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# Effects of Curriculum Intervention on Divergent Thinking Abilities

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## Abstract

The primary objective of this study is to evaluate the divergent thinking abilities of first-year architecture students who are currently enrolled in a course focused on divergent thinking in architecture. The statistical analysis of student's studio works with Wallach Kogan`s divergent thinking pre/post-tests results demonstrated that the post-test score for verbal stimuli fluency was higher than the visual post-test score. In addition, the post-test score for visual flexibility was higher than the verbal post-test score. In originality students got the highest scores in post-tests both in visual and verbal tasks. Besides, the correlation analysis indicated a strong correlation between fluency and originality. These results revealed that design training considerably enhances students' capacity to produce original ideas both in visual and verbal thinking. In terms of their ability to create considerably more and qualified ideas on related themes students demonstrate more improvement in their verbal reasoning abilities than their visual reasoning skills. The present study determined that curricular intervention in the first semester training where the instructor emphasized development of divergent thinking skills improved students' both visual and verbal divergent thinking skills, to a greater degree in originality and to a lesser degree in fluency and flexibility in idea generation.

## Keywords

divergent thinking, first-year architecture students, design training, Wallach Kogan`s divergent thinking test, Statistical Analysis (SPSS)

## Introduction

In light of the significance of divergent thinking (DT) in design training, there has been a growing emphasis on developing creativity through training in divergent thinking abilities (Coleman et al., 2020; Doron, 2016; Raef et al., 2022; Rao et al., 2021; Sopher, 2020; Sowden et al., 2015; Sun et al., 2020; Tran et al., 2020; Van de Kamp et al., 2015). Divergent thinking is considered essential for creativity, which suggests that design training focusing on alternative thinking may be more effective in fostering divergent thinking (Rao et al., 2021). Sun et al. (2020) suggest that training in creative thinking, particularly divergent thinking, has shown promising results for enhancing creativity in higher education and corporate contexts. Similarly, Raef et al. (2022) asserted that students with divergent thinking were more creative. In addition, Tran et al. (2020) conducted a 14-week undergraduate course on creative approaches and found a substantial improvement in participants' divergent thinking in the post-test. Another study revealed that design thinking training promotes ideational fluency and elaboration (Rao et al., 2021).

Within the realm of architectural education, particularly in the context of design studios, students are consistently tasked with the responsibility of identifying and implementing resolutions to various challenges. The term 'designing' can be understood as the act of

'creating,' therefore emphasizing the importance of fostering creativity on an ongoing basis (Hassan, 2016). The inclusion of architectural design education has the potential to not only foster product innovation, but also to strengthen the process of decision-making. The assertion can be made that the primary goal of architectural design education should be on the resolution of design difficulties. This assertion is based on the understanding that creativity inevitably encompasses the process of problem-solving. The problem-solving process necessitates the utilization of both divergent and convergent thinking processes, which are crucial in producing a novel solution as the result of the design process. Architectural education assumes a significant role in creating curriculum that facilitate the cultivation of divergent thinking skills among students, given the inherent requirement of this discipline to challenge established cognitive frameworks.

Mayahi and Mazhari (2023) argue that creativity holds the highest priority and is an essential component of architectural education. The utilization of divergent thinking (DT) empowers a designer to steer their creative process towards a wide range of distinct and expansive possibilities, so exerting a substantial impact on the uniqueness of their work. The integration of creative education within architectural education, particularly in architectural design courses, is of utmost importance. The authors undertake an examination of creative education and its incorporation into the realm of architectural education, with a specific focus on its integration within architectural design courses. In conjunction with facilitating a two-day workshop, the research study procured data from library sources and solicited student responses via a questionnaire. The outcomes of the study indicate that architecture students exhibit a deficiency of knowledge pertaining to creativity and its cultivation. The concept of creativity is often perceived as ambiguous or unknown by a significant portion of individuals. The proponents assert that the incorporation of assignments within the curriculum, particularly in introductory and foundational courses, is crucial for familiarizing architecture students with the notion of creativity and creative education, in order to cultivate and enhance their creative abilities.

As one of the central components of creativity, DT is the capacity to generate various solutions in response to a specific stimulus or problem (Guilford, 1967). DT, which entails the ability to produce ideas, facilitates the resolution of unresolved problems by generating numerous original alternatives or solutions belonging to the same or mutually exclusive conceptual categories or types of responses (Palmiero et al., 2022). It's a cognitive process that diverges in multiple directions. Runco (2008) further expounded on this concept and defined divergent thinking tests as tools that "estimate the potential for creative problem-solving." This perspective underscores testing as estimations and possibilities rather than as guarantees of creative behavior, which stands in stark contrast to the notion equating divergent thinking with creativity (Runco & Okuda, 1988). Divergent thinking is a notably open and unrestricted intellectual exercise characterized by an abundance of connections and potential answers. It empowers individuals to venture beyond the confines of their experiences. According to Guilford (1950), in the realm of DT, a person can construct a novel idea in a situation despite limited evidence and a lack of prior knowledge. Divergent thinking often occurs spontaneously and leads to the rapid generation of multiple ideas (Raef et al., 2022)."

Divergent thinking tests are widely used in numerous studies to assess divergent thinking abilities (Dumas & Runco, 2018; Guilford, 1950; Mumford et al., 2008; Silvia, 2008; Silvia et al.,

