



Research Article

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Developing a Graphic Design Thinking Model to Enhance the Creative Thinking

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Abstract

In this paper, based on Bloom's Taxonomy and Double Diamond Model, this study explores to development of the Graphic Design Thinking Model, which involves the knowledge dimension and the cognitive dimension, and it will be used to improve creative thinking for solving problems in relevant design courses. To test this hypothesis, the researcher will measure the effectiveness of this model used in the implementation of design projects and compare the improvement of various indicators of creative thinking. The respondents are 30 students from one university in China majoring in art and design, who were asked to take a pre-test, and a post-test according to the GDT Model in the graphic design course. The researcher has referred to the Torrance Tests of Creative Thinking (TTCT) and used a Likert scale to determine the pre-test and post-test scores in the design projects. The results analyzed by SPSS show that the GDT Model can help students to realize the creation of graphics, significantly improving their creative thinking.

Keywords: Creative Thinking, Graphic Design Thinking Model, Double Diamond Model, Bloom's Taxonomy

1. Introduction

With the continuous development and innovation of talent training mode, Bloom's Taxonomy system of educational objectives is playing an increasingly important role in talent training and

evaluation in China.

Graphic design refers to a form characterized by visual creativity and is widely used in visual design and communication, and students will create visual graphics that can be conveyed (Wei, 2018). Graphics design course cultivates students' creativity and creative thinking through the application of association and imagination (Balliu, 2017; Serin, 2017; Usarov, 2019). When the researcher applies Bloom's Taxonomy to this course, it is not only an attempt and innovation to rebuild teaching objectives but also an innovative application to supplement teaching knowledge and teaching methods.

Guilford (1950) has long discussed creativity as embodied in originality, design, and compositional approaches, as the ability to generate multiple ideas as divergent thinking, and introduced a model for measuring divergent thinking in education, namely fluency, flexibility, and originality. Creative thinking was the cognitive ability of divergent thinking with fluency, flexibility and originality (McAuliffe, 2016); while Guilford (1950) recognized the importance of convergent thinking, creativity has since been frequently equated with divergent thinking. In addition, divergent and convergent thinking are often considered to be in conflict or competition (Getzels & Jackson, 1962). Guilford (1959) emphasized the aspect of divergent thinking, and Cropley (1999) suggested that divergent thinking is variable. However, Cropley (2006) focused on the contribution of convergent thinking to creative design, which differs from divergent thinking in generating multiple problems or ideas that undergo unexpected combinations to produce the single best solution that can be translated into a new form.

The cultivation and promotion of Creative Thinking need to be trained in practice. The graphic design of this study is closely related to creative thinking. Graphic design requires students to learn and develop creative thinking abilities with specific design theme activities, such as divergent thinking ability, convergent thinking ability and image thinking (Carroll, 2015; Retna, 2016; Woo et al., 2017; Zupan et al., 2018). Recent research focuses on creativity and creative thinking through some training and shows how they can enhance creative thinking. However, there are few studies on how design courses can improve creative thinking, and some universities focus on cultivating skills rather than fostering students' creative thinking in the teaching process (Wu, 2014).

Therefore, the researcher will build a Graphic Design Thinking Model based on existing theories and discuss its effectiveness in creative thinking to improve the creative thinking of higher education students.

2. Literature Review

Design thinking is the higher-order thinking behind inquiry-based design, a process of continuous thinking and innovative behaviour for creatively solving design challenges (Goldman et al., 2014). It is based on creative thinking and the use of cognitive tools and has become both one of the preferred methods for solving wicked, well-defined problems in design development and an effective way to foster creativity (Dewett, 2007; Brown, 2008; Martin, 2009; Liedtka, 2013). Furthermore, design thinking is geared towards problem identification and solution and focuses on identifying problems before solving them (Beckman, 2020; Liedtka, 2015).

The design thinking model has become a practical toolkit to realize the innovative design process. It integrates various design tools and methods into the design process and provides a structured framework for designing different stages (Retna, 2016; Woo et al., 2017; Zupan et al., 2018).

2.1 Design Thinking approach

Based on the Design Thinking approach, the design team created a series of possible solutions through divergent thinking. After this process, the team will choose the most appropriate idea. In the later stage of thinking activities, more convergent thinking is used through small-scale experiments to understand the most suitable design. Then it will be followed by the prototype development stage.

Finally, the prototype is tested to ensure the idea and scheme are good.

