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Using the ADDIE Model to Teach Creativity in the Synthesis of Raw Materials

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Abstract. The goal of this study was to create a training program based on the ADDIE (analysis, design, development, implementation, and evaluation) model (AM) that would help students develop creative skills related to the synthesis of raw materials, and to evaluate its effectiveness compared to a more traditional training program. The sample for the study was made up of 62 art education graduate students at King Faisal University, Saudi Arabia. The study used a semi-experimental approach which was considered suitable. The study tools consisted of a scale of creativity skills related to the synthesis of raw materials (SCSRSRM) developed by the researchers. The study found that there is a close relationship between creativity and training using the AM, which allowed the trainees to go back to previous steps when they feel that there is a gap between their mental perceptions and reality while building the artistic work. The AM program also helped trainees to improve their educational methods and plan to acquire knowledge and develop their creative skills in the field of raw materials synthesis.

Keywords: ADDIE model; creativity skills; visual culture; synthesis of raw materials

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1. Introduction

Creativity is a key indicator of people's growth and people should learn how to be creative. According to the main goals of plastic arts, in general, and the field of handicrafts, in particular, plastic arts play an important role in helping students develop their creativity by revitalizing visual culture and correcting students' ideas about how to see the elements of nature, based on visual analysis methods: how to otherwise sense them, and how to treat them. Educational theories, such as constructivism and behaviorism and various strategies and models that researchers use to develop training programs, can play a crucial role in the development of creative skills. Creativity is one of the most important and complex skills and must be increasingly developed, especially considering the conditions of the twenty-first century.

Creativity is also a component of what makes humans human; it emerges from inside, without a defined goal, as a component of the whole. It is free, natural, pure, lively, and dynamic (Piirto, 2021). It is also considered a complete mental process that incorporates interconnected cognitive, emotional, and ethical aspects, all of which produce a distinct state of mind (Jarwan, 2008).

The authors of this study believe that the process of creative synthesis in the synthesis of raw materials begins with the contemplation of nature and the discovery of its systems. Subsequently, trainees develop awareness of these elements, analyzes them, and draws inspiration from them. They apply and further refine this inspiration within a tight design structure in order to create a technical work through the synthesis of raw materials. ADDIE is an acronym formed from the words analysis, design, development, implementation, and evaluation. The ADDIE model's (AM) five phases provide a framework that echoes this progression. Within the first five stages, trainees are able to follow a variety of experimental practices, such as deletion, addition, collection, replacement, reduction and simplification, in order to reach a tight structure for an artwork. This process is based on creating a dialogue and familiarity with the materials through which trainees achieve the aesthetic dimensions and plastic values that reflect the weight of their own experiences.

The AM is an abbreviation for a systematic approach to instructional development that is almost synonymous with instructional systems development (ISD). There is no original, fully constructed model; rather, there is an umbrella phrase that refers to a family of models with a common, underlying structure (Molenda, 2015). Molenda confirmed that the origin of the term is unknown, but the AM terms, stages, and concepts appear in The American Society, which also referred to the aforementioned five stages.

Activities connected to the development of new curricula are viewed as the primary drivers of educational growth, which might increase performance. As a result, educational specialists and teachers commonly use various research methods and dimensions to assess innovation indicators in art teaching and learning (Mousavi et al., 2017). The development of students' thinking skills, in particular, is increasingly valuable in the face of accelerating changes in science, knowledge, and information flows witnessed in the modern world, making this an urgent necessity and a priority in the philosophy of education (Alawi et al., 2018).

Creativity is a compound ability, which facilitates renewal, the discovery of new relationships between things, flexibility, spontaneity, and freedom of expression (Abd-ElKafi, 2003; Abdul Hamid, 1987). This can lead to innovation within a field. Interestingly, we found that an understanding of this innovative power was lacking among many graduate students, who were enrolled in the course on sculpture using environmental and consumable materials, in the Department of Art Education at King Faisal University. The students' work inspired by the linear relationships and structural systems of plant roots also revealed a lack of understanding of analytical systems, extraction of plastic values and their application within a tight design structure, and the nature and characteristics of the media and raw materials in use. This suggested that a range of creative thinking skills needed to be developed.

In the broad field of education, studies have suggested a number of approaches to the development of creative thinking skills, while further confirming the importance of these skills. Rábanos (2021) considered the development of creative thinking skills in different areas of the curriculum as a cross-sectional competency to be approached in a deliberate and specific manner. Hassan (2018) focused on the designing of aesthetic education programs, and the relationship of this design to creative thinking.

During the COVID-19 pandemic, Jieun and Yongseok (2022) sought to assess the efficacy of online practical courses (OPC) in physical education using the AM. Their findings suggest that timely and high-quality feedback is required for effective OPC adoption, and trainees must be encouraged consistently to decrease technical faults. Piirto (2021), focusing on organic creativity, concluded that there are many relevant educational practices and different ways to teach organic creativity, and proposed eight characteristics and five "core attitudes" that contribute. Similarly, Gafour and Gafour (2020) offered several general practices that promote creativity. This confirms that creative skills are among the most required skills in the twenty-first century as a means to deal innovatively with analyzing ideas and solving problems, and it highlights the need to use different techniques and practices to develop these skills.

