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The Doctoral School "Didactics. Tradition. Development. Innovation"

DOCTORAL THESIS

SUMMARY

Educational Sciences Field

Scientific Supervisor

Prof. Liliana Ciasca, Ph.D.

Student

Drd. Făzăcaș (cas. Stan) Iuliana

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CREATIVE TEACHING-LEARNING OF NATURAL SCIENCES IN PRIMARY EDUCATION

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2025

Statement

The undersigned, Făzăcaș (cas. Stan) Iuliana being a doctoral student at the "Babeș – Bolyai" University, the "Didactica. Tradition. Development. Innovation" I declare the following:

- The doctoral thesis entitled "CREATIVE TEACHING-LEARNING OF NATURAL SCIENCES IN PRIMARY EDUCATION" was carried out by strictly observing the four values of academic integrity – honesty, responsibility, replicability and validity of knowledge.
- The similarity analysis of the doctoral thesis was carried out at the Doctoral School "Didactica. Tradition. Development. Innovation", using the Turnitin Report.
- The editing of the thesis was based on the APA Publication Manual (7th Edition).

- The published studies address the issue of this research and are cited in the thesis.

.... 2025 Signature

LIST OF PERSONAL PUBLICATIONS

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CONTENT OF THE THESYS

INTRODUCTION

Justification for choosing the theme

Creativity is an important competence of the 21st century (Piirto, 2011) because it positively influences the development of other 21st century skills in students, such as communication, scientific and technological literacy, leadership, problem solving, social skills (Ahmadi & Besançon, 2017).

In teaching activities, creativity involves challenging curiosity, observation, inductive thinking, exploration and research. Cultivating creativity in educational institutions can lead to the improvement of school failure.

The teaching of science bears the imprint of creativity, which intervenes in various moments: the formulation of research problems, hypotheses, the design of testing, at the level of methods, materials and tools used, the organization of data and their interpretation.

The importance and timeliness of the theme

However, there is a lack of consensus on aspects related to creativity, such as the way we define and recognize creativity (Beghetto, 2005), which is used in multiple senses: process, manifestation, product, aptitude or ability (Cremin, 2006, Eflick, 2014; Sternberg, 1999). In addition, there is a gap in research regarding what students (especially those of young school age) know and think about creativity.

Specification of the concept

Nwazuoke (1996) shows that many researchers have different opinions about what creativity is. According to the mentioned source, both psychologists and scientists have generically defined creativity through terms such as discovery, uniqueness, imagination, exploration, ingenuity, innovation, intuition, invention, novelty, originality and unusual. Psychologists have tried to distinguish creativity from conformity in thinking. Adelodun (2004) managed to combine the definitions of creativity offered by psychologists, in order to reach the conclusion that creativity means the ability or power to create, to invest in a new form of expression. Torrance (2004), noting the variety of concepts involved in defining creativity, adds to the above list the reference to a process or product that has to do with personality or environmental circumstances. Ahmadi & Besançon (2017, p. 2) explain an approach to creativity based on four main components: "a cognitive factor (e.g., intelligence or knowledge), a conative factor (e.g., personality or motivation), an emotional factor (e.g., the impact of emotions on creative potential), and an environmental factor (e.g., the school's

home environment)." Nwazuoke (1989) proposes three main elements as the basis of creativity: time, place and the uniqueness or novelty of a product.

Relating creativity to the field of natural sciences and their study

This relationship is also a topic of interest but tributary to some curricular, methodological and organizational difficulties. This fact makes the theme of this thesis a challenging one, all the more so since those targeted by the creative approach to the study of natural sciences are primary school students.

Framing the theme in the international and national concerns, respectively of the research team of the Doctoral School

This thesis is part of a series of researches carried out internationally and nationally. Its merit is to place the issue of creativity in school practice, in particular in *the study of science in primary education* and in the approach in a pragmatic and integrated, not fragmentary, manner.

The research team of the doctoral school constantly addresses the issue of creativity in relation to topics such as: game-based learning/gamification, inquiry-based learning, project-based and problem-based learning, STEM education, etc. Also, the creative manifestations of the teacher and students were the subject of studies and publications of the school's doctoral students.

Purpose of the research

The chosen research theme aimed to improve the results in the Natural Sciences discipline of students in the third grade of primary education through an educational intervention program based on the creative teaching of this discipline. The research carried out is of two categories: preliminary research (one interview and five surveys) aiming to identify the methodology capable of stimulating the development of students' creativity and a formative intervention. The formative intervention consisted in the implementation of a program based on the synthesis of two models identified in the literature and in the findings of preliminary research. Both types of tests applied in the formative intervention were based on the Wallach-Kogan creativity test.

Structure of the work

This paper consists of six chapters grouped into two parts, the first dedicated to the theoretical foundation of the issue of creativity and science/learning in science and the second part to the research undertaken by the doctoral student. Each part includes three chapters.

The first chapter focuses on the issue of creativity and defines its specific concepts. The creative personality, the methods of stimulating creativity and the blockages encountered in the development of creativity are also addressed in this first chapter.

Chapter II makes the connection between science and school scientific knowledge, with emphasis on the relationship between the nature of science and scientific literacy. This chapter also discusses the skills that can be developed by primary school students and makes a brief analysis of school textbooks, while presenting comparative studies on science curricula in the country and abroad.

Chapter III deals with the creative teaching-learning of natural sciences: methodological aspects and teacher interventions. The creative interventions carried out on the teaching-learning-assessment strategies used in science are specified here.

The fourth chapter aims to identify the current state of concerns in the field of teaching and creative learning, in order to identify a model of structuring science learning activities. In the continuation of this chapter, the observational research carried out by the doctoral student on the teachers' opinions is presented with reference to both the manifestations of the teacher's creativity in teaching natural sciences, and to the manifestations of students' creativity in the study of natural sciences, but also the exploration of teachers' knowledge regarding learning styles and their usefulness in the development of students' creativity and the exploration of the practices used by teachers for preschool and primary education on the handicraft manufacture of products for teaching use.

Chapter V presents the formative intervention program on the effect of creative teaching-learning on the school performance in science of primary school students and on the level of creativity.

The last chapter formulates conclusions and recommendations regarding the creative teaching of Natural Sciences subjects at the primary education level.

PART I
CREATIVITY. THEORETICAL FOUNDATIONS

CHAPTER 1. CREATIVITY. CONCEPTUAL AND PRAGMATIC CLARIFICATIONS

Creativity is a puzzle, a paradox, some say a mystery" (Boden, 1998, p. 15). It is essential for innovation, novelty and sustainability (Kaplan, 2019, p. 140).

1.1. Creativity. Theoretical foundations and conceptual clarifications

Creativity has been and is an intensely debated topic in education as well, being considered an important element for the development of students and their preparation for a constantly changing society. Fisher (1990 cited in Lee, 2013) states that Piaget promoted the idea that "the main purpose of education is to produce creative people" (p. 103).

The Historical Approach to Creativity

The concept of creativity was introduced into the specialized language around the '30s (Enăchescu, 2015), it being attributed to Allport who took the word from Latin: to create means to give birth, to invent, to do something that had never been seen before.

Jeffrey and Craft (2001, cited by Sæbø et al., 2007) identify four major stages of creativity development, starting from 1950: initially the emphasis was on the individual, on genius and talent, and on the creative personality; In the 1960s the focus shifted to cognitive tests and the measurable outcome of creative ability; In the 1970s, the focus shifted to connecting creativity with imagination and the need to stimulate creativity; In the 1980s, researchers turned to environmental conditioning and social theory to understand the concept of creativity. In this last stage, the research studied creativity in education and the concerns moved from the positivist, large-scale studies, in order to measure creativity, to ethnographic, qualitative approaches to the research of creativity in practice (p.2).

The described approach also influenced the perspective on creativity and the way it is defined.

Specification of the concept

The theoretical foundations of creativity are attributed by Begheto & Kaufman (2022) and Stoica-Constantin (2004) to Amabile, Weisberg, Gardner, Csikszentmihalyi, M.&B. Fustier, Glăveanu, etc. Each of the cited sources highlights components and paradigms.

Rocco (2001) shows that Amabile proposes a structural model of creativity in which he includes knowledge in a field, technical skills, special talents in the field; creative skills and intrinsic motivation for the task.