2008; Torrance, 1974; Wallach, 1970; Zeng et al., 2011). Guilford (1956) originally introduced DT based on the Structure of Intelligence (SOI) framework and methods for evaluating DT. Guilford proposed several indices for DT assessments, including fluency, flexibility, originality, and elaboration, which represent theoretically distinct DT characteristics (Peak, 2003). These indices have been predominantly used in research (Torrance, 1972, 1974; Wallach & Kogan, 1965). Wallach and Kogan (1965) aimed to develop metrics that could describe an intelligence-independent, cohesive aspect of creative thought, distinct from Guilford's framework. They introduced tests such as Instances, Uses, Similarities, Line Meanings, and Pattern Meanings. The utilization of multiple tests is partly influenced by the concepts of creativity and psychometric theory, suggesting that the most reliable assessments are based on multiple indicators (Cheung et al., 2004; Cheung & Lau, 2010; Lemons, 2011; Lissitz & Willhoft, 1985; Richards, 1976; Runco et al., 2016; Silvia et al., 2009; Sowden et al., 2015). Divergent thinking tests serve as predictors of creative performance rather than criteria (Wallach, 1970) by evaluating individuals' idea generation skills through the generation of ideas. These tasks measure idea generation capacity, including ideational fluency (the number of appropriate responses), flexibility (the number of distinct conceptual categories), and originality (the quality of responses) (Reiter-Palmon et al., 2019). Overall, divergent thinking tasks provide a good, although underutilized, tool for statistically assessing changes in creative thinking due to training (Demirkan & Afacan, 2012). In DT activities, participants are required to generate new thoughts or interpretations on a given input. DT tests thus provide the evaluation of an individual's ability to generate novel ideas under specific (controlled) task and stimulus settings (Erwin et al.,2022).

One of the primary objectives of the architectural studio is to impart the fundamental design skills necessary for generating design solutions. Existing literature suggests that design education has effectively enhanced divergent thinking abilities. This study's primary aim is to assess whether a one-semester design studio program can enhance the divergent thinking capabilities of architecture students. The research seeks to ascertain the impact of curricular intervention on divergent thinking skills within the first-year design studio. Two distinct measurement tools were employed: 1) students' design studio projects and 2) Wallach and Kogan's tests of divergent thinking. The choice of the Wallach and Kogan test is due to its content overlap with the studio projects, as the test shares certain aspects with the design works. The study endeavors to evaluate students' divergent thinking skills using four studio works completed as part of the 'Thinking in Architecture Design' course and Wallach and Kogan's divergent thinking tests. Pre- and post-tests were administered at the course's outset and conclusion to gauge whether the course had a positive impact on students' divergent thinking skills. The assessment criteria included fluency, flexibility, and originality as indicators of divergent thinking. For data analysis, the research utilized SPSS software. The Wallach and Kogan's divergent thinking test battery, based on several previously established scales, was employed to examine changes in divergent thinking abilities among first-year architecture students with no prior design knowledge following one semester of architectural coursework. The study involved a relatively small sample (N = 40) of first-year architecture students at Eskisehir Osmangazi University, Eskisehir, Turkey. These students completed the divergent thinking test battery at the beginning and end of their first semester during the fall of 2022-2023.In summary, the study utilized various assessment methods to determine how one semester of architecture education could enhance students' divergent thinking abilities.

## Method

### Participants

The data was obtained from a cohort of 40 first-year undergraduate architecture students during the Fall Semester of the academic year 2022-2023 at Eskişehir Osmangazi University's Department of Architecture in Turkey. During the preliminary stage of evaluation, a total of 160 studio works (SW) were considered as assessment instruments. The mentioned design works were produced by a cohort of 40 students and subsequently submitted for evaluation as part of four separate studio assignments. During the second phase of assessing DT abilities, a survey was administered to the identical group of students at the commencement and conclusion of the academic term. Prior to commencing the survey, all participants were mandated review and sign a consent form carefully created by the authors of the study. The lecturer apprised the students that the examination would be administered through the internet survey tool, SurveyMonkey, accessible at http://surveymonkey.com. The participants were provided with the survey link, along by instructions stating that they had the freedom to allocate as much, or as little time as required to fulfill the assigned tasks. From the group of 45 students that were registered in the course, a subset of 40 students was chosen for further analysis. This subset consisted of an equal distribution of 20 male and 20 female students. The assessment rejected the remaining five students due to their failure to achieve the requirements of the design task. Every participant underwent DT pre- and post-tests at the commencement and conclusion of the 2022-2023 Fall semester, specifically in September and January. The participants were instructed to generate a maximum number of responses for the DT tasks. The participants were provided with instructions that emphasized the insignificance of spelling accuracy and encouraged them to generate and record as many solutions as possible in order to optimize their performance. The completion of the exercise was not bound by any precise time constraint. In order to mitigate potential bias, three raters who were independent from the study were enlisted to evaluate the DT and SW tasks using a standardized scoring methodology. Furthermore, a third evaluator was chosen for the study, who is a scholar from the same department and possesses comparable knowledge to the two original raters (authors). Following the collection of participants' SW and DT responses, the evaluation process was initiated. The raters completed comprehensive training in order to effectively evaluate tasks and works, both on an individual basis and as a group. After receiving training, each of the three raters proceeded to individually rate the student works and DT test results.

### Measures

The study employed two distinct instruments: students' design studio projects and Wallach Kogan's divergent thinking assessments. These instruments were utilized to investigate whether the 'Thinking in Architecture Design' course had a positive or negative impact on the development of students' divergent thinking skills. To assess the changes, pre- and post-tests were administered at the beginning and end of the design course. The reason for using Wallach Kogan's tests of divergent thinking lies in their direct relevance to the design studio approach. In this approach, visual and verbal stimuli serve as primary tools for architectural design thinking in the studio.

#### *Studio Works*

The curriculum for the 15-week, one-semester 'Thinking in Architecture Design' course includes one 50-minute class each week. Throughout the semester, ten design assignments were

developed, but this study focused on four specific assignments. These four selected studio assignments (refer to Table 1) had an equal number of lessons and resulted in a series of design projects in which students were required to articulate and visualize design concepts through architectural representations. Their task was to accomplish this in an original manner, and students received credit for their efforts. Two of the four selected student works are titled 'Abstract Skyline' and 'A Container Composition,' with the aim of enhancing students' visual thinking abilities. The remaining two works, 'Life of X' and 'In the Woods,' are designed to improve students' verbal thinking abilities (see Table 2)The four assignments were designed in a sequence from simple to complex. In the first visual exercise, “Abstract Skyline”, students were instructed to create imaginary city silhouettes using given substrates. Based on visual stimuli, they were expected to create a pattern with simple 2-dimensional shapes. The ways in which organic and geometric shapes would come together on a horizon line, the relationships between each shape and the composition, and their qualitative characteristics as parameters need to be discussed linearly. The final products should not only be an abstract city silhouette, but also demonstrate a highly detailed visual basic design assignment. Using the diverse shapes as thick/thin, linear/nonlinear, horizontal/vertical, angular/curvilinear would bring up the quality of each work.