Sanders and Goh (2020) have analyzed several famous Design Thinking Models, which include the Stanford Design Thinking Model (Stanford d. school, 2010), the IDEO Design Thinking Model (Brown, 2011) and the Design Thinking model of the Hasso-Plattner Institute (Plattner et al., 2009). The Stanford Design Thinking Model consists of "Empathize, Define, Ideate, Prototype and Test" (Plattner, 2010), and the IDEO Design Thinking Model are involved in "Discover, Explain, Envision, Experiment and Improve" (Brown, 2011), and Design Thinking Model of the Hasso-Plattner Institute is used to teach design thinking as a learning project, it involves five stages: understand, observe, define, ideate, prototype, and test (Plattner et al., 2009). Moreover, Design thinking applied to design education can also be concluded into five segments: Empathize, Define, Ideate, Prototype and Test (Doorley et al., 2012)

2.2 The Double Diamond Model

The design thinking model provides cognitive and methodological approaches for defining and solving problems, which requires a divergent and broadening thinking process, followed by a convergence phase of many ideas. The selection of the most creative idea is to be put into practice in the form of visualization (Martin, 2009), where the visualization is presented as sketches, graphics, product diagrams, objects, etc. It also emphasizes the continuous understanding and repeated application of knowledge, and the design process requires repeated iterations, which will facilitate the training and development of learners' problem-solving and creative thinking.

The Double Diamond Model is a crucial design thinking method developed by the British Design Council (2005; 2007). This model can describe the different tools and thinking perspectives used in the design, identify problems, and develop solutions (see Figure 1).

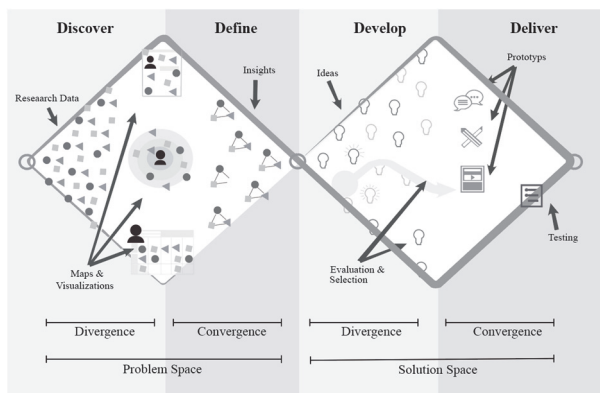


Figure 1: The Double Diamond model (British Design Council, 2005; 2007)

The Double Diamond Model is represented by the shape of a diamond. It includes four stages: discovery, definition, development and delivery. In order to find the best idea, the iterative process in which the idea is developed, tested and improved can be attributed to the combination of divergent thinking and convergent thinking, which is suitable for the creative design process (British Design Council, 2021).

Based on the above Design Thinking Models, the researcher will apply the four stages of the Double Diamond Model and attribute it to Graphic Design Thinking from divergent thinking to convergent thinking, and then from divergent thinking to convergent thinking, which conforms to the process of creative design.

2.3 Bloom's Taxonomy

Bloom's Taxonomy has been applied to teaching in different colleges, which can not only improve students' understanding and training of learning skills but also improve their creative thinking (Retna, 2016; Woo et al., 2017; Zupan et al., 2018; Nentl & Zietlow, 2008).

Anderson and Krathwohl (2001) revisited the cognitive domains. The most significant change is that the revised classification of cognitive goals breaks the original one-dimensional classification system and puts forward a two-dimensional framework of knowledge and cognitive process oriented to teaching goals (Spence, 2019).

Knowledge refers to the relevant contents involved in the learning process, including four categories from concrete to abstract: factual, conceptual, procedural and Metacognitive. Factual is the basic element that learners must be familiar with in order to understand the topic or solve problems; Conceptual focuses on the relationship between the basic elements based on the concept and can make these elements work together; Procedural refers to the method of doing things or the activity process of how to operate, including the standard of using some skills, algorithms and technical means; Metacognitive includes general cognitive knowledge and self-cognitive knowledge (Anderson et al., 2001; Kiesler, 2020). Knowledge classification provides a target classification system for teachers of different disciplines so that teachers can accurately grasp classroom teaching objectives, pay close attention to teaching objectives, and carry out teaching activities and learning process evaluations (Parsaei et al., 2017; Armstrong, 2016).

The cognitive process includes the academic achievement to be mastered in the learning process. It includes six categories: remember, understand, apply, analyze, evaluate and create (Bogdanova & Snoeck, 2017; Crompton et al., 2018). The cognitive category has been used by most traditional education to construct the learning objectives, teaching activities and evaluation of curriculum (Anderson et al., 2000). Six cognitive processes, from a low level to a high level, are combined with four knowledge levels, from concrete to abstract, to form a matrix as an excellent auxiliary tool for creating teaching objectives (Kiesler, 2020; Anderson et al., 2000).

In this study, the researcher will respectively use the knowledge and cognitive part of Bloom's Taxonomy to construct the knowledge system and cognitive process of graphic design, including the knowledge of graphic design involved in the four aspects of Factual, Conceptual, Procedural and Metacognitive. The cognitive process of graphic design also conforms to the six levels of Bloom's Taxonomy from low to high and ultimately achieves the creation of graphics.