Gardner (1995) describes a general, holistic and four-level theoretical framework for the analysis of creativity: subpersonal, personal, intrapersonal and multipersonal, which have as their starting point the biological substrate of the personality in order to arrive at the existence of a tension between the multitude of factors that generate new and original things (Stoica-Constantin, 2004). Csikszentmihalyi (2009) considers creativity as an interaction of three systems: the social institutions that select the individual creations that are important to be retained, the stable cultural domain that preserves and shares the selected new ideas, and the individual, which produces the creative interventions.

Vrânceanu (2022) reviews several meanings of the concept of creativity: fluid intelligence (Cattell); divergent thinking (Guilford), lateral thinking (de Bono); directed creative thinking (Hilgard); creative imagination (Ribot and Piaget); specific problem solving (Bruner), specific problem solving (Newell, Shaw and Simen), the ability to discover new ways of solving problems (Rogers); creative potential (Stoica); the power of the mind (Spearmen); constructive imagination (Osborn); willingness to make or recognize valuable innovations (Lasswell), sensitivity to problems (Levy).

Definitions of creativity can also vary in terms of the level of achievement recognized as creative, e.g., the difficulty of the problem perceived or solved (Zlate, 1994; Taylor, 2001). A third type of distinction is between creativity as achievement, creativity as ability, and creativity as disposition or attitude.

Anderson (1996, cited by Wallace, 1986) suggests the following characteristics (components) of creativity: (i) it involves both the product and the process; (ii) it is a characteristic of life itself; (iii) represents an expression of individuality and originality; (iv) it is located at the interaction with society; (v) manifests/is experienced in the present tense even if the product was made in the past; (v) its genesis is the result of a set of intuitions and thinking skills (p.68).

In the opinion of Nwazuoke (1989) and Tucker (2001), creative behavior is not the monopoly of any group of people (people, community or culture).

The process of creation

Weisberg (2006) looks at creativity as a problem-solving activity, in steps, which starts from known facts, and involves changing the way of thinking in order to reach the solution. Rocco (2001) considers Weisberg's pseudo-linear vision of creativity unrealistic because the process of creation is characterized by combinations and recombinations of knowledge, more precisely by a dynamic of the conscious with the unconscious or subconscious.

Creativity involves a number of *skills*: seeing things from a different perspective; learning from previous experiences and applying knowledge to new situations; thinking outside of patterns or algorithms, breaking down barriers; using novel approaches to solving problems;
to permanently improve the knowledge acquired; to create something unique or original (Duffy, 2006, p. 19). It also refers to *the production of new and original ideas* (Runco & Jaeger, 2012), with innovative people (usually called "creatives") being able to create anything that previously did not exist (Azimi, 2012; Munteanu, 1995). Creativity is based on intuition and inspiration (De Bono, 1991), involves thinking (Amabile, 1996) and is not a concept synonymous with that of originality (Balkin, 1990), inventiveness or imagination. Lee & Carpenter (2013, p.6) link creativity to a "creative event"; that is, a dynamic, exploratory process that involves constantly querying and reshaping the problem and the solution.

Conceptual boundaries

Enăchescu (2015) associates creativity with innovation or invention. Creely et al. (2020, p. 4) challenge this association by pointing out that "creativity is often associated with other terms such as innovation, inventiveness, originality, divergence, risk-taking, novelty, potentiality, possibility, and imagination – however, it resists any simple definition or synonymity." Mihailov (2019, p. 177), Chan (2015, p. 243), Șuteu & Ciascai (2022) also criticize the idea of this association by showing that it makes explicit the concepts with which it is associated: (a) invention - which involves the creation of a new idea, concept or product, in addition to the existing ones; (b) innovation – which has a pragmatic connotation that can be translated into (i) the significant contribution (improvement) of an existing product, process or service; (ii) the application, as a result of a transformation with utility value, of an invention into (marketable) products or services; (c) genius – a high, to exceptional, level of originality, constituting the attribute of a person. In conclusion, the opinions of the researchers highlight different perspectives regarding the definition of the concept of creativity.

1.2. Creativity. Theoretical insights

The issue of creativity can be approached holistically, because it involves a multitude of facets, from the person involved in the creative act through an activity to which he dedicates himself, to the result of his actions, which can be a truly new product and recognized accordingly, i.e. an innovation or invention (Enăchescu, 2015).

Products of creativity

The creative idea, respectively the result of the creative process, can be a formula, a concept, a theory, a tool, a device, a style, an apparatus, a principle, a law, a theorem, a mechanism, etc. The idea of creation does not appear suddenly. Its appearance is preceded by the gathering of information, the activation of known or heard experiences, trials and searches, perseverance in resuming steps or reasoning, anxieties and turmoil, etc.

Mechanisms of creativity

As for the mechanisms of the creative process, they must be related to neuroscience (Carson, 2010). Neuroscience helps to define the factors involved in creativity and brain mechanisms. Carson (2010) shows that everyone has brain mechanisms to think creatively, the difference being how we activate them and form connections between them. They influence creative thinking skills.

There are seven mental modes of human creativity that make up the CREATES model, proposed by Carson (2010, pp. 28-31) and that can represent targets in the activity of developing students' creativity:

- Connection: a floating state of attention that favors associations between different themes.
- Motivation: the state of the brain is conducive to reflection, abstract reasoning and decision-making.
- Vision: thinking, more visual than verbal, favors the perception of similarities between different concepts and imaginaries.
- Absorption: the mind opens up to new experiences and ideas, serving incubation.
- Transformation: dissatisfaction, associated with negative emotions, which leads to the search for a more satisfactory solution.
- Evaluation: appreciation of the value of the ideas expressed, from the perspective of their relevance, usefulness and added value.
- Flow: state of optimal fullness related to immersion in a creative process (Carson, 2010, pp. 28-31).

Creative thinking

Ramalingam et al. (2020 define creative thinking as "the ability to generate many different types of ideas, manipulate ideas in unusual ways, and make unconventional connections to outline new possibilities that have the potential to elegantly fulfill a particular purpose." Creative thinking is essentially a generative process.

Creative thinking involves going through certain stages (investigation, imaginary, elaboration, reflection), the transition from one stage to another being mediated by critical thinking.

Lucas (2022, p. 17) presents a model of 3-dimensional creative thinking developed by the Australian Council for Educational Research (ACER) that aimed to identify a way in which creative thinking skills can be assessed.

- Idea generation - considers the number and scope of ideas.
- Experimentation – involves changing perspective and manipulating ideas.
- Quality of ideas - analyzes suitability for purpose, novelty and elaboration.

Ramalingam et al. (2020, p. 6) involve categories of skills in their creative thinking model, explained below:

(i) Idea generation or ideational fluency (Guilford, 1950). This involves a large amount of ideas and their variety. The production of ideas involves divergent (Guilford, 1950, 1967) and creative (Guilford, 1950; Torrance, 1966). It is important even if the number of ideas does not necessarily reflect their quality. The ideas must not be similar. Divergent thinking has as an important characteristic flexibility, which implies easily changing strategies, depending on the situation. It is original because it produces something unique and is fluid, with the whole process occurring easily.

(ii) Experimenting. An essential aspect of creative thinking is the ability to explore, from multiple perspectives, both pre-existing and newly generated ideas. Experimentation includes two aspects: changing the perspective on the problem and manipulating ideas. Creativity implies flexibility in thinking, allowing the adaptation and synthesis of ideas to find innovative solutions (Lassig, 2013). Creative thinkers redefine problems through a flexible approach, avoiding functional fixity (Duncker, 1945), that is, the tendency to perceive objects or ideas only in their traditional ways.

(iii) Quality of ideas. Creativity involves generating ideas that are new, fit for purpose, and useful. In fact, a creative product must introduce something new. Once the creative answer is obtained, it must be developed to be applied. In this case, we are talking about the elaboration of the creative idea or product (Ramalingam et al. 2020, p. 5).

It is worth mentioning the opinion of Lee and Carpenter (2013, p.6) who, referring to the field of engineering, include in creative thinking (creativity) both divergent thinking that produces ideas and convergent thinking, considered complementary to the former and involved in the selection, evaluation, synthesis and refinement, using logic, of potential ideas into "viable solutions" (Sweeney, 2003 cited in Lee & Carpenter, 2013, p.6).

