# Effect of Design Thinking on Students' Creativity: A meta-analysis

Fuminqiang Guo [1], Junhao Shan [2*],
[1,2] College of Education Science and Technology
Nanjing University of Posts and Telecommunications Nanjing, China
[*] jhshan@njupt.edu.cn

***Abstract:*** *Design thinking is a prevalent pedagogical approach in teaching and learning, aimed at cultivating students' creativity. While a substantial corpus of empirical studies has explored the efficacy of design thinking pedagogy in this regard, a systematic approach to analyzing these studies remains underdeveloped. In order to provide a uniform assessment of the utility of design thinking pedagogy and to explore the effects of moderating variables, this study used a meta-analytic approach to analyze 24 empirical studies. The results showed that design thinking exhibited a moderate effect on the enhancement of students' creative ($g = 0.726$, $p = 0.000$). The moderating effects of educational level, learning environment, and design thinking methods on teaching effectiveness were also analyzed. The exploration of future research directions was also conducted on the basis of this study.*

**Keywords:** design thinking, meta-analysis, creativity

## 1. Introduction

The demand for creative talents is increasing, and greater emphasis is being placed on the cultivation of such talents (Zhang et al., 2024), which must be grounded in specific teaching methodologies or strategies to facilitate a conducive learning environment for students, one that fosters the generation of ideas and the design of products. A plethora of pedagogical approaches for cultivating students' creativity have been documented on an international scale, while the most extensively researched approach is the design thinking pedagogy. Design thinking instruction is defined as an innovative pedagogy that integrates diverse thinking methods through a standardized teaching process in order to systematically cultivate student creativity (Chin et al., 2019; Graves & Fuchs, 2022). Numerous empirical studies have been conducted to ascertain the efficacy of design thinking pedagogy in fostering students' creativity. However, the findings from these studies have been inconsistent. Can design thinking promote students' creativity? This question requires urgent attention.

## 2. Literature Review

Design thinking is a teaching methodology aimed at improving students' creativity. The Hasso Plattner Institute of Design at Stanford University (2023) proposed the EDIPT design thinking teaching model, which has been adopted by many research institutions and primary and secondary schools to standardize the teaching process and cultivate creative talents. Internationally, many studies have focused on the effectiveness of the design thinking instruction in cultivating students' creativity, but the conclusions are not the same. For example, in K-12 schools, Tan (2024) used the design thinking pedagogy in a maker curriculum, and through quasi-experimental research, concluded that the design thinking instruction can effectively enhance the creativity of primary and secondary school student; In higher education, Kuo (2021) hold an empirical study which indicated that design thinking is effective in improving student creativity. However, some studies have also given the opposite answer, for example, Kijima (2021) implemented design thinking instruction at K-12 level and found that the promotion of student motivation on creativity was weak; And according to Liu (2024), at higher education level, the enhancement of student creativity through design thinking instruction was proven to be minimal.

The above studies show that academic research on design thinking instruction to promote student creativity has mostly used quasi-experimental research methods, and it is difficult to give an accurate answer about the effectiveness of the application of design thinking instruction from these isolated findings. Therefore, this study adopted a meta-analytic approach to synthesize and evaluate the results of previous research on design thinking in education, aiming to gain a more systematic understanding of the actual impact of design thinking instruction on student creativity. In addition, the study explored the role of various moderating variables, which include educational level, learning environment, and design thinking method (Bai et al., 2020).