The second exercise was titled 'A Container Composition' **.** The primary objective of this assignment was to transform an abstract three-dimensional Cartesian space into a tangible architectural space. Initially, students were tasked with visualizing a three-dimensional composition using several rectangular prisms of identical dimensions. Subsequently, they were required to illustrate this composition from an isometric/axonometric perspective. Following this, students were instructed to create a living environment by incorporating elements such as human figures, plants, and other architectural visualization features. These added elements, when viewed from the same perspective, conveyed the intended environment as a container-based defined space. The purpose of these two ***visually oriented*** exercises was to enhance students' decision-making and problem-solving skills through the use of diverse visual tools. In the assessment of the final products, key criteria included the richness of content, the utilization of both 2 and 3-dimensional representation techniques, and an awareness of concrete and abstract spatiality, rather than students' drawing abilities."

The third student work was titled 'In the Woods,' which was a verbal-based exercise. The objective of this exercise was to challenge students to imagine themselves lost in the woods and create a survival scenario. Each student crafted a storyline explaining how and where they became lost, whether they were alone, and what tools they had at their disposal. These imaginative decisions influenced their narratives and assisted them in devising a plan for overnight shelter. Within this framework, each student provided simultaneous verbal and visual instructions for creating a shelter. They specified details such as how to fell a tree for the structural elements of the shelter or how to transport water for making mud, among others. Their original ideas for problem-solving at each stage were the primary focus of the exercise. As a final product, they produced a poster containing each step of the entire building process. The final exercise, titled 'Life of X,' was a verbal-based project that challenged students to create a character and write a short story about their daily life. Students were tasked with describing the character's living conditions, including their urban environment, the interior of their home, and the objects they used daily. The goal was to produce a realistic, reality-based linguistic narrative, with no additional restrictions on the creative process.

***Table 1. Content of the students work***

| Activity | | Description | Assignment instruction | Scoring |
|---|---|---|---|---|
| **Visual Stimuli (ViS)** | **SW1. Abstract skyline.** | **Visualize an imaginary cities' skyline.** | *Draw an imaginary city skyline using organic and geometric 2-dimensional basic shapes. Use basic design principles as hierarchy, contrast, balance etc. The more you can give details, the better.* | **Fluency:** Students cannot provide ideas; 0<br>Students can come up with one to two ideas: 2<br>Students can come up with three or more ideas: 4<br><br>**Flexibility:** Students are not able to provide ideas/ methods;0<br>Students can come up with one to two ideas/methods; 2<br>Students can come up with three or more ideas/ methods: 4<br><br>**Originality:** (Students do not general ideas/ common ideas and no originality; 0,<br>Students come up with moderate unique ideas; 2,<br>Students come up with very unique ideas; 4<br>(Jamal et al.,2020) |
| | **SW 2. A container composition.** | **Consider rectangular prisms as containers.** | *Create a 3-dimensional composition of rectangular prisms, consider it as a container architectural project and render it in isometric or axonometric perspective by drawing. The more you add aspects such as figures, furnishing and planting etc., the better.* | |
| **Verbal Stimuli (VeS)** | **SW 3. In the woods.** | **To spend a night in the woods safely, imagine the process of building a shelter.** | *Assuming that you lost in the woods, write down each step of building a shelter process by local materials. The design should depend on your narrative like how long you will stay and what kind of tools you have.* | |
| | **SW 4. Life of "X".** | **Generate a story of a person's daily routine.** | *Imagine a character and generate a daily life for him/her. Write down and draw the details of environment and objects according to your narrative.* | |

Students were encouraged to draw inspiration from their own experiences or their favorite films, television shows, and books . Once they identified the distinguishing characteristics of their character, students were required to develop a poster that visualized the information using both pictures and text. Overall, the objective of the assignments was to empower students to create both visual and verbal solutions to the given problems using architectural design tools. The utilization of verbal stimuli may lead to variations in students' performance in imaginative drawing. Specifically, verbal stimulation refers to the spoken words used to guide students in their creative design work. On the other hand, architectural sketches, as visual

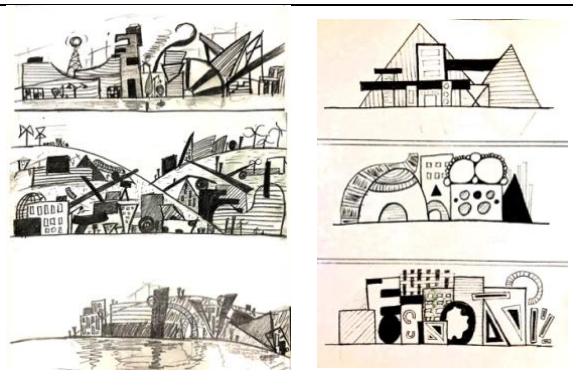
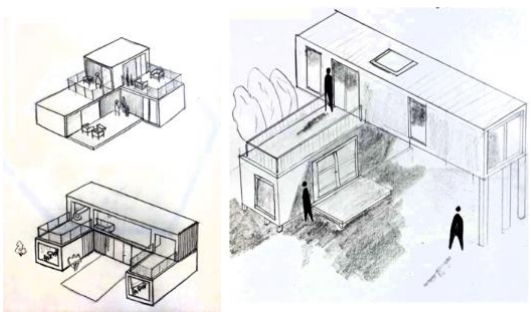
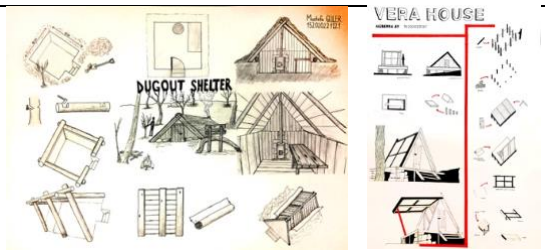
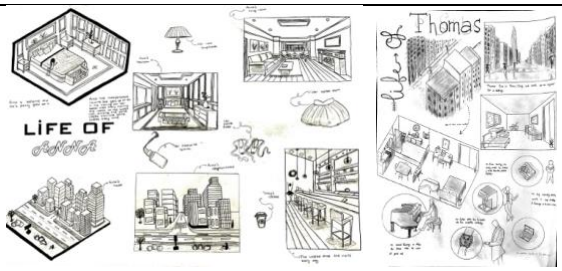
stimuli, served as essential resources for generating creative design ideas throughout the design process. Sketching is a highly effective means of expressing and articulating a designer's inner thoughts, as it is employed by designers to visually translate their design concepts during the conceptual design phase (Lawson, 2006). MacCrimmon and Wagner (1994) noted that stimulus-rich creative approaches have a positive impact on creativity, especially when original ideas are depleted. Based on these arguments, both sketching and verbal expressions were utilized as design tools to foster creative ideas within the design studio. The incorporation of both verbal and visual inputs into the design process was believed to yield more creative solutions, as they were considered integral components of the design thinking process.