Mousavi et al. (2017) stressed that it is necessary to review methodological workshops that are compatible with specific innovation indicators in teaching and learning activities, and to develop theoretical frameworks for teaching arts by integrating innovation in all curricula. Al-Ababneh (2020) confirmed that the process of creativity is linked to personality traits and, therefore, that creativity can be viewed in various ways as a mental ability, as practicality, and as human behavior, and that experience in any activity is an essential element for producing new ideas. According to Clinton and Hokanson (2012), working on educational design and development projects is a positive factor that may contribute to the success of educational goods and applications, which in turn improves the lives of learners.

For education to be most effective, a training program for developing creative thinking skills in the field of handicrafts must include a method for planning, carrying out, and evaluating the training process and its results. The authors chose the AM, which has been used by many researchers over several decades and has led to the improvement of training processes, such as in the study conducted by Zulkifli et al. (2018). In that project, the AM served as the foundation for the development of learning, and one of its most significant outcomes was the development of curriculum-integrable, user-friendly programs. In fact, the authors of that study hoped that this program would eventually help Malaysia establish a more practical approach to the entire teaching of moral education.

Research by Richardo et al. (2023) revealed that the application of augmented reality in education technology contributed to the development of creativity abilities in the field of mathematics among secondary school students in Yogyakarta, Indonesia. According to the researchers, there is a gap in Arab studies that deals with the AM for developing creative thinking skills related to raw material synthesis, which is one of the most important skills in the field of plastic arts, particularly in the field of raw material synthesis. Disciplines, lateral thinking, experimentation, and the second portion are all connected to the "Types of Synthesis," which are thought synthesis, method experimentation, and technique synthesis.

As a result of the researchers' exposure to literature and previous studies that showed positive results using the AM, they expected it to produce positive results in developing creative thinking skills associated with the synthesis of raw materials in the study sample. Therefore, the AM was adopted to help students strengthen their creative thinking skills:
1) The AM program can accommodate many learning concepts and theories (structural, cognitive, social, and other educational theories).
2) Students are given the chance to organize their thoughts and solve challenges.
3) It gives the students flexibility and variety of responses in accordance with the requirements and variables of the creative situation, according to the characteristics of the material and the methods and systems of synthesis.
4) Encourages openness to testing procedures in order to discover existing linkages between pieces.
5) Allows for the systematic development of learning outcomes through formative assessment at each step and across stages in accordance with the perceptual features of learners.
6) Allows the students to evaluate and re-design the works of art based on the synthesis of raw materials through various experimentation processes and the practice of synthesis of all types.

Therefore, the current study aimed to develop students' creative thinking skills in the field of handicrafts, especially in the synthesis of raw materials, using different experimental approaches based on the AM. This is by the fifth stage, within the process of drawing inspiration from the structural and aesthetic systems of plant roots in a tight design structure based on analysis of linear relationships, and employing this inspiration in creating innovative plastic compositions to enrich an artwork. The study aimed to evaluate the effectiveness of gradualism in improving the teaching and learning processes in the field of plastic arts, given the importance of choosing appropriate training and educational strategies to successfully achieve set goals. We also aimed to examine the role of visual perception and imagination in developing creative skills for artistic production.

Therefore, the aim of the study can be framed in terms of the following questions:
1) Is there a difference between the mean scores of the first experimental group (AM training program applied), in the pre-and post-measurements, on a scale of creativity skills related to the synthesis of raw materials (SCSRSRM)?
2) Is there a difference between the mean scores of the second experimental group (traditional training program applied) in the pre- and post-measurements on the SCSRSRM?
3) Is there a difference between the mean scores of the first and second experimental groups in the post-measurement on the SCSRSRM?

2. Literature Review

2.1 The AM and the Development of Creativity in the Field of Raw Materials

Creativity is not limited to the arts but includes all fields. Its application lies in new and effective ways of achieving a desired result, such as arousing aesthetic admiration, provoking a new way of looking at something, or developing new concepts for experience or existence that lead to tangible results, such as the making of fine arts' unrestrained creativity (Cropley, 2011). However, the question is if creativity can be developed and nurtured.

According to Piirto (2021), creativity is associated with five "core attitudes"—trust, risk-taking, openness to experience, self-discipline, and tolerance—as well as the eight traits of intuition, inspiration, insight, improvisation, incubation, imagery, imagination, and intentionality. We add that having relevant specialized knowledge, such as the ability to use tools, design, and technical and analytical skills in the arts, also plays a role in creativity. Here we can reimagine the full AM instructional design framework in an overlay model that acknowledges the importance of creativity, as a systems-based representation of the general processes of instructional design and development, aligned with the five stages of creativity: preparation, problem identification, incubation, illumination, and verification (Clinton & Hokanson, 2011).

Researchers have designed different teaching and learning models based on different teaching and learning theories, such as behavioral, cognitive, constructivist, social constructivist, social, humanistic, etc. (Sahaat et al., 2019). These models are designed to meet students' needs and fit the subjects being taught. The AM is often used in training programs because it helps provide teaching and learning materials based on what students need. The model helps researchers to find suitable theories and methods that can be used to build educational and training strategies (Jusoh et al., 2021). It consists of five stages, and for each stage there are intended behavioral outcomes. With feedback, an integral part of the model's design, everything is discussed with a view to optimize success in achieving the educational objectives, so that use of the model also provides a formative assessment and overall improvement of the educational material itself.