1.3. The Creative Personality

Sternberg and Kaufman (2011) introduce a model of individual creativity with six elements: intelligence, knowledge, thinking styles, personality, motivation, and environment. To them is added imagination in literature ; judgment and taste (Amabile, 1996 and Guilford, 1950), creative potential, the creative process, the created product, the creative personality and the creative environment that can include the creative collective (Roşca, 1981) but also productivity, utility, efficiency, value of products, ingenuity, novelty, originality (Roco, 1981).

Clark (1976) quoted by Wallace (1986, pp. 69-70) describes the creative personality characterized by four dimensions: intuitive, sentimental, sensitivity, rational thinking. Another distinct characteristic of creativity is curiosity. Tucker (2001) noted that creative people look for reasons and explanations for why some things happen.

Stoica-Constantin (2004, pp. 13-14) analyzes the literature and synthesizes the attributes of a creative personality (quoting Catell and Weisberg): remarkable and hereditary intellectual capacities; interests (and needs) for knowledge, independent judgments, self-confidence, intuition, perception of one's own personality as creative, ignorance of rules, openness to new experiences, sensitivity to important problems not noticed by others. Nwazuoke (1996) further emphasizes that creative people generally have ideational fluency, discriminatory observations, superior memory, the ability to synthesize disparate ideas, cognitive flexibility, and the production of unusual but appropriate ideas.

In the literature, it is shown that creative people have an above-average intelligence (Nwazuoke, 1996). However, it is worth mentioning that some non-creative people can be extremely intelligent.

Levels of creativity

After analyzing creativity, from its simplest forms to complex creations, Taylor (1959) developed a theory that indicates 5 levels of it: expressive creativity (child's creativity), productive creativity (imitation), inventive creativity (learned, academic and technical), innovative creativity and emerging creativity.

Anyone can reach the first three levels if they are motivated and persevering, the first being native and the next two acquired through study. The last two levels correspond to those people with exceptional abilities. This type of creative being is born, not developed (Taylor, 1959). Thus, innovative creativity is the level at which new and original works are produced, by violating the rules, patterns or boundaries acquired through academic study or experimentation. Emergent creativity is the highest stage of creativity, producing something

that revolutionizes the system. It is the level of exceptional discoveries in science, artistic creation, technique, where only a few people reach, opening new paths of approach. This level of creativity is characterized as genius.

Appreciating students' creativity

The Lucas et al. model (2013 cited in Lucas, 2022, p. 12) includes five dimensions, each composed of 3 sub-dimensions evaluated through a set of descriptors and objectified as habits in terms of strong, extended, and deep. The corresponding dimensions and sub-dimensions are: (1) inquisitive: the student - wonders and wonders; - explore and investigate; - formulates assumptions; (2) persistent: the student - tolerates uncertainty; - face the difficulty; - accept that it's different; (3) collaborative: the student - collaborates well; - gives and receives feedback; -share the product; (4) disciplined: the student - works and improves; - develops techniques; - reflect critically; (5) imaginative: the student: -operates with the possibilities; - makes connections; -use intuition.

These skills of the creative mind are related in the OECD model to different levels of depth, which facilitates the appreciation of students' creative performance.

The tool is proposed by the cited source for the appreciation of students' creativity (Lucas et al, 2013).

1.4.Modeling the creativity process

The process of creation represents the entire path from the birth of the idea to its perfection, in addition, adding inspiration, intuition, revelation, lightning and illumination.

We present below a set of multifactual, respectively multi-staged models of creativity.

J.P. Guilford (1959) associates creativity with divergent thinking, measurable according to certain factors: a) fluency – the ability to think correctly, quickly and effortlessly to generate a number of ideas, answers, solutions or questions; b) flexibility – the ability to easily abandon old ways of thinking, adopt new ones and produce a variety of ideas, answers, questions or solutions from a variety of categories; c) originality - the ability to develop new, unique or statistically unusual ideas; d) elaboration – the ability to modify or expand an idea, add details; e) sensitivity to problems – the ability to observe and perceive problems before others; f) redefinition - the ability to clarify the idea or to concretize it in a product. To these factors were added later: the capacity for semantic abstraction in the evaluation of two forms of creativity, verbal and figural (Torrance, 1998). Thus, a bifactorial model of creativity has been developed, which formulates the innovative idea of the optimal, new-generating interaction between skills and attitudes, with a wide echo in the educational sciences and beyond (Popescu-Neveanu, 1978).

Mumford proposes an eight-step model: problem construction, information coding, category selection, category combination and reorganization, idea generation, idea evaluation, implementation planning, and solution monitoring (Sternberg & Kaufman, 2011).

Wallas (1926) proposes a model of the creative process, still used today, made up of four stages/stages:

(i) the preparation that consists of intentional study, exploration and investigation for the collection of information regarding the problem or question with which the subject is confronted. Of interest at this stage is to clarify the problem and acquire the necessary information to solve the problem. A work plan based on the information collected is also outlined;

(ii) incubation, in which the search for the idea, the solution is abandoned in the conscious plane but not in the subconscious, which makes various analogies. In fact, thinking continues to process familiar questions and information, even if the person performs other tasks;

(iii) Enlightenment is the stage of the "aha" moment of the emergence of the creative idea or solution to the problem. It is signaled by intimation/insinuation or the moment when we have the feeling that a discovery is imminent;

(iv) The verification aims to establish whether the idea is good or not, through testing, logical-mathematical methods in science and technology, respectively through presentation or exposition in the case of literature and arts. Verification is also the stage of elaboration and revision of the ideas and solutions found, of extension and application of the idea (Wallas, 1926).

Craft (2005, pp. 31-32) develops an elliptical approach to creation, based on the Wallas model (1926), which has 5 stages in each plane: Preparation, Abandonment, Germination, Assimilation and Completeness. The proposed model has the merit of highlighting the fact that once a cycle is over, if the result does not meet expectations or if it is desired to deepen the knowledge, it can be resumed from the preparation stage, which this time is carried out from a higher cognitive level.

The preparation affects the intellectual, emotional (state of frustration and need for change) and physical. It can be done in an individual or collective context. The Abandonment stage involves giving up the search for the answer and a passive attitude. Craft (2005, p. 32, citing Fritz (1943) describes the "germination stage" of ideas that is the one in which the idea appears, which is accompanied by enthusiasm, increased interest, delight and self-confidence. Assimilation is the stage of internalization and development of the creative idea. It takes root

and strength (Craft, 2005). The last stage involves completion: the idea is made explicit and can be put into practice. The quoted source emphasizes that the cycle of creativity resumes because over time creativity develops and multiplies (Craft, 2005, p. 32).

Guilford's (1950) SOI (Structure of Intellect) model values divergent and convergent thinking in equal measure. Guilford also considers intelligence to be composed of three dimensions (Operations, Content, and Product) and a multiple, distinct skill set.

- Operations or mental processes used to solve problems: cognition (recognizing and understanding information); memorization (retaining and recalling/updating information); divergent production (generating multiple solutions to a problem); convergent production (reducing to a single correct solution); evaluation (evaluating information and making judgments).
- Content/ types or categories of information processed: figurative (visual and sensory information); symbolic (abstract symbols: letters or numbers); semantic (language and verbal content); behavioral (social interactions and human behavior).
- Products, i.e. the forms that the processed information takes: units (simple elements of information); classes (categories or groupings of articles); relationships (connections between elements); systems (organized structures of articles); transformations (changes in components or changes in articles); implications (predictions or inferences based on elements).

Franken (1994, p. 396) and Drevdahl (1956) define creativity in relation to practice as the tendency to generate or recognize ideas, alternatives, or possibilities that may be useful in solving problems and thus to produce products or ideas that are essentially new or novel and unknown to the producer, communicating with others, and having fun with others.

1.5. Creativity blockages

The researchers concluded that there are some barriers to creativity. Azimi (2012) identifies the following typology:

- school barriers: mainly categorization, offering ready-made (and not constructed) knowledge, using expository and demonstrative methods respectively teacher-centeredness;
- Environmental barriers: The social environment undoubtedly has a significant negative impact on the development of creativity. If a person is in an environment that doesn't value creativity, they're probably not trying to create new and innovative work. These people imitate the social behavior of others;

- cultural barriers: compliance with standards that, ignored or not respected, lead to the establishment of sanctions.

The blockages, from which we select the following as strongly related to creativity, have been classified into the "cognitive" and "personality" categories (Stoica-Constantin, 2004, p. 159-160):

- poor sensitivity to the new, extreme cognitive style, intellectual conformism, emotional fixity, etc. are caused by cognitive-operational factors;
- lack of self-confidence, fear of failure, non-acceptance of failure, exclusive focus on success, inability to take risks, etc. determined by volative-affective factors;
- lack of perseverance or the need for immediate positive feedback, superficiality, convenience having as its source character factors.