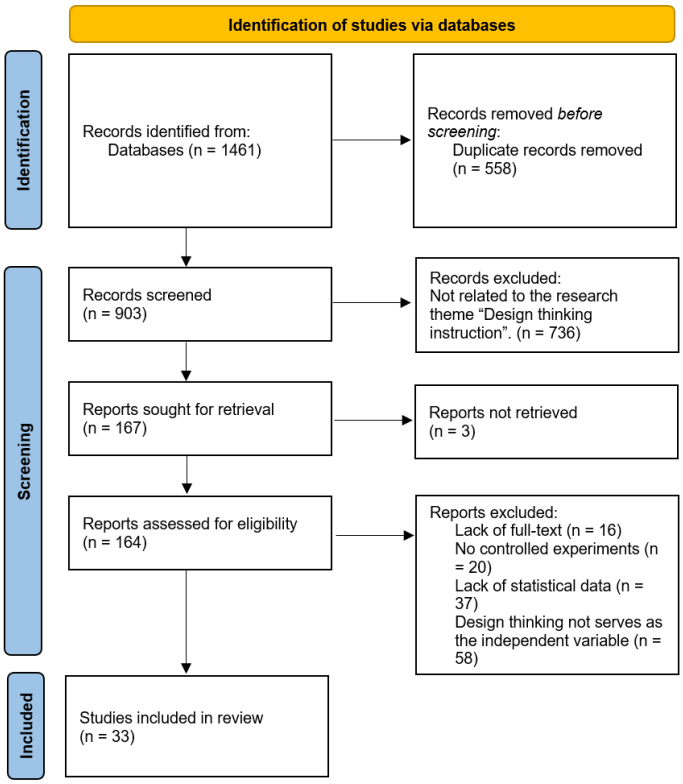
## 3. Research Methods

### *3.1. Literature Search*

To ensure the acquisition of comprehensive and sufficient literature, based on The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Page et al., 2021), we conducted an extensive search of internationally renowned academic databases, including CNKI, Web of Science, Taylor & Francis, Wiley, Springer, Elsevier and ProQuest. The search employed the keywords "design thinking" or "design thinking instruction". The literatures published between 2015 and 2025 were selected and limited to the field of education. A flowchart for literature searching was constructed, as illustrated in Figure 1.

**Figure 1**

*PRISMA flow chart*




### *3.2. Study Selection*

To ensure that the final screened literature is sufficient in terms of data to support meta-analysis and is in line with the purpose of this study, we have established the criteria for literature screening. Specifically as follows:

- It is necessary to study the influence of design thinking on the improvement of students' creativity.
- It must be an empirical study employing a randomized controlled trial or quasi-experimental design.
- This study should include the following data: mean, standard deviation, sample size, t-value, p-value, etc., to meet the data requirements of meta-analysis.

A total of 1032 literatures were obtained from the initial search. Then based on the above criteria for screening, a total of 24 literatures were finally suitable for inclusion in the meta-analysis.

### *3.3. Literature Code*

The literature is encoded according to the following parameters:

- Author.
- Publication year.
- Educational level: university and K-12.
- Learning environment: traditional classrooms, outdoor settings, and maker spaces.
- Design thinking methods: The coding focuses on whether methods are used in each study.

Coding accuracy assessment: The Cohen Kappa consistency coefficient is required to be greater than 0.7 (Cohen, 1969). The inter-rater reliability in this study was 0.95, indicating a strong consistency among the researchers.

## 4. Results

### *4.1. Heterogeneity Analysis*

Heterogeneity analysis was conducted with Cochran's Q and I2 statistics (Hedges & Olkin, 1985; Higgins & Thompson, 2002;), and then we determined the type of model utilized for the meta-analysis. As shown in Table 1, the Q value of this meta-analysis is 125.598, the P-value is 0.000, and the I2 is 72.133, which exceeded 50% (Higgins, 2011). Therefore, a random effects model was employed in this study to calculate the effect size.

### *4.2. Calculation and Combination of Effect Sizes*

#### *4.2.1. Overall effectiveness*

As shown in Table 1, statistical data such as mean, standard deviation, sample size, t-value and p-value were collected from 24 empirical studies. The standardized mean difference (SMD) formula was used to calculate the effect size, with Hedges' g serves as an indicator of the effect size.

A random-effects model for effect sizes was applied, yielding a Hedges' g of 0.726. According to the thresholds proposed by Cohen (1988) to standardize effect sizes, 0.2-0.49 is considered a small effect, 0.5-0.79 a medium effect, and 0.8 and above a large effect. Therefore, the effect sizes derived from this meta-analysis were categorized as medium. Overall, design thinking instruction has a moderate positive impact on student creativity.