The AM provides a structured framework for the five phases of creating an effective educational product. It enables the identification of educational needs in an organized manner, and offers an integrated approach to learning. All stages of the AM are associated with clearly defined knowledge and skills, as demonstrated in Figure 1, so it helps to define and measure the effectiveness of learning (Vulpen, 2023).

Through what has been narrated, researchers can define AM as a training educational model capable of providing learners with educational experiences in all fields through five stages, that allow them to develop and master what has been done in a dynamic and iterative manner.

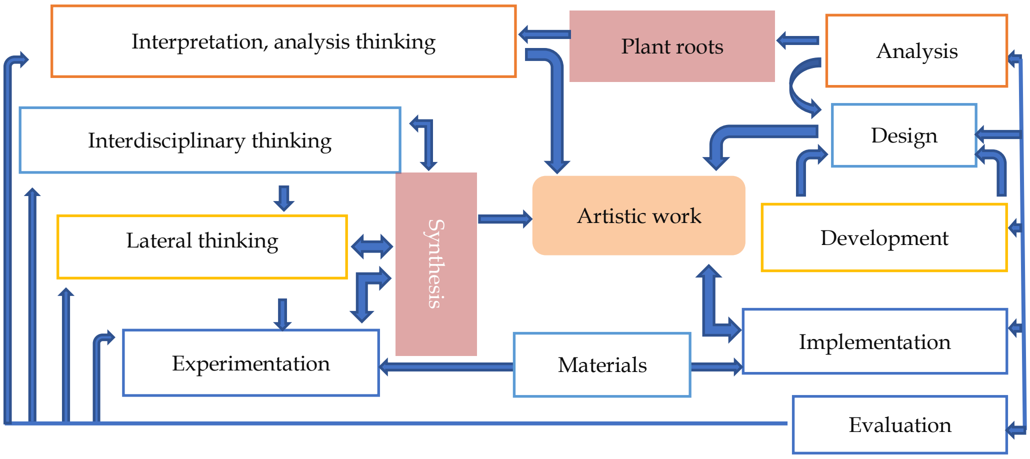

Figure 1: Relationship between the application of the AM and the creativity skills associated with the synthesis of raw materials

Analysis stage: At this stage, the problem and training needs are identified. It is very important to examine and identify the trainees' prior knowledge and skills because it helps in the educational planning of the educator (Sahaat et al., 2019). Here, the problem lies in how to analyze and extract structural systems and linear relationships from plant roots, so it is necessary to use meditation, insight, images, presentations, and video. Through this process, the trainees come to identify the gap between cognitive concepts and executive skills and arrive at linear systems and relationships, such as interlacing, intertwining, seaming, the resulting irregular networks, the diversity of lines, and the perception of aesthetic values in them. Some potential results are shown in Figure 2.

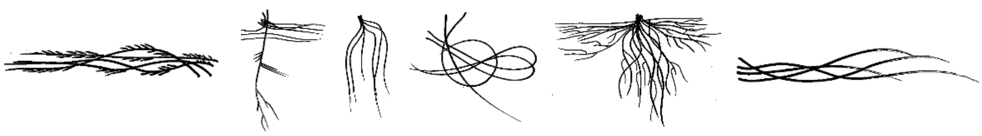

Figure 2: Examples of linear analyses drawn from plant roots

Design stage: This is the stage when the trainee applies the rules of constructive design using what they have learned from linear relationships. This is achieved through inquiry, analysis, the development of ideas, and finding solutions, as well as the processes of inspiration, openness to experience, and depth in design. We can call it a process, and it is one of the stages of creativity, as explained by Cropley (2011). It can also be recognized as a small act of creativity or expansion of the known, where a different application of what is known is possible, and it is possible to apply expressive spontaneity. To produce the largest amount of ideas, it plays a role in some creative training procedures.

During the design process, the trainee goes through certain intellectual practices and stages that are in accordance with the stages of the AM, such as defining the problem, establishing the idea, creative design, reaching a solution, and development (Durmus, 2015). This process is shown in Figure 3.

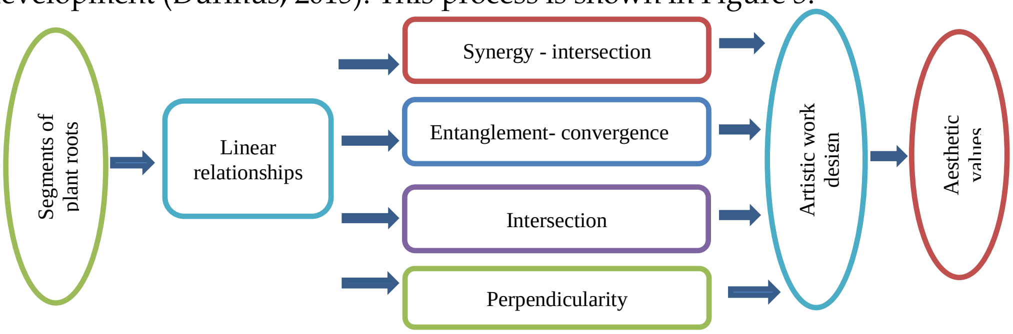

Figure 3: Stages of analysis of linear relationships, structural systems, and aesthetic values of plant roots designed by the researcher

Development stage: This corresponds most strongly to creativity, which is a cumulative process for a large number of organizational decision-making processes, from the idea generation stage to the implementation stage (Kogabayev & Maziliauskas, 2017). At this point, trainees may have formed an integrated vision of their design (Figure 4 shows examples), ready for implementation using raw materials. To do this, trainees must choose the right raw materials and learn the right ways to use them, transforming designs into art. To do this, they must know how the raw materials work, their formative capabilities, the methods and types of synthesis available, and experimental possibilities.