It should be noted that the cited source divides the two categories of blockages into sub-classes. Thus, cognitive blocks can be: perceptual, informational and related to thinking characteristics. Personality blockages can be motivational, temperamental-character and affective (Stoica-Constantin, 2004, p. 159-160).

Recognizing the Signs of Creative Block:

- lack of motivation or enthusiasm for creative projects resulting in repetitive postponement of work on the project or its stop. The lack of progress amplifies the blockage and vice versa.
- using familiar ideas, techniques or models of action.
- lack of interest in experimentation and risk-taking, for reasons of comfort or fear of failure.

Overcoming the blockage can be done by the following steps:

- Exploring and experimenting with new techniques, new ways of thinking and acting, or even collaborating with others can help overcome the blockage. They can stimulate overcoming limits, learning from mistakes and lead to interesting discoveries in terms of ideas, modes of action;
- exploring sources of inspiration – getting out of your comfort zone to discover new ideas in art, literature, music, technique or nature;
- breaks and detachment – temporarily abandoning work and engaging in other activities to allow the mind to rest and recharge;
- collaboration and feedback – working with others or soliciting the opinions of others to get new ideas and overcome bottlenecks;

- accepting failure as a learning opportunity – considering failures as valuable lessons and not as obstacles to creativity;
- setting small, achievable goals – breaking down large projects into smaller tasks to maintain a steady pace and avoid bottlenecks (Levalet, 2024).

Recognizing the signs of blockage is the first step towards unlocking students' creativity.

According to Torrance (1977), in order to overcome these problems, the educational system must be more adaptable and aim to promote creativity and initiative in teaching.

1.6. Methods of Stimulating Creativity

The methods analyzed in this paper are: direct and flipped brainstorming, case study, problem-based learning (PbBL), project-based learning (PBL), discovery learning, collaborative learning, flipped learning. To these are added a great diversity of techniques (Pânișoara (coord), 2024, Sarivan et al. 2003, Temple et al., 2003) such as: mind mapping, random word technique, gallery tour, story map, role-playing technique, "Yes and..." technique, inversion technique, ideal result technique.

We will highlight in the following the brainstorming and the technique of the role-playing game, respectively the "Yes and...".

Brainstorming (Osborn, 1953), also called the "brainstorm", is an interactive method by which the solution of the analyzed problem takes place following debates, discussions and presentations of new ideas. Each of the subjects comes up with a new, personal idea, so that as many solutions as possible are issued, and by combining them, the "key" to the solution of the analyzed problem can be found. The working atmosphere should be relaxing, allowing for the emission of new, bold ideas and a free expression of imagination, triggering a chain reaction.

The method is based on four rules: (i) "search for ideas - large amount of ideas emitted through the use of divergent thinking; (ii) postponement of the judgment of ideas - no criticism of the person or idea; (iii) unusual ideas - orientation towards unusual ideas: the search for new perspectives and hypotheses; (iv) exchange and combination of ideas – the analysis and processing based on association of ideas to achieve the combination" (Oprea, 2008, p. 21).

Role-playing technique. Participants play the role of different characters and explore problems and solutions from their perspective. Depending on the context, participants can play the role of a beginner or an expert, they can reverse the roles to get a broader perspective

on the problem. This method stimulates empathy and creativity, helping teams to develop solutions that are better adapted to needs or more effective.

The "Yes and..." The technique encourages the spontaneous, positive collection and development of ideas. Participants expand on an initial statement by responding with "yes and...", thus avoiding restrictive formulations such as "yes, but...". This method promotes open thinking and creates a safe environment for the free expression of ideas, reducing the fear of judgment and rejection.

CHAPTER 2. SCHOOL SCIENTIFIC KNOWLEDGE

2.1. Scientific knowledge

Mickens & Patterson (2016) define science as the systematic observation, creation, analysis, and modeling of patterns that exist in the physical universe. For a field of knowledge to be considered a science, it must meet the following conditions (Hohenberg, 2010, p. 1; Iliescu, 1998): (i) clearly defined, own, specific terminology capable of expressing explicitly and intelligibly the totality of the knowledge of the respective field; (ii) quantifiability; (iii) controlled experimental conditions; (iv) reproducibility, (v) predictability and testability. It is also collective and public, universal and free from contradictions, it results from (previous) science and is subject to change. The tests and results must be repeatable by other researchers to verify the validity of the conclusions.

Therefore, science is both a body of knowledge and a process.

The emphasis in scientific knowledge falls on research, so science can be defined as a mode of research that aims, starting from good questions about the world, to build answers and evaluate their degree of certainty. The concept of the world includes natural phenomena at different scales of time and extent, social and behavioral phenomena, mathematics and computer science.

Scientific investigation focuses on four major objectives: (i) describing the world, (ii) explaining the world, (iii) specifying what will happen in the world, and (iv) intervening in specific processes or systems. (National Academies of Sciences, Engineering, and Medicine, 2019, pp. 27-28). Hohenberg (2010), citing The US Supreme Court (1993), states that, in order to qualify as "scientific knowledge", an inference or assertion must be validated by the scientific method.

Science is constantly evolving, having a major impact on society, technology, and the understanding of the universe.

2.2. Evolution of scientific knowledge

The history of science follows the evolution of human knowledge about nature and the universe. For the development of students' creativity, knowledge regarding the history of science is the basis for understanding the role of thinking and creativity in the construction of knowledge.

Achi (2021, pp. 29-35), Rosmorduc (1996, 2006) lists the main outstanding achievements of the constitution of science. Thus, the Mesopotamians developed arithmetic methods of calculation, calendars and methods of predicting eclipses, the Egyptians applied

geometry in agriculture and architecture and made the first medical studies, and the Chinese developed advanced numerical systems and geometric and algebraic methods, calculated the number Pi and implemented research in seismology and astronomy. In Ancient Greece, science evolved by moving from religious to rational explanations, through thinkers such as Thales, Pythagoras, Aristotle, Archimedes, and Hippocrates, who laid the foundations of modern philosophy, mathematics, physics, and medicine. In the Middle Ages, scientific progress in Europe stagnated for political and religious reasons, but the Islamic world experienced a period of scientific flourishing, capitalizing on the Greek heritage. Knowledge of optics was obtained through the scientific method and clinical trials (experimental medicine). The Renaissance and the Age of Enlightenment revived interest in science through the work of scholars such as Copernicus, Newton, and Galileo, culminating in the Scientific Revolution. The heliocentric theory was developed, classical physics and anatomy were developed. The twentieth century brought major discoveries in physics, genetics, computer science, and space exploration, radically changing the understanding of the world and marking a continuous evolution of science.

2.3 Nature of Science (NOS)

There is no one way to do science (therefore, there is no universal scientific method).

The Nature of Science (NOS) is the English name for the method/methods/process of scientific knowledge. It can be broadly defined as the way in which people develop, test and refine scientific knowledge (Stark & Murray, 2013). For the description of NOS , Rubba and Anderson (1978) combined factors identified in the literature: (i) morality (scientific knowledge cannot be considered as morally good or bad in itself); (ii) creativity (scientific knowledge is a product of human creativity) (iii) tentative nature (scientific knowledge is tentative in nature); (iv) simplicity (scientific knowledge tries to achieve simplicity of explanation); (v) testability (scientific knowledge supports empirical testing) and unifying (specialized sciences contribute to an interconnected network of laws, theories and concepts).

Scientists use a variety of methods such as observation, exploration, experiment, inquiry, in-depth mathematical modeling to answer scientific questions. There are three main types of investigations: descriptive, comparative, and experimental. The data collected through descriptive investigations are used to formulate an explanation or build predictions and hypotheses, which are then tested in comparative or experimental investigations. If the results prove to be supported by evidence, then they are validated and lead to the development of applications.

In conclusion, scientific knowledge is largely, though not entirely, based on observation, experimental evidence, rational arguments, and is tributary to skepticism. Scientific ideas are affected by the social and historical environment. This medium blocked or stimulated the evolution of knowledge at some point. Scientific knowledge is the product of scientific processes and their social context (McComas et al., 2002, pp. 6-7; Ciascai, 2001, pp. 15-25).