**Table 1.**

*Overall effectiveness.*

| | | Effect size and 95% confidence interval | | | | Test of null (2-Tail) | | Heterogeneity | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Model | N | Hedges's g | Standard error | Lower limit | Upper limit | Z-value | P-value | Q | P | I-squared |
| Random | 24 | 0.726 | 0.066 | 0.596 | 0.856 | 10.948 | 0.000 | 125.598 | 0.000 | 72.133 |

#### *4.2.2. Moderator analysis*

- Educational level:

As illustrated in Table 2, the differences in effect sizes for the two educational levels—university (g=773, N=13, p=0.000), and K-12 (g=0.708, N=23, p=0.000)—are not statistically significant (Q=0.190, P=0.663).

- Learning environment:

There was a significant difference in the effect of learning environment on the effectiveness of design thinking instruction (Q=16.865, P=0.000). Makerspaces (g=0.797, N=21, p=0.000) were the most effective, followed by traditional classrooms (g=0.759, N=11, p=0.000) and outdoor settings (g=0.376, N=4, p=0.000).

- Design thinking methods:

The effectiveness of design thinking instruction was influenced by the methods used, with instruction applying design thinking methods being more effective (g=0.815, N=28, p=0.000) than those lacking any design thinking method (g=0.402, N=8, p=0.000). And a statistically significant difference was found (Q=13.602 P=0.000).

**Table 2.**

*Moderator analysis.*

| Moderator factors | Group | N | Hedges ' g | Standard error | Lower limit | Upper limit | Z-value | P-value | Q-value | P-value |
|---|---|---|---|---|---|---|---|---|---|---|
| Educational level | K-12 | 23 | 0.708 | 0.076 | 0.559 | 0.857 | 9.305 | 0.000 | | |
| | university | 13 | 0.773 | 0.130 | 0.017 | 0.518 | 1.028 | 0.000 | | |
| | Total between | | | | | | | | 0.190 | 0.663 |
| | Overall | 36 | 0.724 | 0.066 | 0.596 | 0.853 | 11.033 | 0.000 | | |
| Learning environment | makerspaces | 21 | 0.797 | 0.087 | 0.627 | 0.968 | 9.185 | 0.000 | | |
| | outdoor settings | 4 | 0.376 | 0.069 | 0.240 | 0.511 | 5.439 | 0.000 | | |
| | traditional classrooms | 11 | 0.759 | 0.131 | 0.503 | 1.016 | 5.796 | 0.000 | | |
| | Total between | | | | | | | | 16.865 | 0.000 |
| | Overall | 36 | 0.571 | 0.050 | 0.473 | 0.669 | 11.432 | 0.000 | | |
| Design thinking methods | Not using | 8 | 0.402 | 0.086 | 0.235 | 0.570 | 4.701 | 0.000 | | |
| | Using | 28 | 0.815 | 0.072 | 0.674 | 0.957 | 11.299 | 0.000 | | |
| | Total between | | | | | | | | 13.602 | 0.000 |
| | Overall | 36 | 0.644 | 0.055 | 0.536 | 0.752 | 11.669 | 0.000 | | |

### *4.3. Sensitivity Analysis*

To ensure the robustness of the meta-analysis results, a sensitivity analysis was conducted in this study. By excluding each study one by one, it was found that the effect size always remained within the 95% confidence interval (95% CI=[0.596, 0.856]) and was statistically significant.

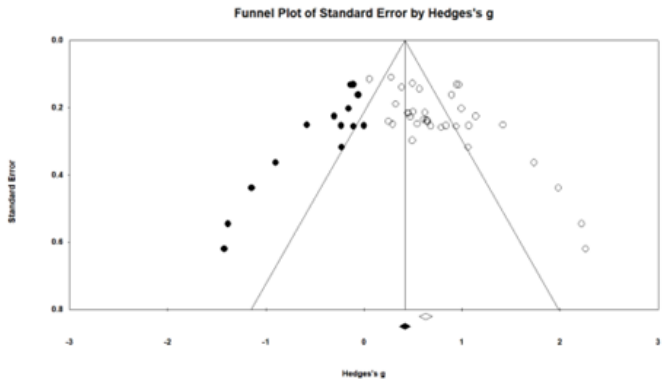
### *4.4. Publication Bias*

Publication bias is the phenomenon whereby statistically significant studies are more likely to be published than non-significant ones (Borenstein et al., 2009), which can significantly influence the results of a meta-analysis.