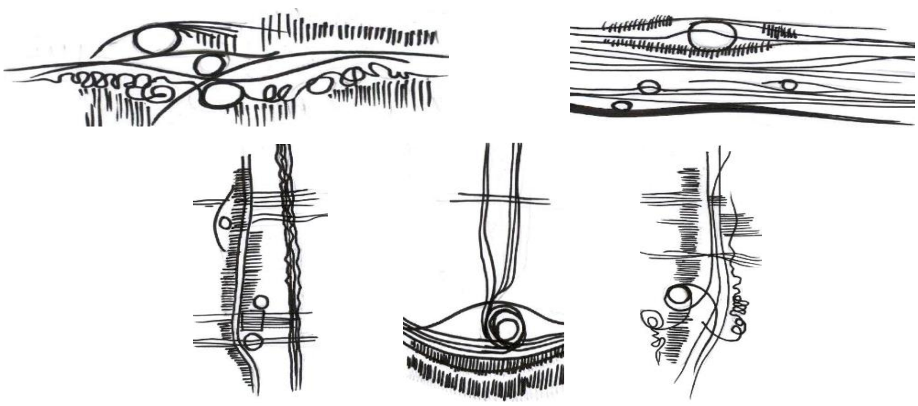

Figure 4: Examples of design models for trainees

Implementation stage: The researchers believe that the implementation stage is linked to creativity skills such as experimentation and lateral and multidisciplinary thinking. Working with raw materials requires taking into account the characteristics of raw materials (burlap, sisal ropes, ropes, copper wires, beads, semi-circles, stereoscopic semi-circular wire supports, cork, and cotton threads) and methods of dealing with plastic potentials. Here, the trainees must be helped by clarifying the types of synthesis in raw materials and methods of experimentation so that they can put their ideas into practice. Figure 5 shows some of the results.

Figure 5: Some of the work produced by trainees taught using the AM

Evaluation stage: Evaluation is an integral part of each step. For example, after the first training session, there will be some obvious points of improvement and unanswered questions that were not noticed in earlier planning stages. Addressing and implementing these quickly will increase the impact of the training (Vulpen, 2023). The role of a physical product in overall evaluation is, however, particularly obvious in fine art, where specific works or performances are judged by specialized critics, as well as interested members of the public (Cropley, 2011).

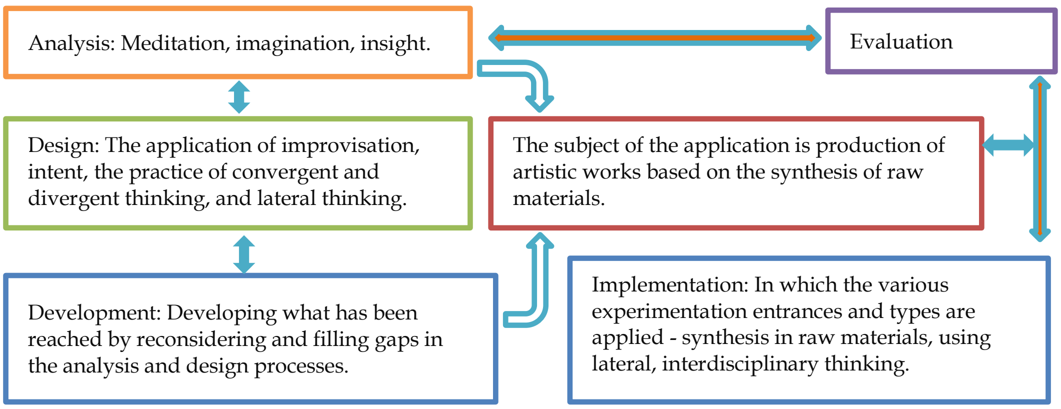

Figure 6: Design of a training program based on the five phases of the AM

2.2 Creative Skills

Creativity, in its simplest form, is the behavior of producing something new, whether it is an idea or a product (American Psychological Association, 2023). According to Hossieni and Khalili (2011), "Creativity is every new and valuable innovation which is discovered," and creativity "has three dimensions cognitive, motivated and none cognitive." There are many creative skills, including divergent thinking, objectivity, imagination, and problem identification. According to Guilford's model of creativity, there are four types of problem-solving ability: sensitivity to problems, fluency, flexibility (consisting of spontaneous flexibility and adaptive flexibility (Education Summary, 2023), and evaluative thinking. Creativity can be defined across four different areas: the person and his attributes, the process (including the steps, techniques, and tools used), the product, and the press (the atmosphere in which people are creative); these form the 4Ps (López-Mesa et al., 2011). Furthermore, creativity is grounded in everyday abilities, such as thought association, recall, perception, illogical thinking, structured problem-space searching, and reflective self-criticism (Clinton & Hokanson, 2012).

Further, we consider in the following section some of the skills that benefit the development of students' competence in the field of raw materials synthesis.