*Divergent Thinking Task*

In this study, divergent thinking (DT) was assessed using the Wallach-Kogan Creativity Test (WKCT) (Wallach & Kogan, 1965) for two primary reasons: (1) it is a widely used divergent thinking test to evaluate the creative process of idea generation (Antonietti, 2010), and (2) its psychometric properties and suitability for Turkish samples are well-established (Sur, 2020; Togrol, 2012). We determined that the Wallach-Kogan divergent thinking tests were the most effective means of evaluating students' divergent thinking abilities, as they align with the content of the studio assignments. To ensure accuracy, the WKCT and its instructions were subjected to a back-translation process and translated into Turkish. The initial translation was completed by a researcher proficient in both English and Turkish. Subsequently, two bilingual academics familiar with creativity literature carried out the back-translation process. After incorporating their feedback and making necessary adjustments, the final translated version was approved. The WKCT (Wallach & Kogan, 1965) assesses divergent thinking and evaluates both visual and verbal information. Wallach and Kogan (1965) propose two visual subtests (ViS): Pattern Meanings and Line Meanings (interpreting abstract patterns and lines). The ViS task includes Incomplete Drawing (ID) and Pattern Meanings (PM) items, which require participants to generate ideas about what the presented drawing would look like if completed and what the presented image represents (see Table 2). Participants were instructed to generate as many ideas as possible within a given time for each ViS item."

The Wallach and Kogan (1965) DT test also encompasses three verbal subtests (VeS): Instances (e.g., list all the round objects you can think of), Alternative Uses (e.g., for a shoe). Two of these verbal items were adapted from the Wallach-Kogan Creativity Tests (WKCT). Specifically, the Instances (I) item required participants to generate instances of things that make a sound and things that are round, respectivelyIn the Alternate Uses (AU) item, participants were asked to list alternative uses for a brick and a shoe in the pre- and post-tests, respectively. The Similarities (S) item in VeS required participants to list the similarities between 'broccoli and a banana' (pre-test) and 'an apple and an orange' (post-test) (see Table 3). The selected DT tasks were based on simple verbal information and were chosen due to their high reliability and validity, as documented in previous studies (Antonietti, 2010; Aslan & Puccio, 2006; Cheung et al., 2004; Cropley & Maslany, 1969; George & Wiley, 2020; Runco & Okuda, 1988; Runco et al., 2016).

***Table 2. Examples of some student works***

| Activity | Studio Assignment | Some Students work |
|---|---|---|
| **Visual Stimuli (ViS)** | **SW1. Abstract skyline.** |  |
| | **SW 2. A container composition.** |  |
| **Verbal Stimuli (VeS)** | **SW 3. In the woods.** |   |
| | **SW 4. Life of "X".** |   |

*Scoring*

The scoring approach for SW and DT pre and post-tests was based on the fluency, flexibility, and originality scoring approach outlined by Torrance in 2006, as cited in Jamal et al. (2020). Table 3 illustrates the scoring criteria established by Torrance (2006) for DT tasks and studio works. These criteria were used to compute the scores for items in both categories. Each item in this area is worth no more than four points. This section comprises three distinct aspects. Therefore, individuals with a very high degree of inventiveness can score a maximum of 12 points. According to Torrance (1974), fluency is defined as the quantity of ideas generated. Flexibility refers to the number of different categories or techniques produced. Originality

pertains to the unique or uncommon ideas generated by students. Fluency is scored based on the number of ideas students provided in the assignment. However, fluency was not only measured by the total number of ideas but also considered their relevance to the task (Ilsever, 2000). This study associates fluency with the quality of ideas, rather than relying solely on the quantity of ideas generated. Evaluators may also award points based on the quality of ideas, considering factors such as usefulness, feasibility, and originality (see Table 4). Flexibility is also linked to the number of ideas in the design work, but in this case, the category or method needs to be described. In this study, flexibility is assessed through idea clustering, where raters categorize the generated ideas into clusters based on similarities and assign scores based on the number of distinct clusters formed. This approach considers the diversity of ideas produced, not just the quantity of distinct concepts. Equally vital is the number of unique combinations of ideas developed. This not only considers the variety of ideas presented but also the ability to synthesize and integrate diverse ideas to create unique solutions. As an example of flexibility scoring, if a student provides ideas or methods for combining ideas, such as *'Anna has an indispensable routine. She wakes up at six in the morning for her ballet class every day and walks to the ballet hall,*' the participant would receive a flexibility score of two points for describing the 'indispensable routine,' including the time she wakes up and her journey to the hall. Originality relates to the uniqueness of the ideas presented in the story and is also connected to the novel aspects of the visual images created by students based on the stories they crafted. Originality, or uniqueness, is the ability to think independently and creatively (Roue, 2014). In this study, originality also encompasses the unique visual expressions within the story, including the combination of design elements from different styles in a novel way, the variety of 2D and 3D architectural representations, and the quality and unusual details of the representations. It relates to the fusion of creativity and an individual perspective in the design work (see Table 4).