Therefore, Bloom's Taxonomy is applied to the model construction of the graphic design, while the Design Thinking model, especially the Double Diamond model, is used in the implementation stage of graphic design. Students will design the divergent graphics through divergent thinking to convergent thinking, and then conduct the next round of divergent thinking to convergent thinking based on these graphics, and finally, design more creative graphics.

3. Methodology

This study developed the Graphic Design Thinking (GDT) Model based on Bloom's taxonomy. The knowledge dimension and cognitive dimension of Bloom's Taxonomy were taken as the theoretical basis for the GDT Model.

3.1 Knowledge dimension of Bloom's taxonomy

Students will acquire the graphic design knowledge system based on the knowledge dimension of Bloom's Taxonomy (see Table 1).

Table 1: Graphic design follows the knowledge dimension of Bloom's taxonomy

Level	Knowledge system of Graphic design
Factual	Overview of graphic design; The development of graphic language; Principles of graphic design; Significance of graphic design
Conceptual	The concept of graphic design and creative thinking; Thinking mode of graphic design (divergent thinking, convergent thinking, etc.); Technique and expression of graphic design
Procedural	Project theme analysis→ Design research→ Divergent thinking→ Mind map→ Design conception→ Scheme design of divergent graphics→ Scheme evaluation and selection→ Creation of convergent graphics→ Various innovative combinations→ Reporting design works
Metacognitive	Divergent thinking; Convergent thinking

Factual requires students to understand the overview of graphic design, including the development of graphic language and the principles of graphic design. Creative thinking in design is usually transformed into the graphic language to convey content (Wei, 2018).

Conceptual focuses on the related concepts of Graphic Design, Creative Thinking, and creative graphics techniques (Li & Hu, 2013). Divergent thinking is the essential thinking of graphic design. Zhao et al. (2018) and Geng (2016) believe that divergent thinking refers to the thinking method that takes a specific problem or goal as the centre, spreads outward in different directions and angles, puts forward various ideas to solve problems from many aspects through thinking forms such as association, imagination, inspiration and intuition, and explores various or even strange ideas. The process is characterized by a broad vision of thinking and a multidimensional divergence of thinking. However, convergent thinking is just the opposite of divergent thinking. It is a thinking process that integrates many graphics, analyzes and integrates them, focuses different graphics and Thinking on the same central point, and finally extracts the design scheme that best expresses the theme from a large number of possibilities (Zhao et al., 2018; Geng, 2016).

Students will follow the procedure to implement Graphic Design Projects. The theme of the Graphic Design Project is the redesign of national elements. The first step is to think about the design theme and carry out a sufficient investigation. The second is the design of creative positioning and divergent graphics. Students should use various creative thinking methods related to creating a number of divergent graphics from different angles and different expression methods. The third step is the generation of convergent graphics. Based on the second step, further vertical divergent thinking or multi-directional thinking is carried out, and then these graphics are compared and analyzed. It is an innovative integration, purposeful selection and reorganization of existing graphics so as to achieve the final design.

For Metacognitive, students should recognize that Fluency, Originality, Elaboration, and Flexibility are the goal of convergent graphic design (Wei, 2018).

3.2 The cognitive dimension of Bloom's taxonomy

The GDT Model will follow the cognitive dimension, and students gradually obtain all cognition of graphic design through the six levels. The first three levels belong to low-level design thinking. The design process from divergent thinking to convergent thinking is adopted to form the design results of divergent graphics. On this basis, the latter three levels continue to adopt the thinking method from divergence to convergence and finally form the design of convergent graphics, which is the process of advanced creative thinking (Narayanan et al., 2015) (see Table 2).

Table 2: Graphic design follows the Cognitive dimension of Bloom's taxonomy (Anderson & Krathwohl, 2001)

Level	Cognitive level of Graphic design
Remembering	Recall knowledge; Case collection
Understanding	Theme analysis; Design research; Brainstorming; Association; Imagination; Divergent thinking
Applying	Convergent thinking; Freehand sketch; Scheme design of divergent graphics.
Analyzing	Scheme analysis of divergent graphics; Scheme selection of divergent graphics; Determine the evaluation criteria
Evaluating	The Torrance Test of Creative Thinking (TTCT) was used to evaluate the alternatives.
Creating	Fluency; Flexibility; Originality; Elaborate design

The graphic design pays attention to the use of creative thinking. The creative thinking of graphics should focus on the independence and innovation of thinking. Students should be good at connecting two seemingly unrelated things and creating new graphics (Wei, 2018).

3.3 Research Design

Graphic design needs not only divergent thinking to create more divergent graphics but also needs convergent thinking to make reasonable choices. The purpose of the graphic design project is to stimulate and train students' creative thinking. Only the combination of the two can train an excellent graphic creative thinking mode (Zhang, 2019) (see Figure 2).