2.4. Scientific literacy

Science literacy is defined as a person's ability to understand, apply, and communicate about science, participate in informed discussions, and make evidence-based decisions (Osborn & Dillon, 2008). It involves critical thinking, interpreting research, and understanding how scientific knowledge develops (Duschl, 1990, Klopfer, 1969).

Scientific literacy was a target in the PISA tests promoted by the Organization for Economic Cooperation and Development (OECD)/Organization for Economic Co-operation and Development (OECD). According to the OECD, scientific literacy is the ability to use scientific knowledge, identify questions and draw evidence-based conclusions to understand and help make decisions about the natural world and the changes it has made through human activity (OECD, 2004, p. 133). Subsequently, the OECD (2007, p.34-37) completes the 2003 definition of scientific literacy:

• Scientific knowledge and the use of this knowledge to identify questions, acquire new knowledge, explain scientific phenomena and draw evidence-based conclusions about science-related problems.

• Understanding the characteristic features of science as a form of human knowledge and research.

• Awareness of how science and technology shape our material, intellectual, and cultural environments.

• Willingness to engage in issues related to science and with the ideas of science, as a reflective citizen (OECD, 2006, p.23).

The OECD (2006-2007) view of science literacy becomes even more complex at the following OECD tests (2016, p. 15; 2018, pp. 23-26), being defined in relation to a person's ability to engage in science-related issues and in relation to the ideas of science, as a reflective citizen.

Scientific literacy is progressive, being described on five levels: from lack of literacy, to nominal, functional, procedural and multidimensional – the latter involving a holistic, interdisciplinary vision, and commitment to the role of science in society.

However, in practice, scientific literacy is often compromised by inadequate teaching methods: excessive emphasis on isolated facts and jargon, quick presentation and without connections to the student's experiences. These shortcomings limit the development of an authentic and thoughtful understanding of science.

2.5. The Specifics of the Process of Scientific Knowledge in School Practice

McComas (2017, p. 72) indicates the motivations for introducing the NOS theme in the Science subjects studied in school: the usefulness, the need to ensure equal, cultural, moral rights, facilitating the learning of scientific knowledge (McComas, 2017, p. 72).

Integrating scientific knowledge into learning helps students solve scientific problems, motivates them to study science, develops their reasoning, scientific skills and gives them a holistic perspective on the world. It also develops their critical thinking and decision-making skills.

Rubba et al. (1981) present textbook patterns and behaviors of science teachers that are at odds with the nature of science, as the two most obvious sources for misconceptions about the nature of science.

The recognition that science is not just a collection of facts, but also a process of research and discovery has numerous implications even at the level of pre-university education. In fact, Hmelo-Silver et al. (2007) point out, the study of science in primary education must be based on experiment and critical analysis. The doctoral student believes that at this school age the experiment can be substituted by observational activities, exploration and investigation (inquiry).

The discrepancy between curricular standards and the specifics of scientific research means that the emphasis is on covering a wide range of topics in science, rather than on the freedom of students to explore a few topics in depth (Harlen & Qualter, 2009).

The development of scientific skills and processes must start at early school age and continue throughout life.

2.6. Science School Curricula and School Textbooks in Romania and Abroad

The Romanian school curriculum, through its provisions, organizes the process of scientific knowledge of students that leads to the acquisition of declarative (knowing what), procedural (knowing how) and conditional (knowing where and when) knowledge.

Declarative knowledge studied by students at school age includes:

a) scientific facts and phenomena, concepts and principles;

b) the vocabulary, terminology and scientific conventions used in science;

c) instruments, apparatus and techniques for investigation and measurement;

d) aspects regarding occupational safety.

The curriculum for the discipline of Natural Sciences for the third and fourth grades (2014) indicates the following general competences necessary to be developed by students in the discipline of Natural Sciences:

(1) exploring the characteristics of bodies, phenomena and processes;

(2) investigation of the environment using specific tools and procedures;

(3) solving problems in everyday life by capitalizing on acquisitions about one's own body and the environment (MEN, 2014).

The science curriculum is an important component part of education in primary education and aims to stimulate children's natural curiosity and understanding of science. Students are encouraged to explore the environment, acquire critical and analytical skills, and learn through discovery (Dewey, 1916).

School textbooks are an essential tool in the education process, as they facilitate the transmission of knowledge.

Following the use and analysis of science textbooks for primary education in Romania, the doctoral student finds that they generally offer a structured content: the knowledge is accurate, up-to-date, varied and objectively presented, in a sober, clear and correct style. However, there are several important shortcomings that prevent the full achievement of the educational objectives set by the national curriculum:

- Insufficiently attractive presentation – the textbook has images but does not provoke students' curiosity and interest.
- Lack of stimulation of debates and collaboration – the textbook does not support student-teacher interaction through discussions and group work, in order to lead to meaningful learning Popescu (2019).
- Low emphasis on student involvement in learning – textbooks favor the transmission of knowledge, neglecting the necessary support to be given to the implementation of strategies such as exploration, experiment and inquiry, designed to help students deepen learning.
- Limited skills development – the strategies suggested or proposed by the textbook do not effectively contribute to the formation of scientific skills and critical thinking, which are essential for quality learning.
- Lack of adaptation to the challenges of the digital world - textbooks do not provide enough tools to support students in filtering information.

- Lack of relationship to the real world – the scientific texts used are not always in line with the life experience of today's children, limiting the relevance and applicability of knowledge.
- Low contribution to personal development – textbooks do not sufficiently support the formation of a balanced personality, responsible thinking and a value system necessary for life in society.

Textbooks from other European countries are based on learning activities that propose the construction of knowledge by students through "research": systematic observation, experiment, modeling, problem solving (Ciascai, 2002). Textbooks in our country also suggest a series of experiments, but the lack of laboratories and material equipment prevents teachers from putting them into practice.

In Finland, science is taught interdisciplinary, integrated into a thematic curriculum. Students learn through applied activities (projects, plant cultivation, measurements in nature), and the evaluation is continuous, focused on practical skills, not on written tests. In the UK, the disciplines of biology, physics and chemistry are approached in an accessible and interactive way. The textbooks propose practical investigations, outdoor activities and the development of scientific thinking from the primary cycle. Assessment combines written tests with projects and practical activities. In the US, science is part of the STEM curriculum, with a focus on collaborative learning and applied projects. The evaluation is continuous and focused on activity, experiment and solving real problems, supported by advanced technological resources.

In contrast, in Romania, although the textbooks include some experiments, the lack of laboratories and teaching resources prevents them from being carried out in practice. The methods are mostly the traditional ones, focused on frontal teaching and memorization, with little emphasis on exploratory and experimental activities. The evaluation is mainly done through written tests, focused on the reproduction of information, with a low weight of practical activities.

The conclusion is that, unlike other high-performance educational systems, in Romania science learning is still predominantly passive, based on the transmission of information, with little support for investigation, collaboration and application of knowledge in real contexts.

The PhD student emphasizes the need for a reform in the design of Romanian textbooks, so that they become more dynamic, applied and adapted to the educational needs

of today's students. A modernization of educational approaches, assessment and equipment is essential to bring the Romanian school closer to the models of international success.

2.7. Scientific Skills Possible to Be Developed in Students

Effective science education in primary school involves more than the transmission of information: it means involving students in processes of active exploration, investigation and reflection, with the support of creative methods and appropriate resources. Students must not only memorize facts, but understand how science works, ask questions and seek answers critically and collaboratively.

Young children learn science in three essential ways (Frost, 1997):

- Learning facts, concepts, and asking questions.
- Understanding exploratory knowledge, methods and procedures and interpreting data and developing technical know-how.
- Exploring the relevance of science in everyday life and its cultural value. (Frost, 1997).

These types of learning match children's natural inclinations for exploration and curiosity. Outdoor activities, nature exploration, and free play contribute significantly to their holistic development—aesthetic, cognitive, sensory, and socio-emotional (Wilson, 1995).

Young children's ways of knowing and learning make them excellent candidates for exploring nature. Such explorations favor the child's health, ability to concentrate and emotional attachment to the natural world. Experiences in outdoor playgrounds tend to be rich in opportunities to cultivate growth in all areas of development, including aesthetic, cognitive, communication, sensory-motor, and socio-emotional (Wilson, 1995).

2.8. Methods specific to scientific knowledge

According to Klopfer (1969), the methods used in scientific research and the way in which scientific knowledge is developed and acquired characterize the essence of science. We present below the methods closely related to the process of scientific knowledge.