For example, a participant may create unique interpretations of the story they generated, such as '...a hotel with a different spatial arrangement during the day and at night, a place where space constantly transforms: from a pyramid to a cube.' A response like 'space is constantly transforming' would receive a higher originality score compared to a common response like 'rectangular-shaped space.' As shown in Table 2, one of the student's design stories was: 'Anna is a ballerina, and she is exceptionally talented. She follows a daily routine religiously. She wakes up at six in the morning for her ballet class, and every day, she walks to the ballet hall while sipping her coffee from the same coffee mug.' The student received a fluency score of 4 since she provided more than two related ideas.

***Table 3. Testing structure, scoring, and items of pre and posttest DT tasks (This table is developed from the discussion in Wallach Kogan 1965)***

| Activity | | Description | Task instruction | Scoring |
|---|---|---|---|---|
| Visual Stimuli (ViS) | | | | Fluency: Students cannot provide ideas:0 Students can come up with one to two ideas:2 Students can come up with three or more ideas:4) Flexibility: Students are not able to provide ideas/ methods:0 Students can come up with one to two ideas/methods:2 Students can come up with three or more ideas/ methods:4) Originality: (Students do provide general ideas/ common ideas and no originality:0, Students come up with moderate unique ideas:2, Students come up with unique ideas:4 |
| | Incomplete Drawing (ID) | Guess possible meanings of the line shown in a drawing. | *Here is an unfinished drawing. Write down all the things you can think of that this drawing could be when it's finished. The more you can write, the better.* | |
| | Pattern Meanings (PM) | Figure out possible interpretations of the given pattern in a drawing. | *Interpret the line you see below. Write down everything that comes to your mind about what this line might mean. The more you can write, the better.* | |
| Verbal Stimuli (VeS) | Alternate Uses (AU) | Think of a possible use for an object | *Write down all the uses of a brick/shoe you can think of. The more you can write, the better.* | |
| | Instances (I) | Generate possible instances of a concept. | *Write down all the examples you can think of things that make sounds/ that are round. The more you can write, the better* | |

For the flexibility score, the student received 2 points as they suggested a method for connecting the ideas described in the story, such as '*...walks to the ballet hall, drinking the same coffee from the same coffee mug every time.*' As for the originality score, the student received 2 points as they came up with moderately unique ideas. However, the quality of architectural representations of the spaces was not original enough to score higher. In another example (refer to Table 2; SW 4: Life of X, picture on the right side of the row), the student received 0 points for fluency since they provided no specific details or ideas about his design story. Due to the lack of description, he also received 0 points for the flexibility score. For the originality score, the student received 2 points as they came up with moderately unique ideas. Graphical and architectural representations were better than most in the study, and the combination of design elements from different styles was unique. Current research on DT and SW tends to focus on fluency, followed by originality and flexibility. Elaboration is excluded

from scoring, which refers to the details within each idea. In the flexibility scale, one of the categories that encompasses elaboration in student responses covers individually generated accompaniments.

***Table 4. Scoring Items Based on Fluency, Flexibility, and Originality (Torrance ,2006; cited in Jamal et al.,2020)***

| Creativity Domain | Score | Description |
|---|---|---|
| **Fluency** | 0 | Students cannot provide qualified ideas |
| | 2 | Students can come up with one to two related qualified ideas |
| | 4 | Students can come up with three or more related qualified ideas |
| **Flexibility** | 0 | Students are not able to provide ideas/ methods |
| | 2 | Students can come up with one to two ideas/methods |
| | 4 | Students can come up with three or more ideas/ methods |
| **Originality** | 0 | Students do not general ideas/ common ideas and no originality |
| | 2 | Students come up with moderate unique ideas |
| | 4 | Students come up with very unique ideas |

## Results

### Statistical Analysis of the SW and Pre and Post-test Scores in DT Tasks

Three raters scored the students' design works and responses to the DT items in the flexibility and originality categories, and the student's score for each item was obtained by averaging the raters' scores. Therefore, inter-rater reliability was analyzed before obtaining mean student scores. Each rater independently scored each design work generated in SW1 and SW2 for the visual stimuli score and SW3 and SW4 for the verbal stimuli score. The average of the raters' ratings was used to calculate the score for each item. Additionally, the same raters scored the pre- and post-tests for divergent thinking, including Incomplete Drawing and Pattern Meaning for the visual score (ViS) and Alternate Uses and Instances for the verbal score (VeS). Each student provided multiple qualified ideas (fluency) for DT task items, and the student works resulted in flexibility and originality scores, which are the sum of all scores for each response. Three raters assessed all student responses to DT questions and SW in terms of flexibility and originality. Before calculating the mean student scores, inter-rater reliability was examined to determine the extent to which different judges' evaluation decisions were consistent. The rater judgments for the flexibility and originality scores for the ViS and VeS items in the pre-test, post-test, and student works yielded inter-rater reliability scores that ranged between good (G) and excellent (E). (ICC[a] ranged between .835- .991) (Table 5).

***Table 5. Response-based interrater reliability results for DT tasks pre, post-test and SW***

| DT Tasks (n=40) | Flexibility | | | Originality | | |
|---|---|---|---|---|---|---|
| | ICCa | | | ICCa | | |
| | SW | Dt task | | SW | Dt task | |
| | | Pre | Post | | Pre | Post |
| Visual Stimuli (Vis) | .971 | .926 | .885 | .964 | .953 | .955 |
| Verbal Stimuli (VeS) | .916 | .835 | .844 | .961 | .963 | .991 |

[a] *The Intraclass Correlation value was calculated as a two-way random-effects model with a consistency definition. The reported value is the average measures for the three rater judgments per participant response (p<0,05).*

[c] *Agreement Classifications for Intraclass Correlation were assigned based on Koo and Li (2016) where P is Poor (<0.50), M is Moderate (0.50 - 0.75), G is Good (0.75 - 0.90) and E is Excellent (>0.90)*

Overall, the Intraclass Correlation (ICC) analyses revealed good to excellent agreement between the three rater judgments for flexibility and originality scores for the DT tasks, both pre- and post-test, and for students' works. Thus, a mean score for the SW and DT items was calculated for each student based on the three raters' judgments. The subsequent analyses of DT tasks in the pre- and post-test were based on the students' mean scores.