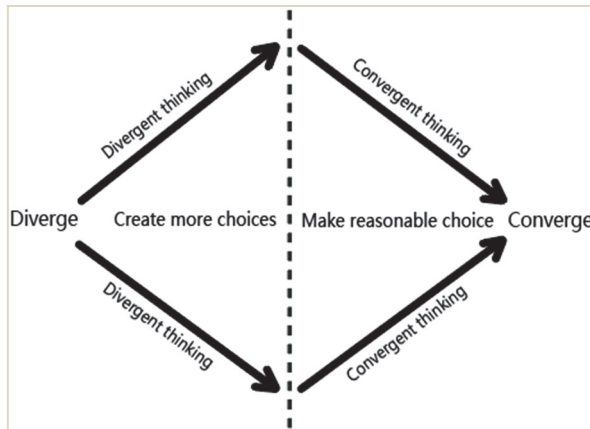


Figure 2: Process of creative thinking (Zhang, 2019)

The researcher develops the Graphic Design Thinking Model based on Bloom's taxonomy and the Double Diamond model (see Figure 3), and students will implement graphic design projects based on this model.

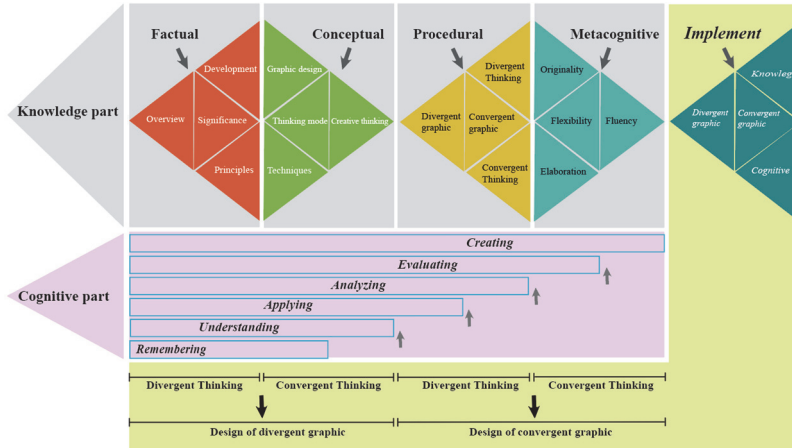


Figure 3: The GDT Model based on Bloom's Taxonomy

In Graphic Design Projects, the knowledge dimension is horizontal, and the cognitive dimension is vertical cognition from a low to a high level. Students create new graphics through continuous divergent thinking and convergent thinking.

In the first three levels of cognitive dimension in the graphic design project, students should associate related things or elements around the project theme, which can be the association of similar form or similar meaning or the association of similar form and meaning at the same time. Then, two or more associative graphics are reorganized into new graphics through convergence, which is a transformation process from divergent thinking to convergent thinking. By analogy, multiple divergent graphics conveying the connotation and meaning of the same theme are produced.

For the latter three levels of cognitive dimension, students must carry out secondary creation based on existing divergent graphics. The reconstructed works can not only remind people of the original works but also have new meanings. This model encourages students to pay attention to the thinking activities of construction and reorganization and consciously aggregate the existing graphics towards the same theme centre by understanding the similarity and correlation between graphics to improve students' creative thinking ability to a new level.

3.4 Participants and Sampling

The researcher taught an 8-week 64 class hour Graphic Design Course, and 30 students from one Chinese university participated in a quasi-experimental study, majoring in visual communication art design.

In the first stage, let students understand the relevant knowledge points of graphic design, and then let students carry out the first Graphic Design Project as the pre-test. In the second stage, the knowledge system and cognitive dimension of GDT Model are described in detail to teach students to deeply understand the model and how to use the model. On this basis, according to the theme, students will use this model to implement the project, and this will be used as a post-test to verify the effectiveness of the model.

3.5 Research Instrument

In this study, the Torrance Test of Creative Thinking (TTCT) was used as an evaluation tool, which is based on Guilford's idea. It is a widely used and studied creativity test, which is mainly developed for


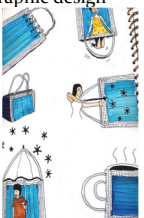

students (Guilford, 1950; Torrance & Goff, 1989). According to Treffinger et al. (2002), there are five indicators to assess creative thinking, including Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking, and the five indicators will be used to evaluate students' design works.

3.6 Pre-test and Post-test

The experiment of the Graphic Design Projects produced data for analysis, including pre-test data without GDT model and post-test data after learning using the GDT model. Table 3 describes the two projects received by one student.