Systematic observation is a research method, i.e. data collection in an organized and structured way. It involves tracking behaviors, events or phenomena, based on a plan and simultaneously recording the data thus obtained.

Exploration can have several stages, depending on the context in which it is used (scientific, geographical, personal, etc.) In general, the stages of exploration include (Table 1.2):

Table 1.2

Stages of exploration (Șuteu & Ciascai, 2022)

Stage	Activities
Preparing for exploration	Defining the purpose of exploration
	Collection of preliminary information
	Information on the necessary material resources and how to use them
	Training on personal protection during exploration
	Identification of possible obstacles and risks
Planning	Organization of the necessary resources
	Making assumptions or predictions
	Observation and preliminary analysis
	Adjusting the Initial Plan
Actual exploration	Discovery of new information, data, facts or territories
	Testing the initial assumptions/predictions
	Documenting findings (findings, data, evidence)
Data analysis and interpretation	Reporting results to prior knowledge
	Identifying patterns or patterns
	Formulation of conclusions
Sharing results	Writing reports or journals
	Presentation of colleagues' findings
	Proposing new themes for exploration
Reflection	The results and the observation process are analyzed

The exploration is addressed to students of early school age (grade zero or grade I and II) who are not competent in formulating causal hypotheses, as a result they will be asked to formulate assumptions or predictions.

Students can make predictions with reference to a multitude of facts, for example the traces left by the movement of glaciers on the ground, the speed of melting of ice in carbonated water, etc.

The experiment is a research method used throughout history and until today. It involves the following stages (Ciascai, 1999, pp. 65-66):

(i) Selecting a question or problem relating to facts and phenomena or observing facts or phenomena and identifying the problem to be studied.

(ii) Documentation to clarify the problem and identify the variables involved.

(iii) Formulating a hypothesis, assumptions or good/testable explanations regarding the phenomenon studied.

(iv) Planning and designing the experiment. Planning involves identifying the type of variables (independent, dependent, control), formulating assumptions and the necessary equipment. The design of the experiment organizes the experimental approach (the sequence of applied tests, the way of collecting and systematizing the data).

(v) Carrying out the experiment based on the experimental project.

(vi) Analyzing the data through statistical or graphical methods and interpreting them to explain whether (or not) they support the hypothesis.

(vii) Drawing conclusions based on the data obtained: the hypothesis has been confirmed (the data is evidence) or refuted.

(viii) Sharing the results in the scientific community or with colleagues (in the case of students).

The experiment is a cyclical approach: if the hypothesis is not supported by the findings, then it must be reformulated. To ensure the reproducibility of the experiment, it must be described in detail.

All scientific knowledge is based on scientists' careful observations and measurements of natural events.

Inquiry is a research process, used in science/research but also in other fields, including education, to discover new information or solutions to problems or questions. The main steps are presented in Table 2.2.

Table 2.2

Stages of investigation (inquiry) (Ciascai, 2016; Turşan, 2024)

Stage	**Activities**
Inventory/generation of questions or problems.	Identifying problems from life experience.
Documentation for the selection of the question to be researched	Identifying a problem or question to investigate. Collection of information related to the question. Clarification of the problem. Formulating preliminary hypotheses as a solution to the problem.
Planning the investigation	Choice of research methods (observation, experiment, interviews, etc.) Establishing the necessary resources.

	Creating an action plan.
Data collection and analysis	Observation, measurement and documentation of results. Organize your data into tables, graphs, or charts. Comparing information to identify patterns.
Interpretation of results and formation of conclusions	Reporting the results to the initial hypothesis. Forming evidence-based conclusions. Establishing the limits of the investigation.
Communication and reflection	Presentation of results through reports, presentations or debates. Reflection on the process and on the results.
Resumption of the investigation cycle	Identifying new questions. Possible revision of assumptions and further exploration.

The investigation can be carried out through several activities, depending on the complexity of the problem or the degree of involvement of the students. When they have the main role in carrying out the activities and the teacher has only a mediator role, the students will need a longer period of time to carry out the investigation.

The natural sciences must be taught in context, including adapted to contemporary social problems. Issues related to protecting the environment and applying scientific achievements in everyday life must be included in science lessons in Romania as in other countries.

CHAPTER 3. CREATIVE LEARNING IN THE NATURAL SCIENCES

3.1. Pedagogy of Creativity

The relationship between creativity and learning is an important theme for this thesis. Runco (2007) emphasizes that creativity is both a personal characteristic and a process that can be cultivated under appropriate learning conditions. This indicates that education should focus on both the transmission of knowledge and the development of students' creative skills.

As research has highlighted (mentioned in chapter 1), the essential traits of creativity are: novelty, originality, efficiency, productivity and usefulness of products, creativity implying the ability to find connections between elements (Drevdahl, 1956; Franken, 1994, p. 396).

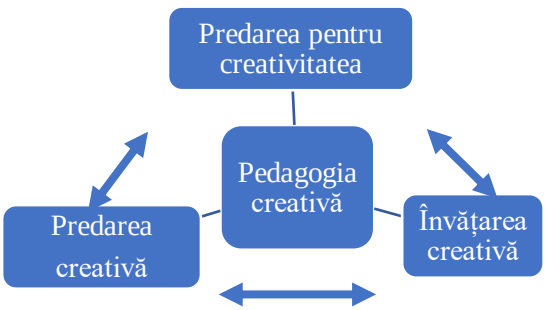
Creative products arise by combining knowledge acquired through observation, play, conversation, reading, study and life experience, and their quality depends on the quality of the educational act.

In the field of education, creativity is not only about exceptional artistic or scientific products, but also about original thinking and innovative ways of solving problems (Plucker et al., 2004). An idea that is new to the student, even if it is not new in an absolute sense, can still be considered creative (Ramalingam et al., 2020, p. 5). The teacher should explicitly model and encourage the valorization of unusual responses (Ramalingam et al., 2020).

Lin (2009) distinguishes between the components of creativity pedagogy, highlighting two levels of teacher intervention: creative teaching and teaching centered on educating students' creativity. To these are added the support of creative learning.

Figure 1.3

The three components of the pedagogy of creativity (Jeffrey & Craft, 2004; Lin, 2009).



Cropley (1997) revealed that it is not enough to teach students about creativity, but we must provide them with an appropriate educational environment that encourages creativity and innovation, alternating traditional education with modern and creative education.

Creativity is a transversal skill that can be applied to any discipline, and the pedagogy of creativity can be integrated into any classroom, regardless of the subject (Coppey Grange et al, 2016, p. 96).

The Australian Curriculum, Assessment and Reporting Authority (ACARA) advocates for the development of an 'integrated' way of thinking, which includes creative thinking and critical thinking. The foundations of this model are found in Guilford's SOI model (1950) and the Wallas model (1926).

Table 1.3

The ACARA Model of Thinking (adaptation, Şuteu & Ciascai, 2022)

Critical thinking	**Creative thinking**
Constructive critical analysis of facts and situations. ▪ Students learn: o recognize or develop an argument. o use evidence to support an argument. o draw reasoned conclusions. o Use the information to solve problems. ▪ Examples of skills: o interpretation, analysis, evaluation, explanation; o succession, reasoning, comparison, questioning; o deduction, formulation of hypotheses, testing, generalization. Products of critical thinking: o Objective analysis of the facts. o Development of judgments.	Generating and applying new ideas. ▪ Students learn: o to look at situations/facts from a new perspective; o identify alternative solutions and explanations; o to learn by doing/making something; o use multiple ways of thinking; o to look for new ideas; o to create new connections between situations and facts. ▪ Examples of skills: o combining elements to form something original; o selecting and refining ideas; o building theories, objects, acting on intuition. ▪ Products of creativity: o Complex representations and images. o Investigations, shows. o Digital results, virtual reality.
Provisions that promote critical and creative thinking: • Curiosity. • Reasoning. • Intellectual flexibility. • Openness and correctness of mind. • Willingness to try alternatives. • Perseverance.	

The development of creative thinking can be evidenced by three descriptors (Craft (2005, in Coppey Grange et al., 2016, p. 99):

- Divergent thinking – students are encouraged to find multiple solutions to a problem and explore alternatives, training their mental flexibility.
- The emotional component and the imaginary – emphasize imagination, dreaming and fantasy, essential for creative thinking. Imagination has a central role in the mental exploration of reality, but it is not enough without concrete application.
- Concretization of inventiveness – creative thinking is capitalized by applying it in knowledge building activities. This process, called "creative education", involves the student's involvement in active and reflective creation.