As illustrated in Figure 2, t the distribution of the white filled sample points on both sides of the central axis shows asymmetry, indicating a significant deviation. In order to assess publication bias more precisely, we performed Egger's test (Card, 2011). The results revealed the presence of publication bias, with the following statistics: INTERCEPT = 2.990, 95% CI = [1.458,4.521], t = 3.967, p =0.000. The effect size was subsequently adjusted using the trim-and-fill method (Jeong et al., 2019; Duval & Tweedie, 2000) as shown in Figure 2, where black dots indicate the addition of potentially missing studies. The adjusted effect size was g = 0.445, Q = 309.893, 95% CI = [0.298,0.592], suggesting that after adjusting for publication bias, the intervention still has a moderate positive effect; although the original results were overestimated, the core conclusions remain robust.

**Figure 2**

*Funnel Plot (corrected by the trim-and-fill method)*




## 5. Discussion and Conclusion

### *5.1. Major Findings*

#### *5.1.1. Overall effect*

Overall, the design thinking teaching method can help enhance students' creativity and holds certain instructional value for the development of their creative thinking. The design thinking teaching method generates certain educational value in both basic education and higher education. The effective implementation of design thinking teaching relies on standardized teaching procedures and clear, practical cognitive scaffolds.

#### *5.1.2. Analysis of moderating variables*

- Educational level:

University students have demonstrated greater gains than their K-12 counterparts with design thinking. The reason may be due to the fact that university students have a higher level of knowledge, expertise, and creative experience. On the other hand, university equipment and instruction materials are generally more advanced than those available in K-12 schools, and are more capable of assisting students in their creative activities and enhancing their creativity.

- Learning environment:

The efficacy of design thinking instruction is contingent upon the learning environment, with makerspaces yielding the most significant outcomes, followed by traditional classrooms and outdoor settings. The makerspaces provide tools and equipment that can facilitate creative practices, which may lead to a stronger enhancement of the effectiveness of design thinking instruction in makerspaces. Less effective in outdoor settings, possibly due to the lack of systematic norms for teaching in such environments and the low motivation of students to learn.

- Design thinking methods:

The employment of design thinking methods also significantly influences student learning outcomes. An instruction approach that incorporates design thinking methods has proven to be more effective. The reason is that the scaffolds of design thinking provide students with a framework for innovative problem-solving, help standardize the creative process, train logical thinking, and enhance divergent thinking.

### *5.2. Major Contributions*

The conclusions of this study emphasize the beneficial effects of design thinking instruction on student creativity, and suggest that design thinking constitutes a significant instruction method for fostering core competencies among learners. In addition, this study outlines the impact of moderating variables on instructional effectiveness. Therefore, educators are encouraged to select design thinking approaches wisely and be mindful of moderating factors in order to improve student learning outcomes.

### *5.3. Limitations*

Despite the reliability of the study's conclusions, certain limitations remain. Notably, publication bias may have distorted the results of the meta-analysis. In addition, due to missing data in several empirical studies, they were excluded from the meta-analysis.

### *5.4. Suggestions*

#### *5.4.1. Suggestions for future studies*

Although this study affirmed the positive impact of design thinking instruction, it is important to be aware of the possible negative aspects. Therefore, future research efforts should accumulate a more comprehensive sample size, which would facilitate the reliability of subsequent meta-analyses and allow for a more comprehensive analysis of moderator variables.

#### *5.4.2. Suggestions for instructional designers and teachers*

Design thinking instruction needs to focus on the application of advanced technology and thinking scaffolds, empowering the upgrading of the teaching environment through digital intelligence technology. For example, generative artificial intelligence can be utilized to build intelligent agent to assist students in their personal creative activities.