In the pre-test scores, Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking are 2, 3, 2, 3, 3, respectively. In the post-test, Fluency₁, Originality₁, Elaboration₁, Flexibility₁ and Metaphorical thinking₁ are 3, 4, 3, 3, 4, respectively. Obviously, the creativity of the design work of the first project is weak. However, through learning GDT Model, the student has a better understanding of the model, and the design work level has improved.

Table 3: Sample of the Graphic Design Projects

<p>Pre-test / Poster design of Festival theme The creative exploration of graphic design around this theme requires students to choose their familiar festival to create graphics. For example, Halloween, the prominent representatives of Halloween are pumpkins, ghosts, candy and witches.</p>	<p>Description and analysis: The design of divergent graphics through association lacks the concept of isomorphism of convergent thinking, and the project is not implemented according to the complete process of creative thinking. The student associates the hot-air balloon in the air with the pumpkin and combines the images of witches and ghosts. However, it lacks the formal combination of visual symbols and innovative ideas. The festival features and stories are not accurately conveyed, and the graphics are less fun and visual tension.</p>	<p>Sample:</p> 
<p>Post-test / COVID-19 poster design COVID-19 has promoted the awareness of prevention and control among all mankind. This topic requires students to complete a poster based on their own experience and feelings. Combine the elements of graphic design to test the divergent and convergent thinking under the use of GDT Model.</p>	<p>Description and analysis: Creative process: 1) Divergent graphics use masks, viruses, medical staff and related action elements to advocate people all over the world to fight viruses. 2) The convergent graphic selects viruses and medical personnel as creative elements, uses medical personnel wearing protective clothing to ask questions, and advocates that people all over the world work together for world peace and tranquility with clenched fists to overcome difficulties! This work contains different thinking concepts, such as fluency, that is, how many covid-19 related elements are used; Originality, that is, how unique the work is, embodies the isomorphism of various forms.</p>	<p>Sample: Step 1: Divergent graphic design</p>  <p>Step 2: Convergent graphic design</p> 

4. Results of Data Analysis

4.1 Descriptive statistics

The descriptive statistical analysis was performed. The pre-test scores and post-test scores of 30 students are assessed by five indicators: Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking. They are based on the five levels of 0, 1, 2, 3, and 4. Detailed descriptive statistical analysis is shown in Table 4.

Table 4: Summary statistics

	N	Full-distance	Minimal value	Large value	Mean value	Standard deviation	Variance	Skewness	Kurtosis			
	statistic				Standard error			Standard error	Standard error			
Fluency	30	3	1	4	2.43	.141	.774	.599	.477	.427	-.025	.833
Originality	30	2	1	3	2.20	.121	.664	.441	-.242	.427	-.634	.833
Elaboration	30	2	1	3	2.20	.121	.664	.441	-.242	.427	-.634	.833
Flexibility	30	3	0	3	2.00	.144	.788	.621	-.453	.427	-.034	.833
Metaphorical thinking	30	2	1	3	2.03	.131	.718	.516	-.050	.427	-.954	.833
Pre-test score	30	60	20	80	55.00	2.537	13.896	193.103	-.774	.427	.431	.833
Fluency ₁	30	2	2	4	3.17	.108	.592	.351	-.040	.427	-.082	.833
Originality ₁	30	2	2	4	3.30	.098	.535	.286	.174	.427	-.535	.833
Elaboration ₁	30	2	2	4	2.87	.104	.571	.326	-.028	.427	.208	.833
Flexibility ₁	30	3	1	4	2.73	.117	.640	.409	-.556	.427	.864	.833
Metaphoricalthinking ₁	30	3	1	4	2.93	.143	.785	.616	-.338	.427	-.170	.833
Post-test score	30	40	55	95	75.00	2.171	11.890	141.379	-.363	.427	-1.114	.833
N	30											

Firstly, in the pre-test, the maximum value of Fluency was 4, the minimum value was 1, the maximum value of Originality, Elaboration, Flexibility and Metaphorical thinking was 3, the minimum value of Fluency, Originality, Elaboration and Metaphorical thinking was 1, and the minimum value of Flexibility was 0; The mean values of Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking were 2.43, 2.20, 2.20, 2.00 and 2.03 respectively, the standard deviation was 0.774, 0.664, 0.664, 0.788 and 0.718, with the variance of 0.599, 0.441, 0.441, 0.621 and 0.516 respectively.

Secondly, from the data of post-test results, the maximum values of Fluency₁, Originality₁, Elaboration₁, Flexibility₁ and Metaphorical thinking₁ all reached 4, the minimum value of the first three was 2, and the minimum value of the latter two was 1. Their mean values were 3.17, 3.30, 2.87, 2.73 and 2.93, and the standard deviations were 0.592, 0.535, 0.571, 0.640 and 0.785, respectively. The variances were 0.351, 0.286, 0.326, 0.409 and 0.616. It can be seen that for the standard deviation and variance, Fluency₁ < Fluency, Originality₁ < Originality, Elaboration₁ < Elaboration, Flexibility₁ < Flexibility, and Metaphorical thinking₁ > Metaphorical thinking.