These descriptors help assess flexible and innovative thinking and provide teachers with a framework for action.

3.2. Didactic creativity

Lucas (2001, cited by Sæbø et al., 2007, p. 6) rejects the idea that creativity cannot be learned and proposes four essential conditions for teaching creativity:

- Offering challenges in a sustainable environment.
- Elimination of negative stress.
- Providing relevant and constructive feedback.
- Accepting uncertainty and developing flexible learning structures (Sæbø et al., 2007, p. 6).

Overall, three key concepts in education are distinguished: creative teaching, teaching for the development of students' creativity and creative learning. All of them involve a complex process, without fixed formulas, in which the teacher has an essential role as a facilitator and model.

On the didactic level, in relation to creativity, we speak of creative teaching, teaching to develop students' creativity and creative learning (Jeffrey & Craft, 2004).

3.3. Creative Teaching and the Creative Teacher

Creative teaching as an innovative educational approach that aims to develop students' imagination, curiosity and critical thinking. It involves original solutions to educational problems and is based on originality, innovation and the active involvement of students (Cheung, 2012). Creative teaching involves instructional techniques designed to help students learn in new ways that will allow them to transfer what they have learned to solving new problems (Mayer, 1984). In the long run, encouraging students to be creative helps them become better at standardized tests and acquire life skills such as innovation, endurance, and adaptability (Torrance, 1977).

Essential Attributes of Creative Teaching (Jeffrey, 2006, p. 3):

- Relevance – adapting learning to students' values, identity and culture
- Control of the learning process – students are self-motivated.
- Ownership of knowledge – learning is personal and meaningful to the student.
- Innovation – the generation of new ideas or solutions with practical applicability.

These attributes are interdependent: relevance stimulates motivation, which leads to control and, ultimately, to the assumption of knowledge and creative results.

Methodological practices associated with creative teaching (Lucas & Venckutė, 2020, p. 27):

- Student-centeredness, who is encouraged to explore and experiment.
- Inter and transdisciplinary approach, connecting knowledge with real life.
- Methodological diversity, adapted to the age and needs of the students (gamification, STEAM, didactic game).
- Development of transdisciplinary skills, such as critical thinking, resilience, collaboration.
- Formation of personal and social attitudes and values.
- Constructive feedback that encourages progress and active learning.

Robinson (2001) argues that education must cultivate critical and creative thinking. But the pressure exerted by the curriculum to cover a large amount of material in a short time is an obstacle. This can prevent teachers from allocating time to creative activities, as traditional teaching methods seem better for standardized assessments.

Creative teaching is an essential strategy for training autonomous, engaged and future-ready students, but it requires systemic support, curricular flexibility and teachers open to innovation.

The creative teacher

The creative teacher has the ability to transform learning experiences into stimulating and meaningful activities, through enthusiasm, energy and innovation (Azimi, 2012). Pedagogical creativity is not only an innate trait, but a skill that is developed through practice and continuous training (Sternberg, 2003).

Qualities and practices of the creative teacher:

- Adaptation - creative teachers are able to adapt teaching methods to the specific needs of students, using interdisciplinary activities, group projects and educational games (Sternberg, 2003).
- Imagination – activities that stimulate divergent thinking and idea generation (Șuteu & Ciascai, 2022; Morais & Azevedo, 2011).

- Flexibility – diversification of teaching strategies and their adaptation to unforeseen contexts (Oliver, 2006).
- Creative thinking – encouraging initiative, exploring new, relatively original ideas.
- Critical thinking – promoting questions, analyses and alternatives (Morais & Azevedo, 2011).
- Collaboration – promoting the exchange of ideas, cooperation, communication and constructive reflection.

Creative teaching not only makes learning more efficient, but contributes to the development of students' self-confidence and social and emotional competences (NACCCE, 1999). This prepares them for the challenges ahead, in life and profession.

Creative teachers are really concerned with educating their students, not only creatively but also involving personal, social, emotional and intellectual development, "teaching people to be people" (Brehony, 1992; Elbaz, 1992; Noddings, 1992; Woods & Jeffrey 1996, p. 57). It is about communication, relating, mutual respect, working together, emotional well-being, self-knowledge and knowing others. Creative teachers are passionate about their work. They care very much about their students (Elbaz, 1992; Noddings, 1992).

Challenges faced in teaching by the creative teacher are educational and institutional barriers, such as curriculum standardization and reluctance to change (Ball & Bowe, 1992). In this context, creative teachers must find the balance between innovation and the demands of the education system.

Continuous teacher training

Continuous training is essential to support teachers in the process of pedagogical innovation. Professional development programs should encourage risk-taking and experimentation with new methods (Davis & Rimm, 2004).

The literature describes the conditions of a teacher training course in the pedagogy of creativity:

- knowledge of institutional expectations in this field;
- raising teachers' awareness of their possible influence on the development of their students' creativity;
- understanding the main mechanisms of the creative process and the factors that promote creativity, with the aim of mobilizing them through teaching (Besançon et al., 2005; Lubart, 2003 cited in Copey Grange, 2016, p. 96);

- differentiating and understanding the different levels/degrees of creativity.

3.4. Teaching for the Development of Students' Creativity

Teaching for the development of students' creativity focuses on developing and educating their creative skills. This involves creating a learning context that provides opportunities for students to explore, experiment and generate new ideas. In such a context, critical thinking and the ability to solve problems are also developed. Teachers play a key role in this process, encouraging the free expression of ideas, tolerance of mistakes and independent thinking.

To promote creativity in science learning, students must use educational approaches that encourage critical thinking and exploration. Through these opportunities, students' creativity must come to the surface (Starko, 2010).

To encourage and develop students' creativity, teachers must aim to carry out an extensive set of activities. Two of these activity models are presented in Table 2.3.

Table 2.3

The teacher's tasks in the development of students' creativity. Patterns.

Model 1. The development of students' creativity. The teacher's tasks (Ciascai, 2022; Joubert, 2001; Lucas, 2001, quoted by Sæbø et al., 2007, p. 6-7; Rachmawati, 2010 quoted by Mayar, 2022, p. 33; Stenberg & Williams, 1996, p. 5):	**Model 2. The development of students' creativity. The teacher's tasks (**Steinberg, 2007, pp. 8-20, adapted by Șuteu & Ciascai, 2022):
a. Preparation for creative teaching-learning: - to ensure a safe and welcoming environment in the classroom, based on respect for the student, where the ideas of all students are listened to, respected and, where appropriate, accepted; - to support the individual knowledge interests of its students, along with the specifications of the curriculum; - to focus the activity on students, stimulating independent work; - encourage active learning using multiple learning styles (Visual, Auditory and Kinesthetic/VAK) and types of intelligence (multiple intelligences); - to use the full variety of questions (what, who, when, how, under what conditions, where, why, why) in the post-idea generation debate.	a) The stage of preparation and maintenance of creativity: - popularizing creative ideas to help students understand the importance of creativity for society; - Exemplifying the importance of creativity in human history can help students appreciate creativity.
b. Selection and use of creativity development techniques: - define and redefine problems; - to focus the learning activity on questions, not answers or explanations; - to put students in front of ambiguous ideas and situations as frequently as possible, encouraging emotional responses;	b) Stages taken in the creativity process: - Confronting a problem or task and accepting it (not rejecting it). Lubart (1994 cited in Lee, 2013, p. 94) points out that not all tasks are creative; the truly creative ones are the tasks of solving problems that involve certain constraints;

- to exhibit unpredictable behaviors and an open attitude; - stimulate the generation of different ideas and points of view; - stimulate divergent thinking, encouraging the search for multiple solutions to problems; - to verbalize the creative thinking in a given situation; - to constitute models of creativity, demonstrating creative thinking and using innovative training strategies/methods; - to give students the necessary time to exercise critical thinking; - evaluate and highlight creative ideas and products.	- Redefining the problem: Problem analysis involves identifying the variants of the given problem and identifying the diversity of solutions. In the first phase, neither the problem nor the solutions must be only those considered possible, credible or known from various sources; - the interrogation and analysis of the assumptions that guide the process of creation.
c. Organization of the activity (including environment): - carry out learning activities in various environments (laboratories, museums, nature, community); - provide students with schemes, patterns and suggestions instead of a standardised model; - to provide students with opportunities for exploration (visual, tactile, olfactory, auditory and gustatory), experimentation or carrying out practical activities and projects; - use technology and innovative instructional strategies (e.g. inquiry learning, STEM integrated learning, etc.) - demonstrate their passion for creative activities so that students are inspired to develop their own creative skills; - encourage student collaboration in creative activities.	c) ensuring an environment that encourages creativity: - encouraging the generation of ideas through different methods or techniques: brainstorming, concept mapping, graphic organizers, etc. - recognition of the role of prior knowledge: promoting or hindering the generation of ideas; - generating ideas in the conditions of risk-taking and tolerance of ambiguities; - choosing the solution in the conditions of delayed satisfaction; - supporting students in doing what they love.
d. development of creative skills: - monitor the development of students' creative skills; - to reward creative manifestations; - to aim to develop a culture of creativity in their classroom and school.	d) reflection, validation and support of students in developing their own effectiveness: - verification/testing of the solution/idea; - sharing the solution with colleagues; - - transfer to other situations of - Solution.