Furthermore, design thinking methods should be appropriately embedded in instruction strategies, such as the use of brainstorming and six-hat thinking method to facilitate students' teamwork, creative thinking dispersion, and holistic thinking about the problem so as to improve their creativity and the outcome of work.

## Acknowledgements

This paper is a research outcome of the 2024 Jiangsu Provincial Social Science Fund Youth Annual Project titled "Research on the Model Construction of Enhancing Teachers' Interdisciplinary Teaching Ability Empowered by Generative Artificial Intelligence" (Project No.: 24JYC005).

## References

Bai, S., Hew, K. F., & Huang, B. (2020). Does gamification improve student learning outcome? Evidence from a meta-analysis and synthesis of qualitative data in educational contexts. Educational Research Review, 30, Article 100322.

Borenstein, M., Hedges, L. V., Higgins, J. P., & Rothstein, H. R. (2009). Introduction to meta-analysis. John Wiley & Sons.

Card, N. A. (2011). Applied meta-analysis for social science research. Guilford Publications.

Chin, D. B., Blair, K. P., Wolf, R. C., Conlin, L. D., Cutumisu, M., Pfaffman, J., & Schwartz, D. L. (2019). Educating and measuring choice: A test of the transfer of design thinking in problem solving and learning. Journal of the Learning Sciences, 28(3), 337–380.

Cohen, J. (1969). Statistical power analysis for the behavioral sciences. Routledge.

Cohen, J. (1988). Statistical Power Analysis for the Behavioral Sciences (2nd ed.). Routledge.

Duval, S., & Tweedie, R. (2000). Trim and fill: A simple funnel-plot-based method of testing and adjusting for publication bias in meta-analysis. Biometrics, 56(2), 455–463

Graves, M., & Fuchs, J. (2022). Teaching the design thinking mindset: A practitioner's perspective. In I. Schmidberger, S. Wippermann, T. Stricker & U. Müller (Eds.), Design Thinking im Bildungsmanagement: Innovationen in Bildungskontexten erfolgreich entwickeln und umsetzen (pp. 69–78). Springer Fachmedien Wiesbaden.

Hasso Plattner Institute of Design at Stanford University. (2023). Get started with design thinking. https://dschool.stanford.edu/resources/getting-started-with-designthinking.

Hedges, L. V., & Olkin, I. (1985). Statistical methods for meta-analysis. Academic Press.

Higgins, J. P., Altman, D. G., Gøtzsche, P. C., Jüni, P., & Moher, D. et al. (2011). The Cochrane Collaboration's tool for assessing risk of bias in randomised trials. BMJ, 343, Article d5928.

Higgins, J. P., & Thompson, S. G. (2002). Quantifying heterogeneity in a meta-analysis. Statistics in Medicine, 21(11), 1539–1558.

Jeong, H., Hmelo-Silver, C. E., & Jo, K. (2019). Ten years of computer-supported collaborative learning: A meta-analysis of CSCL in STEM education during 2005-2014. Educational Research Review, 28, Article 100284.

Kijima, R., Yang-Yoshihara, M., & Maekawa, M. S. (2021). Using design thinking to cultivate the next generation of female STEAM thinkers. International Journal of Stem Education, 8, 1–15.

Kuo, H. C., Yang, Y. T. C., Chen, J. S., Hou, T. W., & Ho, M. T. (2021). The impact of design thinking PBL robot course on college students' learning motivation and creative thinking. IEEE Transactions on Education, 65(2), 124–131.

Liu H. Y. (2024). Effects of the design thinking pedagogy on design thinking competence of nursing students in Taiwan: A prospective non-randomized study. Nurse education today, 138, 106197.

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., & Hoffmann, T. C. et al. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ, 372, Article 71.

Tan, J., Kinshuk & Wu, L. The effectiveness of design thinking on K-12 school students' creativity in a maker curriculum. Education Tech Research Dev 72, 1091–1110 (2024).

Zhang, Y., Wang, Y., & Su, Y. (2024). From no distinction to direction: The impact of motivation on creativity—The contribution of environmental resources and grit. Thinking Skills and Creativity, 53, Article 101609.