According to the output results of descriptive statistics, the absolute values of kurtosis and skewness corresponding to the test items are all less than 10 and 3, respectively. Overall, the data collected in this study can be accepted as the normal distribution.

4.2 T-test analysis of paired samples

Paired samples 1 were set as pre-test scores and post-test scores, Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking with Fluency₁, Originality₁, Elaboration₁, Flexibility₁ and Metaphorical thinking₁ formed paired samples 2, 3, 4, 5 and 6 respectively, and the results of paired samples t-tests for each index included paired samples statistics (see Table 5), correlation coefficients of paired samples (see Table 6), and paired samples test (see Table 7).

Table 5: Paired samples statistics

	Mean value	N	Standard deviation	Mean of Standard error
1 Pre-test score	55.00	30	13.896	2.537
Post-test score	75.00	30	11.890	2.171
2 Fluency	2.43	30	.774	.141
Fluency ₁	3.17	30	.592	.108
3 Originality	2.20	30	.664	.121
Originality ₁	3.30	30	.535	.098
4 Elaboration	2.20	30	.664	.121
Elaboration ₁	2.87	30	.571	.104
5 Flexibility	2.00	30	.788	.144
Flexibility ₁	2.73	30	.640	.117
6 Metaphorical thinking	2.03	30	.718	.131
Metaphorical thinking ₁	2.93	30	.785	.143

Table 6: Correlation coefficient of paired samples

	N	Correlation coefficient	Sig.
1 Pre-test score & post-test score	30	.835	.000
2 Fluency & Fluency ₁	30	.665	.000
3 Originality & Originality ₁	30	.602	.000
4 Elaboration & Elaboration ₁	30	.618	.000
5 Flexibility & Flexibility ₁	30	.821	.000
6 Metaphorical thinking & Metaphorical thinking ₁	30	.677	.000

Table 7: Paired samples test

	Paired Differential					t	df	Sig.
	Mean value	Standard deviation	Standard error of the mean	95% confidence interval of the difference				
				Lower limit	upper limit			
1 Pre-test score - post-test score	-20.000	7.656	1.398	-22.859	-17.141	-14.308	29	.000
2 Fluency - Fluency ₁	-.733	.583	.106	-.951	-.516	-6.886	29	.000
3 Originality - Originality ₁	-1.100	.548	.100	-1.305	-.895	-11.000	29	.000
4 Elaboration - Elaboration ₁	-.667	.547	.100	-.871	-.463	-6.679	29	.000
5 Flexibility - Flexibility ₁	-.733	.450	.082	-.901	-.565	-8.930	29	.000
6 Metaphorical thinking -Metaphorical thinking ₁	-.900	.607	.111	-1.127	-.673	-8.115	29	.000

Original and alternative hypotheses:

H₀: $\beta_1 = \beta_2$ (no significant difference between the scores of the two groups before and after)

H₁: $\beta_1 \neq \beta_2$ (there is a significant difference between the scores of the two groups before and after)

- Paired sample 1 (comparison between pre-test and post-test)

The paired samples statistical scale revealed that the mean of the pre-test scores was 55, with a standard deviation of 13.896 and a standard error of the mean of 2.537. The mean of the post-test scores was 75, with a standard deviation of 11.890 and a standard error of the mean of 2.171. It can be tentatively concluded that the student's creative thinking skills has improved after the training.

From the table of correlation coefficients of paired samples, we can get the sig value (p-value) of 0.000 of the pre-test scores and post-test scores, less than 0.05, and it means that there is a significant difference between the two groups scores.

Moreover, the results of the analysis show that there is an extremely strong correlation between

the scores before and after training, with a correlation coefficient of 0.835, a standard error of the mean of 1.398, and a 95% confidence interval of the difference from lower limit of -22.859 to upper limit of -17.141.

From the output results, it can be seen that the pre-test scores are significantly different from the post-test scores, and the post-test scores are meaningfully higher than the pre-test scores, indicating that the student's creative thinking has significantly improved after the training of using the GDT Model.

- *Paired sample 2 (comparison between Fluency and Fluency₁)*

The results of the study indicate that the mean Fluency score before training was 2.43, with a standard deviation of 0.774 and a standard error of the mean of 0.141. After training, the mean Fluency₁ score was 3.17, with a standard deviation of 0.592 and a standard error of the mean of 0.108. This suggests that the student's performance in the Fluency section has enhanced after training.

From the results of correlation coefficients, we can see the p-value corresponding to Fluency scores before training and Fluency₁ scores after training was 0.000, not more than 0.05, which means that there is a substantial difference between the two groups, rejecting the original hypothesis (H₀).