2.2.1 Interpretation and Analysis

This is the ability to extract and analyze a group of structural relationships and systems of the elements of nature, to employ them effectively in the structure of the artistic work, and to consider possible perspectives.

2.2.2 Interdisciplinary Thinking

Synthesis in raw materials works to fill the gaps between the fields of plastic art. Based on broad interdisciplinary explorations, the framework extends from the micro- to the macro-level (Ambrose, 2021). Trainees should be more creative and generate ideas, so their roles should be expanded. Due to the multiplicity of raw materials, their morphological capabilities, and their physical properties, trainees will need a variety of experimental approaches, and this requires multidisciplinary thinking, starting from the design stage. Design testing involves imagining future scenarios that depict the idea using divergent and convergent patterns of thinking and cognitive strategies (thinking patterns), which require the practice of integration, oscillation, formulation, and rephrasing (Jacobs, 2018). Divergent thinking, a well-studied aspect of creativity, is defined as the ability to find multiple alternative solutions to a given situation or problem, some traditional and some original, and as a means of perception that leads in different directions (Runco & Pritzker, 2011). Cropley (2015) argued that, in the context of the design process or creative problem-solving, emphasis should be placed on divergent synthesis and convergent analysis, because it demonstrates an important element in the design structure. Cropley further considered divergent thinking an introduction to convergent thinking. Divergent thinking is invited when an individual is faced with an open-ended task (Runco, 2014), to the implementation stage and the application of types of synthesis in raw materials. Subsequently, the best solutions come from fields and disciplines, according to Einstein, "we cannot solve our problems with the same thinking we used when we created them", by thinking of a person doing a combination of skills, ideas, and techniques that may not have been thought of before (Smart, 2021).

2.2.3 Lateral Thinking

Lateral thinking refers to using logic or unconventional reasoning to find an indirect or out-of-the-box approach to solving a problem (Smart, 2021). As Edward de Bono explained "Lateral thinking is not concerned with playing with existing pieces but with seeking to change those very pieces" (Snow, 2014). Therefore, trainees should strive to provide more modern plastic designs and solutions.

2.2.4 Experimentation

The etymology of the word "experiment" goes back to the Latin verb *experiri*, "to test or try," and its related noun *experimentum*, "experience, test, or proof". As the earliest recorded uses of the word "experimental" mean "having the experience" or "based on experience," the experimental quality of art is likely to be understood as a matter of degree of innovation (Attridge, 2018). The signs of experimentation began when Plato launched his materialistic theory within the framework of the philosophy of truth, goodness, and beauty, which allowed the artist the right to expression and continuous experimentation in thought and application, in turn allowing the gaps between the arts to be resolved. In the field of art education, experimental work occupies a special place because it is linked to the educational goals and philosophy that seek to develop an awareness of the foundations of composition and to further the development of creative skills among students.

Creative thinking is divergent and interdisciplinary thinking, characterized by research and movement in multiple directions, this is consistent with the concept of experimentation, and is indeed, what art education calls for. Experimentation has many entrances, such as finding some premises, such as exchange, grouping, succession, reflex organization, deletion, and addition (Qutb, 1994). Experimentation has many motives, and we define what the current research aimed to achieve in developing creativity skills related to the synthesis of raw materials and finding innovative plastic and design combinations through seeing and analyzing linear relationships and discovering the structural and aesthetic systems of plant roots and how to benefit from them in the structure of the artistic work. Experimentation is the translation of ideas into commodities of value, and requires sessions of brainstorming. There are thousands of variables that can only be discovered through experimentation to obtain a new cognitive vision, so experimentation helps us to make more informed decisions about our ideas (Saarelainen, 2017).

2.3 Types of Synthesis

The idea of artistic synthesis means making something new that cannot be reduced to the sum of its parts. It also means combining different art forms into a single work of art that aesthetically organizes human material imagination, as well as making sure that all of the parts work together in terms of scale, proportion, and rhythm (The Free Dictionary, 2023). There are several types of synthesis in the field of materials synthesis, which we will discuss as follows.

Synthesis in thought: What is meant by this is trying out different styles or ways of putting together the parts of an artistic work. This means that the work is subject to overlapping mental processes, such as removing and adding parts or putting one on top of another, which gives rise to plastic ideas (Abd-ilah & Hussein, 2019).

Experimentation in method: This is the use of specific plastic methods or the combination of several methods to achieve compatibility and harmony between the various materials in the structure of the artistic work.

Synthesis in technique: In the field of experimentation with raw materials, there are often preferences for the raw materials used. The trainee or practitioner, by selecting the material, determines the appropriate technique to subject it to expression. The technical diversity and experimental methods make the work unique.

Therefore, a person who works in the field of raw materials synthesis must be able to adapt raw materials and give them many different texture effects, as well as use their latent expressive and plastic capabilities. This person must also have a vision and grasp of visual culture that allow them to be inspired and see the areas of beauty, while also knowing the properties of plastic raw materials and how to use them. This allows the mixing of many techniques that "enrich" the raw materials.

3. Methodology

3.1 Research Approach

The study followed a semi-experimental approach and the design of the two experimental groups. Using the training model (AM or traditional) as an independent variable, the experiment sought to record its impact on the development of creative skills related to the synthesis of raw materials as a dependent variable. Therefore, the first experimental group was subjected to training according to the AM, while the second was trained in the traditional way.