Student pre- and post-test scores for DT tasks and studio works were first tested for normality using the Lilliefors corrected K-S test in SPSS v.29. Mean fluency, flexibility, and originality scores rejected the null hypothesis that the data were not normally distributed. Given that the majority of the scores did not present a normal distribution, the non-parametric Wilcoxon Signed-Rank test was used to determine whether participant scores in the pre- and post-test and student works had a significant difference in their mean values. This could help test the null hypothesis: *'There is no difference in the divergent thinking ability of first-year architecture students following the first semester of the curricular intervention.'* Table 6 displays the descriptive statistics and Wilcoxon Signed-Rank test results for the fluency scores and the mean rater scores for flexibility and originality for DT pre- and post-test items for a 95% confidence interval ($p < 0.05$). The Wilcoxon Signed-Rank test results were interpreted to determine the effect of the curricular intervention on the fluency, flexibility, and originality components of first-year architecture students' divergent thinking skills.

**Fluency** refers to the quantity and quality of ideas provided by students in their responses to both student works (SW) and divergent thinking (DT) tasks in the pre- and post-tests. Pre- and post-tests, as well as student works, demonstrated statistically significant decreases in the mean fluency scores for visual (Vis) tasks. The decrease in post-test scores was not statistically significant. However, there was a statistically significant decrease in mean fluency scores for both pre- and post-test scores as well as student works ($p = 0.001$, $p < 0.001$) for Vis tasks. The results for verbal (VeS) tasks were similar to Vis. Statistically significant decreases in mean fluency scores were observed across all three tests. The decrease in pre- and post-test scores was not statistically significant, but the decrease in mean scores for both pre- and post-test scores and student works was statistically significant. (p=.002, p <.001) (see table 6).

**Flexibility** is assessed as the idea clustering by the three raters for each student. In the visual (Vis) tasks, there was a statistically significant mean increase in the pre-and post-test scores, and the result was statistically significant (p= .031). However, there was a statistically significant mean decrease between the pretest and students' works' flexibility score, but the decrease was not statistically significant. Additionally, there was a statistically significant mean decrease between the posttest and students' works score, and this decrease was statistically significant (p= .019). In the verbal (VeS) tasks, there was a statistically significant mean increase in the pre- and post-test scores, and the result was statistically significant (p<.001). Moreover, there was a statistically significant mean increase between the pretest and SW flexibility score, and this increase was statistically significant (p<.001). There was also a statistically significant mean increase between the posttest and SW flexibility score, but the increase was not statistically significant (see table 6).

**Originality** scores were calculated using the a priori categories of participant responses judged by the three raters for each student, as described in section 2.2.3. There was a statistically significant mean increase between pre- and post-test scores in Vis tasks, and the increase was statistically significant (p<.001). Similarly, there was a statistically significant increase in the mean originality score between the pretest and the students' work, and this increase was statistically significant (p= .004). In contrast, there was a statistically significant mean decrease between the pre- and post-test scores and the students' work, and this decline was statistically significant (p<.001). In VeS tasks, there was a statistically significant increase in mean scores between the pre- and post-tests, and the increase was statistically significant (p<.001). The same outcome may be seen between pre-test scores and student work (p= .011) (see table 6).

Overall, the findings indicate that students received the highest mean scores for originality on the posttest for both verbal and visual stimuli. Additionally, the mean score for flexibility in visual tasks was higher in the posttest. In addition, posttest fluency scores for verbal tasks were the highest for students. All these findings were statistically significant; hence the null hypothesis that there is no difference in the divergent thinking ability of first-year architecture students after the first semester of the curricular intervention is rejected.

***Table 6. Descriptive statistics, Wilcoxon signed-rank test results for the SW and DT tasks in pre-and post-test groups.***

| FLUENCY | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| DT Tasks *(n=40)* | Mean | | | *Wilcoxon Signed Rank* | | | | | |
| | DT | | SW | *Pre/post* | | *Pre /sw* | | *post /sw* | |
| | pre | post | | z | q | z | q | z | q |
| Visual Stimuli (Vis) | 2.98 | 2.95 | 2.08 | -344 | .731 | -3.190 | .001 | 4.005 | <.001 |
| Verbal Stimuli (VeS) | 3.08 | 3.28 | 2.45 | 1.272 | .203 | -3.166 | .002 | 4.344 | <.001 |
| FLEXIBILITY | | | | | | | | | |
| DT Tasks *(n=40)* | Mean | | | *Wilcoxon Signed Rank* | | | | | |
| | DT | | SW | *Pre/post* | | *Pre /sw* | | *post /sw* | |
| | pre | post | | z | q | z | q | z | q |
| Visual Stimuli (Vis) | 1.632 | 1.890 | 1.417 | 2.161 | .031 | -.895 | .371 | 2.349 | .019 |
| Verbal Stimuli (VeS) | 1.415 | 2.066 | 2.367 | -3.715 | <.001 | 5.080 | <.001 | -2.047 | .041 |
| ORIGINALITY | | | | | | | | | |
| DT Tasks *(n=40)* | Mean | | | *Wilcoxon Signed Rank* | | | | | |
| | DT | | SW | *Pre/post* | | *Pre /sw* | | *post /sw* | |
| | pre | post | | z | q | z | q | z | q |
| Visual Stimuli (Vis) | .8750 | 1.958 | 1.508 | 4.698 | <.001 | 2.853 | .004 | 3.477 | <.001 |
| Verbal Stimuli (VeS) | 1.107 | 2.425 | 1.692 | -3.844 | <.001 | 2.533 | .011 | 4.326 | <.001 |

