Cao, L. Li, Review and prospect: Research on the development of domestic sports drawing. Journal of Xichang University (Natural Science Edition), 2016(30), 116-118+133.
[22] J. J. Lu, P. F. Zhang, Discussion on the role and learning methods of sports drawing. Bulletin of Sports Science and Technology, 2018(26), 68-93.
[23] S. L. Ji, et al., Design and practice of offering scientific paper drawing courses in colleges and universities. Research and Practice on Innovation and Entrepreneurship, 2022(5), 17-20.
[24] Y. W. Hao, S. L. Ji, H. L. Chen, C. Q. Jing, Z. J. Yang, Exploration and practice of developing medical characteristic aesthetic education courses—Taking "Scientific Paper Drawing Course" as an example. China Medical Education Technology, 2023(37).
[25] S. L. Ji, Y. W. Hao, G. Y. Wan, L. Zhao, Design and practice of high-quality online courses on drawing for postgraduates—Taking the biological technology drawing course as an example. Research and Practice on Innovation and Entrepreneurship, 2024(7), 58-61.
[26] W. Tang, F. Wang, Practice and experience of the course on anatomical structures and surgical illustrations. Anatomical Research, 2024(46), 94-98.
[27] A. Styn et al., Effects of tablet-based drawing and paper-based methods on medical students' learning of gross anatomy. Anatomical sciences education, 2023(16), 266-279.
[28] J. Wu, A brief discussion on the application of electronic drawing in biology teaching. Middle School Biology Teaching, 2024, 53-55.
[29] J. Sweller, P. Ayres, S. Kalyuga, in Explorations in the Learning Sciences, Instructional Systems and Performance Technologies. Cognitive Load Theory. (Springer New York, NY, USA, 2011).
[30] F.X. Wang, Y. Huang, X.X. Leng, Z.Y. Kuang, Self-generated instruction promotes multimedia learning: The role of drawing. Journal of Soochow University (Educational Science Edition), 2023(11).