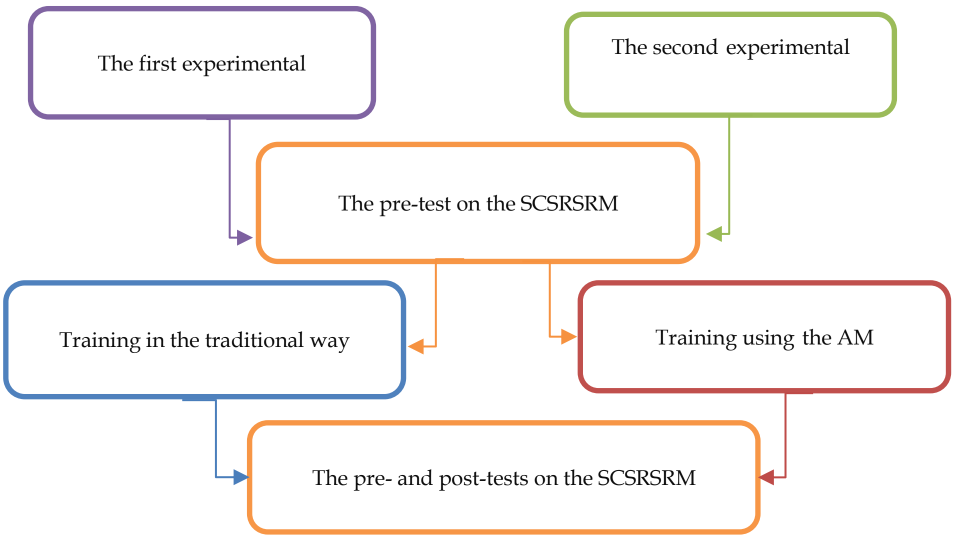

Figure 7: Quasi-experimental research design

3.2 Research Sample

The study population consisted of all graduate students from the Department of Art Education at King Faisal University in Al-Ahsa, Saudi Arabia, between the years 2019 and 2022; these totaled 203 male and female graduates. The sample of the main study consisted of 62 male and female graduates (from the bachelor's

level), who were non-randomly chosen. Their ages ranged between 22 and 26 years old, with a mean of 23.63 years and a standard deviation of 1.36±.
This study was conducted in the first semester of the years 2022–2023. The necessary approvals to implement the program, training from the university and the approval of scientific research ethics from the Deanship of Scientific Research at King Faisal University and the participants in the study were obtained.

3.3 Inclusion Criteria

1. The participants were all from the Department of Art Education, College of Education, King Faisal University.
2. The participants lacked creative thinking skills associated with raw material synthesis.
3. The participants lacked the skills of synthesizing raw materials and the entrance to experimentation.

3.4 Exclusion Criterion

1. Participants who did not have teaching experience in the field of shaping with environmental and consumable materials were excluded.
2. Participants at the postgraduate stage were excluded.

3.5 Research Instruments

3.5.1 Scale of creativity skills related to the synthesis of raw materials (SCSRSRM)

The researchers used a scale to collect data because it fit with the goals of the study, the way it was conducted, and the people who took part in it, and because it helped them to answer the questions posed. The final scale was in four parts: following a review of the literature related to the subject of the study, after consideration of a number of approvals, followed by the study related to the subject of the study, as well as the data and questions of the study and its objectives.

To determine the validity of the scale and ensure that it measures what it was intended to measure, it was presented in its initial form of 12 items to seven experts in the field of art education. The majority of these experts agreed on the adjustments that were required, and three items were added, bringing the total number to 15.

The reliability coefficient Cronbach-alpha (α) was used to calculate the reliability of the two factors of the scale and their total score, and the results showed that the Cronbach-alpha of the two factors were 0.873 and 0.725, respectively. The general reliability coefficient of the questionnaire was 0.881, and these values confirmed that the questionnaire had a high degree of reliability.

3.5.1.1 Inclusion Criteria

Participants were graduate students from the Department of Art Education, King Faisal University.
Participants had a basic understanding of how to be creative when putting together raw materials.
Participants were knowledgeable of the AM.

3.5.1.2 Exclusion Criteria

Participants did not display any creative skills related to the synthesis of materials.

3.5.2 Training Program

A training program was devised, based on the AM, to develop students' creativity and materials synthesis skills. It consisted of 12 sessions over a period of 12 weeks, at a rate of four hours per week. For validation, it was presented to a group of reviewers specialized in the field of art education, and some modifications were made due to the reviewers' opinions.

The use of the AM in the five stages (see Table 1) provided a simplified approach through iteration and reflection to develop creative skills and synthesize raw materials. Students were expected to produce works of art based on exploration and analysis of the structural systems of plant roots, employing the relationships and linear systems, discovered in an elaborate design structure, through the application of experimental methods and types of synthesis. As an end result, the student should be able to demonstrate plastic fluency, modernity, originality, and imagination skills.