**Correlations Between the Measures of DT and SW**

Given that the majority of scores did not exhibit a normal distribution, the non-parametric test statistic, the Spearman's rho test, was used to analyze the relationship between the participants' performance on the verbal and visual divergent thinking tests to establish the degree to which these two measures of DT were associated. The correlation coefficients in Table 7 indicate that the performance of students on these tests was associated in the majority of indices. The correlation analysis was performed separately for each of the test items to determine the relations between fluency, flexibility, and originality. We assessed the strength of the relationship as follows: if the absolute value of r falls between 0.5 and 0.7 ($0.5 < r < 0.70$), it means there is a moderate relationship; if $r > 0.70$, there is a strong relationship between items. If the absolute value of r is between 0.3 and 0.5 ($0.3 < r < 0.5$), there are weak correlations between items. If $r < 0.3$, we assumed that there are none or very weak correlations (Mindrila & Balentyne, 2023). In ViS_pretest, fluency was correlated with both flexibility and originality (r= .442, r= .744), and flexibility was correlated with originality (r= .419) (see Table 7). There was a weak correlation between fluency and flexibility, but the correlation between fluency and originality was strong. In VeS_pretest, only fluency moderately correlated with originality (r= .505). However, flexibility and originality, as well as fluency and flexibility, were not correlated (see Table 7). In ViS_posttest, visual fluency was correlated with flexibility (r= .465). Also, flexibility was weakly correlated with originality (r= .339). In ViS_posttest, fluency was weakly correlated with originality (r= .339), and flexibility was correlated with

originality (r= .371). Accumulating evidence indicates weak correlations between flexibility and originality measures (see Table 7). In ViS_SW test, fluency moderately correlated with flexibility (r= .613). In contrast, fluency weakly correlated with originality (r= .374). However, there was no correlation between flexibility and originality. In VeS_SW test, fluency weakly correlated with flexibility (r= .485). Likewise, fluency weakly correlated with originality (r= .406). Besides, there was a weak correlation between flexibility and originality (r= .437) (see Table 7).

Overall, the findings indicate various correlations between all items. The most significant finding was the moderate to strong correlation between fluency and originality. Similarly, there were moderate correlations between fluency and flexibility. However, the correlations between flexibility and originality were weak in most of the scores. This result was consistent with the study of Dumas and Runco (2018) as fluency and originality are best conceptualized as distinct but positively correlated constructs. Correlational analysis showed that fluency was highly correlated with originality in the visual tests, whereas originality was weakly correlated with flexibility in the verbal test.

## Discussion

The present study employed a series of pre- and post-divergent thinking assessments as well as students' design projects to investigate the impact of curricular intervention on changes in divergent thinking abilities over the initial semester. The study encompassed a cohort of novice architecture students enrolled in the "Thinking in Architecture Design" course during their initial semester, with no previous experience or background in design. The intervention sought to improve the design thinking capabilities of the students by placing emphasis on the development of visual and verbal divergent thinking skills. The activities were specifically created to enhance participants' capacity to transform abstract concepts into visual depictions, foster the ability to make connections between different ideas, and cultivate spatial aptitude by honing two-dimensional visual talents. If pupils achieve the highest scores on the post-divergent test, it can be inferred that the training program has effectively enhanced their visual and linguistic abilities. Nevertheless, the post-test scores pertaining to visual stimuli fluency exhibited a notable decline in comparison to the pre-test scores, and this decline was shown to be statistically significant. On the other hand, it is noteworthy that students attained the most elevated average fluency score on the verbal posttest, and this rise exhibited statistical significance. The results indicate that students experienced an enhancement in their verbal reasoning abilities following their completion of a semester-long course titled 'Thinking in Architecture Design.' This improvement in verbal reasoning facilitated their capacity to develop a notably higher number of thoughts pertaining to relevant subjects. Furthermore, a notable and statistically significant rise was observed in the average flexibility scores of pupils after engaging in visual examinations. Nevertheless, the scores achieved by the students' effort were comparatively lower in comparison to both the pre-test and post-test scores.

***Table 7. Spearman's rho test results for the DT and SW tasks***

| PRE TEST VISUAL | | | |
|---|---|---|---|
| **Spearman's rho** | | **1** | **2** |
| 1. Pre_ViS_Flueny | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 2. Pre_ViS _Flexibility | Correlation Coefficient | **.442**** | |
| | Sig. (2-tailed) | **.004** | |
| 3. Pre_ViS_Originality | Correlation Coefficient | **.744**** | **.419**** |
| | Sig. (2-tailed) | **<.001** | **.007** |
| PRE TEST VERBAL | | | |
| **Spearman's rho** | | **1** | **2** |
| 4. Pre_VeS_Fluency | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 5. Pre_VeS_Flexibility | Correlation Coefficient | .189 | |
| | Sig. (2-tailed) | .243 | |
| 6. Pre_VeS_Originality | Correlation Coefficient | **.505**** | .299 |
| | Sig. (2-tailed) | **<.001** | .061 |
| POST TEST VISUAL | | | |
| **Spearman's rho** | | **1** | **2** |
| 1. Post_ViS_Flueny | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 2. Post_ViS_Flexibility | Correlation Coefficient | **.465**** | |
| | Sig. (2-tailed) | **.003** | |
| 3. Post_ViS_Originality | Correlation Coefficient | .307 | **.339*** |
| | Sig. (2-tailed) | .054 | **.032** |
| POST TEST VERBAL | | | |
| **Spearman's rho** | | **1** | **2** |
| 1. Post_VeS_Fluency | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 2. Post_VeS_Flexibility | Correlation Coefficient | .132 | |
| | Sig. (2-tailed) | .418 | |
| 3. Post_VeS_Originality | Correlation Coefficient | **.339*** | **.371*** |
| | Sig. (2-tailed) | **.032** | **.018** |
| SW VISUAL | | | |
| **Spearman's rho** | | **1** | **2** |
| 1. SW_Vis_Flueny | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 2. SW_Vis_ Flexibility | Correlation Coefficient | **.613**** | |
| | Sig. (2-tailed) | **<.001** | |
| 3. SW_Vis_Originality | Correlation Coefficient | **.374*** | .270 |
| | Sig. (2-tailed) | **.018** | .092 |
| SW VERBAL | | | |
| **Spearman's rho** | | **1** | **2** |
| 1. SW_Ver_Fluency | Correlation Coefficient | | |
| | Sig. (2-tailed) | | |
| 2. SW_Ver_ Flexibility | Correlation Coefficient | **.485**** | |
| | Sig. (2-tailed) | **.002** | |
| 3. SW_Ver_Originality | Correlation Coefficient | **.406**** | **.437**** |
| | Sig. (2-tailed) | **.009** | **.005** |

*Correlation is significant at the 0.05 level (2-tailed)

** Correlation is significant at the 0.01 level (2-tailed).

The visual post-test yielded the highest mean score, suggesting that the student demonstrated proficiency in concept clustering. This proficiency was assessed by quantifying the number of distinct combinations of visual concepts generated. This result also illustrates the student's ability to combine and incorporate diverse visual elements in order to provide innovative solutions. On the other hand, the studio works produced by the students had the highest degree of verbal flexibility, exceeding the performance observed in the pre-test but not reaching the level achieved in the post-test.