Furthermore, the correlation coefficient was 0.665, and the correlation coefficient was momentous; that is, there is a strong correlation between Fluency and Fluency₁. The paired samples test results show that the mean difference between the two scores before and after training was -0.733, with a standard deviation of 0.583, a standard error of the mean of 0.106, and a 95% confidence interval of the difference of (-0.951, -0.516). The sig (two-sided) value was 0.000, which is less than 0.05, thus refusing the original hypothesis.

Therefore, the students could associate more images and reflect more widely after using the GDT Model and generated a more important number of creative ideas, representing a higher Fluency of creative thinking.

- *Paired sample 3 (comparison between Originality and Originality₁)*

Table 5 demonstrates that the mean value of the Originality score was 2.20, with a standard deviation of 0.664, a standard error of the mean of 0.121. The mean value of the Originality₁ score was 3.30, with a standard deviation of 0.535, and the standard error of the mean of 0.098.

It can be tentatively determined that the student's performance in the Originality section had improved after the training. From Table 6, it can be seen that a sig value (p-value) corresponding to the Originality score and the Originality₁ score after training was 0.000, which is less than 0.05, and it is considered that there is a significant difference between the two groups scores. The correlation coefficient value was 0.602, which is large; that is, there is a solid correlation between the two.

Then, from Table 7, it can be concluded that the mean value of paired differential Originality-Originality₁ was -1.100, with a standard deviation of 0.548, a standard error of the mean of 0.100, a 95% confidence interval of the difference of (-1.305, -0.895), and a sig (two-sided) value of 0.000, which implies that the original hypothesis is not valid and supports the alternative hypothesis (H₁).

These results indicate that the students were able to come up with unusual and unique creative ideas after the training used the model, the originality of creative thinking was advanced than before, and they were able to exert the power of convergent thinking to enhance the novelty and innovation of their design works in new combinations.

- *Paired sample 4 (comparison between Elaboration and Elaboration₁)*

The mean value of the Elaboration scores was 2.20, with a standard deviation of 0.664, and a standard error of the mean of 0.121; the mean value of Elaboration₁ scores was 2.87, with a standard deviation of 0.571, and the standard error of the mean of 0.104. It can be preliminarily indirect that there are some improvements in the students' Elaboration scores after the specific training.

The sig value (p-value) corresponding to the Elaboration and Elaboration₁ scores was 0.000, which means a momentous difference between the two group scores, overturning the original hypothesis. Moreover, the correlation coefficient is 0.618, which is significant, i.e., there is a strong correlation between the two.

Next, from Table 7, it can be seen that the mean value of Elaboration-Elaboration₁ was -0.667 points, with a standard deviation of 0.547, a standard error of the mean of 0.100, a 95% confidence interval of the difference of (-0.871, -0.463), and the sig (two-sided) value was 0.000, which is less than 0.05. Therefore, the results designate that the students were able to express the creative ideas through their design works after training using the model, and it is inconsistent with original hypothesis.

- *Paired sample 5 (comparison between Flexibility and Flexibility₁)*

The mean value of the Flexibility scores was 2.00, with a standard deviation of 0.788, and a standard error of the mean of 0.144; the mean value of the Flexibility₁ scores was 2.73, with a standard deviation was 0.640, and a standard error of the mean of 0.117.

It can be tentatively concluded that the student's scores in Flexibility improved more after the training. The sig value (p-value) corresponding to Flexibility and Flexibility₁ scores was 0.000, which is less than 0.05, so the original hypothesis is rejected, i.e., which is considered that there is a significant difference between the two group scores.

Moreover, the correlation coefficient was 0.821, which is significant, i.e., there is a strong correlation between the two. The mean value of Flexibility - Flexibility₁ was -0.733, with a standard deviation of 0.450, a standard error of the mean of 0.082, and a 95% confidence interval of the difference of (-0.901, -0.565). The sig (two-sided) value was 0.000, less than 0.05. This explains a substantial difference in Flexibility scores before and after training, and the creative thinking is more flexible and adaptable after training.

- *Paired sample 6 (comparison between Metaphorical thinking and Metaphorical thinking₁)*

The mean value of the Metaphorical thinking scores was 2.03, with a standard deviation of 0.718, and a standard error of the mean of 0.131; the mean value of Metaphorical thinking₁ scores was 2.93, with a standard deviation of 0.785, and the standard error of the mean was 0.143. It can be determined that the student's performance in Metaphorical thinking's performance improved more.

The sig value (p-value) corresponding to the scores of Metaphorical thinking and Metaphorical thinking₁ was 0.000, which is less than 0.05, so the original hypothesis was rejected, which means that there is considered a significant difference between the scores of the two group. Moreover, the correlation coefficient was 0.677, which is significant, i.e., there is a strong correlation between the two.