Table 1: Stages of implementing the training program

Program stages	Program objectives
Stage 1 (Sessions 1-2)	Understanding the steps of the AM and the importance of applying them to develop creative skills and methods of exploring linear systems of selected plant roots. Basic concepts (linear relationships, systems of linear relationships, semiology of plant roots, aesthetic values, concepts of raw materials synthesis, creative skills experimentation, interpretation, interdisciplinary learning, lateral thinking).
Stage 2 (Sessions 3-4)	Implementation of the AM in the five phases (analysis, design, development, implementation, and evaluation). Structural foundations for artistic work design, development of design outputs, and selection of appropriate materials for idea implementation.
Stage 3 (Sessions 5-10)	The implementation phase, in which actual practices for the synthesis of raw materials are carried out using the entrances of experimentation in terms of thought, technique, and implementation. Distinguishing the characteristics of the material, the synthesis systems, and the methods of formation that are commensurate with the structure of the artistic work in order to achieve originality, flexibility, and imagination, and the reevaluation of these ideas to provide feedback for continuous improvement.
Stage 4 (Sessions 11-12)	The finishing stage and an overview of the artistic work.

3.4 Data Analysis

Data were coded and analyzed using SPSS version 22. An independent samples t-test was used for equivalence between the two study groups. Mann-Whitney and Wilcoxon correlation tests were used to analyze the data and answer the study questions. The study found a statistically significant difference between the mean scores of the two experimental groups in the post-measurement on the

SCSRSRM in favor of the first experimental group, to which the AM training program was applied. P<0.01 was considered significant.

4. Findings

The data were subjected to the following questions and statistical analysis:

4.1 Is there a difference between the mean scores of the first experimental group (to which the AM training program was applied) in the pre-and post-measurements on the SCSRSRM?

Table 2: The value of t for the difference between the mean scores of the first experimental group in the pre- and post-tests on the SCSRSRM

Scale dimensions	Group	N	M	SD	df	T	P	d
Interpretation, analysis thinking	Pre-test	31	7.55	1.03	30	-35.294	<0.001	6.34
	Post-test	31	14.29	0.46				
Interdisciplinary thinking	Pre-test	31	9.68	0.79	30	-22.441	<0.001	4.03
	Post-test	31	13.81	0.83				
Lateral thinking	Pre-test	31	9.35	1.05	30	-25.097	<0.001	4.51
	Post-test	31	14.42	0.50				
Experimentation	Pre-test	31	14.29	2.12	30	-39.045	<0.001	7.01
	Post-test	31	29.52	0.57				
Total	Pre-test	31	40.87	3.35	30	-46.693	<0.001	8.39
	Post-test	31	72.03	1.66				

It appears from Table 2 that there is a statistically significant difference between the mean scores of the first experimental group (to which the AM training program was applied) in the pre- and post-measurements on the SCSRSRM in favor of the post-measurement, where the value of t for the total score of the scale was -46.693 and p<0.001. In order to measure the size of the effect of the AM training program (an independent variable) on the application of the SCSRSRM (a dependent variable), using Cohen's treatment, d = 8.39, which indicates a significant effect of the AM training program on the development of creativity skills related to the synthesis of raw materials among graduate students (members of the first experimental group).

4.2 Is there a difference between the mean scores of the second experimental group in the pre-and post-measurements on the SCSRSRM?

Table 3: The value of t for the difference between the mean scores of the second experimental group in the pre- and post-tests on the SCSRSRM

Scale dimensions	Group	N	M	SD	df	T	P	d
Interpretation, analysis thinking	Pre-test	31	7.39	1.23	30	-12.819	<0.001	2.30
	Post-test	31	12.68	1.72				
Interdisciplinary thinking	Pre-test	31	9.29	1.13	30	-10.300	<0.001	1.85
	Post-test	31	12.61	1.20				
Lateral thinking	Pre-test	31	9.16	1.27	30	-9.184	<0.001	1.65
	Post-test	31	11.97	0.98				
Experimentation	Pre-test	31	14.23	2.20	30	-18.187	<0.001	3.27

Scale dimensions	Group	N	M	SD	df	T	P	d
	Post-test	31	24.61	2.64				
Total	Pre-test	31	40.06	3.62	30	-27.358	<0.001	4.91
	Post-test	31	61.87	1.80				

It appears from Table 3 that there is a statistically significant difference between the mean scores of the second experimental group (who were trained according to a traditional program) in the pre- and post-measurements on the SCSRSRM in favor of the post-measurement, where the value of t for the total score of the scale was -27.358 and p<0.001. To measure the size of the effect of the traditional method on the creativity skills associated with the synthesis of raw materials, Cohen's treatment was used, and d = 4.91, which indicates an effect on the development of creativity skills related to the synthesis of raw materials among graduate students (members of the second experimental group).

4.3 Is there a difference between the mean scores of the first and second experimental groups in the post-measurement on the SCSRSRM?

Table 4: The t value of the difference between the mean scores of the first and second experimental groups in the dimensional measurement on the SCSRSRM

Scale dimensions	Group	N	M	SD	df	T	P	η^2
Interpretation, analysis thinking	The first exp. group	31	14.29	0.46	34.295	5.042	<0.001	0.43
	The second exp. group	31	12.68	1.72				
Interdisciplinary thinking	The first exp. group	31	13.81	0.83	60	4.543	<0.001	0.26
	The second exp. group	31	12.61	1.20				
Lateral thinking	The first exp. group	31	14.42	0.50	60	12.372	<0.001	0.72
	The second exp. group	31	11.97	0.98				
Experimentation	The first exp. group	31	29.52	0.57	32.786	10.102	<0.001	0.76
	The second exp. group	31	24.61	2.64				
Total	The first exp. group	31	72.03	1.66	60	23.068	<0.001	0.90
	The second exp. group	31	61.87	1.80				

It appears from Table 4 that there is a statistically significant difference between the mean scores of the first and second experimental groups in the post-measurements on the SCSRSRM in favor of the first experimental group, where the value of t for the total score of the scale was 23.068 and p<0.001. To measure the size of the effect of the AM training program (independent variable) on the performance on the creativity skills scale associated with the synthesis of raw materials (dependent variable), we used the eta squared coefficient and $\eta 2 = 0.90$, which indicates a significant impact of the AM training program on the development of creativity skills associated with the synthesis of raw materials.