These results showed that in studio work, students are more capable of idea clustering than in divergent thinking tests. This may be due to students producing verbal ideas through visual representation in the studio, whereas in DT, students generate ideas based on verbal instructions. Unexpectedly, in students' studio works, the ratio of student scores for fluency to those for flexibility was the lowest. While the students did not generate many verbal and visual ideas in the studio design works, there was a strong relationship between the concepts generated. In terms of originality scores, the assessment of the tasks produced the predicted outcome. Students achieved the highest scores in post-tests, both in visual and verbal tasks, and the results were statistically significant. The curriculum intervention had a positive effect on enhancing students' originality in terms of both visual and verbal thinking. Also, the correlation analysis indicated a strong correlation between fluency and originality, as Carroll (1993) described fluency and originality have often been proposed as core aspects of DT. Additionally, our findings supported the idea that theoretically, fluency is a prerequisite for giving an original answer (originality) (Weiss, et al., 2021). The findings indicate that fluency and originality are best characterized as different but positively associated entities, with originality exhibiting stronger construct reliability than fluency (Dumas & Dunbar, 2014).

In general, the statistical examination of student studio works and Wallach Kogan's DT pre/post-tests indicated that the post-test score for verbal stimuli fluency surpassed the visual post-test score. Furthermore, the post-test score for visual flexibility had a greater magnitude than the post-test score for verbal flexibility. The post-test evaluations for originality were found to be the highest for both the visual and verbal tasks. The results of the correlation analysis demonstrated a strong and consistent association between fluency and inventiveness. Regarding their ability to generate a greater number of ideas on interconnected subjects, pupils demonstrated higher advancement in their verbal reasoning skills compared to their visual reasoning skills. This outcome demonstrates the student's aptitude for amalgamating and incorporating a range of verbal concepts in order to generate innovative resolutions. According to Xia et al. (2021), the inclusion of design training has the potential to augment both types of creativity, with a more pronounced impact observed in the domain of divergent thinking. The curriculum intervention was designed to promote students' creativity by activating their divergent thinking capacity, with the anticipated outcome of improving their visual and linguistic aptitudes. Visual stimuli, including photographs, illustrations, and sketches, play a crucial role in facilitating students' ability to articulate their visualizations and design concepts. In addition, the presentation of visual stimuli serves to stimulate students' inclination to observe, analyze, and interpret visual information, so equipping them with the ability to understand and tackle a wide range of design challenges. On the other hand, verbal stimuli, such as scenario and story compositions, provide students with the opportunity to express and elucidate their design thinking process and reasoning. Verbal stimuli facilitate the development of critical thinking skills and the articulation of ideas.

The curriculum intervention facilitates the development of multidimensional thinking by using both visual and verbal inputs. This method empowers students to analyze design difficulties from multiple perspectives. The present study provides evidence for the effectiveness of implementing a curriculum intervention early in the training program, specifically targeting the development of divergent thinking skills. This intervention yielded significant enhancements in students' capacity to generate original ideas, both in visual and verbal formats. However, it is worth noting that the observed growth in divergent thinking abilities was more prominent among individuals with stronger verbal aptitudes. This phenomenon can be attributed mostly to the fact that the participants were first-year students who had no prior experience in graphically representing ideas. It is common for students who begin their design education straight after graduating from high school, without any prior experience in design education, to have enhanced verbal communication skills. The researchers hypothesized that students would enhance their visual skills throughout the course of the semester. This led us to the conclusion that there is a need for curriculum modification. In the realm of design initiatives, an effective strategy for enhancing accessibility involves a substantial augmentation of visual exemplifications, encompassing artworks, images, and diagrams. The objective of this strategy is to enhance students' familiarity with diverse design styles, techniques, and visual compositions, hence expanding their knowledge and understanding of the design discipline. Furthermore, it is advisable to promote the practice of sketching among students, as it facilitates the enhancement of their capacity to transform mental imagery into visual depictions. Additionally, it is imperative to underscore the essential visual components, including line, shape, color, texture, and form, alongside the principles of design, including balance, contrast, emphasis, and unity. It is imperative to offer students the chance to use these aspects and principles within the context of their own design work. Furthermore, the integration of visual analysis and research activities might be included in the curriculum. The subject matter involves the examination and interpretation of visual artifacts originating from diverse cultural backgrounds, historical epochs, or design fields. This academic pursuit facilitates students in acquiring a more profound comprehension of visual communication and its relationship to cultural milieu.

It should be noted that the sample size of design works in this preliminary study, consisting of 160 works collected from 40 students, represents a substantial portion of the students participating in the 'Thinking in Architecture Design' course. However, it is important to acknowledge that this limited sample size may be perceived as a potential limitation of the study. This study is perceived as an initial endeavor towards conducting a broader and more extensive study, which would involve collecting data from a larger cohort of students enrolled in diverse academic disciplines.

## Conclusion

The primary objective of this study was to examine the influence of a curriculum intervention on the divergent thinking abilities of first-year design studio students. The research employed two distinct assessment tools: the students' design studio tasks and Wallach Kogan's tests of divergent thinking. The results indicated that the curriculum intervention, which emphasized the development of divergent thinking skills during the first semester of training, led to improvements in students' visual and verbal divergent thinking skills. These improvements were particularly evident in terms of originality, while gains in fluency and flexibility in idea generation were comparatively modest. The findings of our study offer valuable

recommendations. Firstly, divergent thinking should be incorporated into design training programs to encourage the production of more original design ideas. Secondly, teaching divergent thinking as an integral part of the design training program, informed by research, would be ideal. Additionally, educators should foster divergent thinking at early stages of education. Consequently, future studies on creativity should prioritize the examination of diverse thinking among students.

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