The mean value of paired differential of Metaphorical thinking-Metaphorical thinking₁ was -0.900, and the standard deviation was 0.607, with a standard error of the mean of 0.111, a 95% confidence interval of the difference of (-1.127, -0.673). The sig (two-sided) value was 0.000, which is less than 0.05, and contrary to the original hypothesis, which indicates that the Metaphorical thinking of students has improved after training.

5. Findings

5.1 The degree of change of each paired sample

From the above data analysis, it can be gotten that each index has significantly improved after using the GDT Model to implement the projects. The degree of improvement of each component was as follows: Originality > Metaphorical thinking > Fluency = Flexibility > Elaboration.

5.2 Correlation of each paired sample

The correlation between the pre-test and post-test scores was the highest, with a correlation coefficient of 0.835. The correlation between the pre-test and post-test scores for the other indicators was in this way: Flexibility (0.821) > Metaphorical thinking (0.677) > Fluency (0.665) > Elaboration (0.618) > Originality (0.602).

These results indicate that students' Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking all improved after the training following the Graphic Design Thinking model, with the greatest improvement in Originality and the least improvement in Elaboration, suggesting that the GDT model was effective in cultivating students' creative ideas, and students' divergent thinking and convergent thinking could be greatly exercised to give good original ideas to their design works, which can enhance their creative thinking and design creativity.

6. Discussion

Teaching strategies can be developed according to students' actual needs, and students can be motivated to learn and improve their creative interests and thinking skills (Radzi & Sulaiman, 2021). There are some problems in the theory and teaching practice of Graphic Design Course, which only emphasize the interpretation and transmission of knowledge, often neglecting the study in the areas of application, analysis, evaluation and creative thinking (Salehudin, 2019). Therefore, this study is precisely for Graphic Design Projects developed using the GDT Model, which not only follows Bloom's taxonomy of educational objectives but also conforms to the laws of creative thinking in the Double Diamond Model and helps students understand the basics of Graphic Design Projects and improve their creative thinking and comprehensive design skills through project training. It is also beneficial for teachers to improve traditional teaching strategies, reconstruct teaching objectives, and stimulate students' learning interests.

Zhao et al. (2018) pointed out that creative thinking is a comprehensive expression of multiple minds, and creative thinking of graphics is characterized by openness, uniqueness, linkage, and effectiveness. This is consistent with the in-depth elaboration and cognition of creative thinking in this study, and the creative thinking process requires students to make connections with external related things from many different perspectives and levels to complete divergent thinking rather than single linear thinking. The GDT Model shows that creative thinking is a process from divergent thinking to convergent thinking and again from divergent thinking to convergent thinking. After using the GDT model to teach, students can break through the inertia of traditional thinking and dare to innovate from new or multiple perspectives, and it is the comprehensive use of multiple thinking that reflects the flexibility and linkage of thinking.

Divergent thinking implies as many creative ideas or solutions as possible and involves fluency in the operation of creative thinking; originality allows for the generation of unique and novel ideas; flexibility refers to the exploration of different concepts and multiple categories of generating ideas; and elaboration emphasizes the ability to be more detailed and responsive (Guilford, 1967; Palmiero et al., 2019, 2020; Torrance, 1987). Accordingly, this study shows the effectiveness of creative thinking using the GDT Model and verifies the improvement of Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking in the implementation of Graphic Design Projects, thus showing the GDT model can enhance creative thinking greatly.

7. Conclusion

The Graphic Design Thinking model constructed in this study enables students to move from the low-level 'remembering, understanding and application' to the high-level 'analysis, evaluation and creation of the graphic design. The GDT model not only maximizes students' divergent and convergent thinking but also improves students' creative thinking and design ability.

The GDT model not only maximizes students' divergent and convergent thinking but also enhances their creativity and design skills and stimulates their interest in learning. Because Bloom's taxonomy provides a systematic method and basis for teachers to set teaching objectives, it enables students to acquire a scientific knowledge system and cognitive level and improves students' ability to think independently, organize, analyze, synthesize and think creatively, which has practical application value for teachers' teaching and students' learning.

In addition, the comparison and analysis of the pre-test results and post-test results showed that students performed well after the implementation of the GDT model, and the creativity level of their design works improved significantly compared with the pre-test, and the five indicators of Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking all had The five indicators of Fluency, Originality, Elaboration, Flexibility and Metaphorical thinking have different degrees of improvement, which is the role and efficacy of creative thinking, which fully proves the effectiveness and feasibility of GDT model for improving students' creative thinking.

In this study, the generation of creative graphics was not solely a function of divergent thinking; the researcher integrated divergent thinking, which implies generating many ideas or solutions, and convergent thinking, which generates a creative idea or a complete design solution. Therefore, the GDT model will reflect a continuous cycle from divergent to convergent thinking, focused together to present the effectiveness of creative thinking.

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