5. Discussion

The results indicate a significant impact of the AM training program on the development of creative thinking skills among the trainees, where the AM approach provided an opportunity to organize problem-solving ideas in the synthesis of raw materials with the flexibility and versatility of plastic uses. It may have fostered openness to the processes of experimentation to find relationships based on aesthetics emerging from the analysis of linear relationships of plant roots. The AM training also provided the trainees with opportunities to develop learning outcomes through formative assessment at each stage and between stages, in a systematic manner consistent with the perceptual characteristics of the learners.

The study showed that there were differences in the average scores of the second experimental group, to which the traditional method was applied, in favor of the dimensional measurement and continuous evaluation, in addition to the use of specific educational media. The results also showed that there were significant differences between the mean scores of the first experimental group and those of the second experimental group, in favor of the first, on the creativity skills scale related to the composition of raw materials.

The AM is considered one of the entrances to cognitive representation, which may have helped in organizing the multidisciplinary educational material. In accordance with the model, many strategies were used that could have contributed positively to the development of creative thinking skills, such as brainstorming, active learning, reinforcement, and continuous evaluation, which allowed the trainees to assimilate. Also contributing were visualizations, extraction of linear relationships and aesthetic values of plant roots, elaborately employing them in a tight design structure, in addition to having positive risk-taking skills in raw material experimentation processes.

The current study findings agreed with some previous studies, such as that of Piirto (2021), where creativity processes go through many stages, but they are not required to be arranged, and where various training processes are found to enhance creativity, such as imagination, improvisation, and insight. In another study by Gafour and Gafour (2020), the results indicated that employing lateral thinking helped the trainees create many different perceptions and explorations in the composition of raw materials, which led to different outputs resulting from the experimental processes in the proposed plastic hypotheses and solutions.

Our results also support the claim Sahaat et al. (2019), that formative evaluation provides the trainer with information on the standards and strategies needed for training and that each stage in the AM provides initial information for moving to the next stage. In addition, our results support the findings of Hassan (2018), who found that providing trainees with the opportunity for free expression played an important role in developing their imagination, mental perceptions, and intellectual representation. Our research confirms that the AM provides opportunities for trainees to receive immediate feedback in a timely manner, whether from peers or the trainer, which increases the effectiveness of the training program and the trainees' development of creativity skills related to the composition of the materials.

Considering our results, we agree with Mousavi et al. (2017) that experiential learning is effective in enhancing the abilities of trainees and that the experimental practices followed by trainees are the path to innovation, because they include many practices that work to integrate previous experiences into new educational and creative situations. In addition, the results of the current study are also in agreement with those of Richardo et al. (2023), that the use of the AM had a significant impact on the development of creativity skills among high school students in the field of mathematics, divergent thinking skills, and idea generation. This is because the training pattern of the AM is a non-linear pattern, and it also offers many alternatives and options that help trainees access appropriate plastic and design solutions, taking into account the foundations of the structural design of the artistic work in the analysis and design stage. This allowed them to develop a vision of design and how to transform it into a tangible work systematically using the entrances of experimentation and various synthesis methods, during the process of implementation and evaluation.

6. Conclusions and Recommendations

The current study dealt with a training program to develop creativity skills associated with the synthesis of raw materials using AM in its five stages. This was to produce artistic handicrafts using environmental materials based on the synthesis of raw materials in structural systems that achieve formative values (rhythm, unity, diversity, and balance) and tactile and color values, based on the analysis of linear relationships resulting from the intersection of plant roots. The study sought to build the concepts of synthesis and experimentation in raw materials and the concepts of skills of creative thinking among art education graduate students at King Faisal University.

The study reached the following conclusions: there is a close relationship between creativity and training using the AM, which allows the trainees to go back to the previous steps when they feel that there is a gap between their mental perceptions and reality while building an artistic work. The AM program also helped trainees to improve their educational methods and plans to acquire knowledge and develop their creative skills in the field of raw materials synthesis. Choosing appropriate training strategies helps trainees with the flow of ideas. Fostering creativity comes through focusing on a range of processes, such as improvisation, imagination, insight, and the practice of lateral and divergent thinking. Formative assessment can provide information on standards and strategies needed for training. Plant roots possess structural systems that make them a rich source of inspiration in the field of raw materials synthesis.

During the experiment, the practice of interdisciplinary thinking contributed to the abolition of the frameworks between the arts disciplines, the creation of concepts, and the development of the ideas of the trainees to find diverse and new plastic solutions to synthesize the materials. The study points to the need to use various strategies during the teaching and training of students or trainees, and to be careful to choose the appropriate strategies for the training objectives, with a focus on vocational education and social development. It also recommends conducting interdisciplinary studies in the field of arts.

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