Both models suggest a phased approach. In the first model, the variety of activities for the development of students' creativity proposed by the teacher prevails, and in the second model, the purpose of these activities put into practice by the creative teacher.

The literature (Lee, 2013, p. 27) appreciates that the method of teaching creative education involves four stages (Torance, 1988): preparation, incubation, illumination and verification. Students can be stimulated to be more creative if teachers encourage them to use creativity when identifying and solving problems; whether teachers educate students (explicitly) in the field by "informing students about the nature of creativity and providing

them with clear strategies for creative thinking" (DeHann, 2009, p. 176 cited in Lee & Carpenter, 2013, p. 25).

Such training helps students understand the roles of creativity and imagination in producing scientific knowledge, such as designing experiments, predicting, presenting data, and analyzing data (Quigley, Pongsanon, & Akerson, 2010). When the development of creativity is a target in the teaching-learning process in science, students' attitudes towards science improve (Hendrix, et al., 2012).

Creative teaching-learning is not only a way to stimulate innovation and critical thinking, but it is also a way to actively involve students in their own learning and improve their problem-solving skills (Sawyer, 2011).

Strategies for developing students' creativity

The teaching-learning methods that stimulate creativity are diverse and sometimes dedicated to a specific discipline. In addition, each teacher must use those suitable for his group of students. According to Rogers and Freiberg (1994), student-centered education stimulates meaningful learning and authentic personal development. This training framework puts the student at the center of the learning process and encourages him to actively participate in it. Therefore, teachers must choose the right teaching-learning methods to meet the needs of each student, including discovery learning, project-based learning, portfolio and collaborative methods (Beghetto & Kaufman, 2010; Robinson, 2011). In fact, Bruner (1961) argues that learning through discovery increases autonomy and problem-solving ability, encouraging active exploration. Thus, creativity is stimulated not only as a result of learning, but as a continuous process of building knowledge. Constructivist theory (Vygotsky, 1978; Piaget, 1952) shows that students learn better when they are involved in activities that activate their critical and creative thinking. Creative teaching thus transforms learning into an active and personalized process. Project-based learning (PBL) develops creativity and academic performance (Bell, 2010). The strategies listed above and interdisciplinary projects, including STEAM activities, provide authentic contexts in which students can generate original ideas, build solutions together and learn from each other. Educational games also contribute to the development of critical thinking and problem-solving (Gee, 2003).

Technology fosters collaboration and access to varied resources (Mishra & Koehler, 2006) and as a result, students' creativity. Its effectiveness depends on how it is used and digital skills (Selwyn, 2011).

Evaluation should value creativity through alternative methods, such as portfolios and projects (Beghetto & Kaufman, 2010). For teachers to be creative, they need adequate resources and institutional support (Amabile, 1983).

3.5. Creative Learning

Creative learning involves a combination of intra- and interpsychological processes that result in new and meaningful understandings on a personal level and for others (Begheto, 2021, p.473).

Pedagogical art and creativity go hand in hand, because the potential of creativity is teachable. Roco (2004, p.12) says that "any man can be creative, but in order to be fulfilled in this direction, a series of conditions are necessary".

Puozzo Capron and Martin (2014), quoted in Coppey Grange et al. (2016, p.99) suggest that when studying children's productions, it is necessary to differentiate between reproductive and genuine creative activities. The activity of reproductive creation consists of the child reproducing what he has already seen or experienced, according to past experiences stored in memory. This reproduction inherently bears the imprint of his creativity, although most often it is a simple execution (Șuteu & Ciascai, 2022). Creative or combinatorial activity would mobilize imagination as a higher psychic function, by associating, combining, and merging past experiences to create something new, hybrid (Puozzo Capron & Martin, 2014 cited in Coppey Grange et al., 2016, p. 99). This distinction, according to the quoted source, proves to be particularly fruitful for assessing the levels of creativity demonstrated by students. Specifically, considering creative thinking as a combinatorial function triggers learning through creation, going beyond the first stage of execution.

Seen as a training approach, creative learning has the following stages (Șuteu & Ciascai, 2024). These stages can be easily adapted to primary school students.

Stage I. Stimulating curiosity: teachers and students ask open and challenging questions, stimulating free expression.

Stage II: Idea generation: students formulate various solutions through creative techniques (brainstorming, concept maps, etc.), exploring diverse perspectives and sorting relevant ideas.

Stage III. Refinement and presentation: ideas are analyzed, clarified and expressed creatively through sketches, prototypes or concrete concepts.

Stage a-IV-a. Elaboration of solutions: ideas are concocted, reasoned solutions are formulated and their applicability in other contexts is explored.

Stage V. Reflection and application: the solutions are reviewed and improved, tested in practice and the creative process is analyzed for optimization.

Stage VI. Integration and expansion: the knowledge acquired is applied in new situations, integrated into existing schemes and personal styles of learning and exploration are developed. In the context of this approach, learning is more efficient, more motivating and prepares students with a style of approaching life situations completed by solutions, if not innovative, then at least creative.

Lucas & Spencer (2020) highlight the five dimensions of creative, detailed thinking applicable to the field of the Natural Sciences discipline: curiosity, tenacity, collaboration, discipline, imagination.

3.6. Teaching and Creative Learning in the Natural Sciences Discipline

Creative teaching of Natural Sciences in primary education

The creative teaching of natural sciences involves, in addition to divergent thinking, convergent thinking skills, the ability to think abstractly and systematically (systematic thinking also depends on the richness and fluency of ideas), the ability to restructure the problem (flexibility) and originality of the solution, the application of methods and the obtaining of diverse products. To these are added curiosity, involvement in exploration, the desire to answer questions, orientation towards scientific goals, persistence in the task, as well as tolerance for ambiguity, uncertainty and complexity, non-conformity, motivation and sustained research work (Heller, 2007, p.55). By benefiting from creative science teaching, students learn to solve problems, collaborate, think critically, and work together (Craft, 2005).

Learning in science can be an opportunity for students to improve their critical thinking and creativity. Craft (2005) emphasizes the importance of providing as many opportunities as possible for the development of creativity in learning activities. Studies show that the educational environment plays an important role in the development of students' creativity (Runco, 2007).

The relationship between science learning and creative learning is one of reciprocity.

In primary education, manifestations of creativity in science can include activities such as conducting experiments imagined by students, creating simple new and original models and products, or creating interdisciplinary projects that combine knowledge from different fields. Students can be encouraged to think divergently through activities that allow them to find alternative solutions to problems or to formulate new predictions and hypotheses based on their observations. In this way, science education will not focus exclusively on the

acquisition of limited scientific knowledge, but will involve the development of scientific understanding, skills and attitudes, that is, the development of scientific literacy.

Consequently, a creative science education involves complex problem-solving through critical reflection, innovation, and experimentation (Sawyer, 2011). Practitioners concerned with creativity, according to Boden (2001), manage to balance curricular requirements with the creative development of students. Fraser and Tobin (1993) identified such excellent practitioners who effectively manage the classroom, apply methods centered on understanding and creativity, and create student-friendly learning environments.

One of the main difficulties in preparing teachers for creative science teaching in primary school is the lack of a specialization in the field. Many teachers are afraid of children's complex questions and feel insecure in carrying out scientific investigations, especially due to time constraints and requirements for effective management.

3.7. Creativity-Based Teaching-Learning-Assessment Strategies in Science Lessons

The family, as well as schools, must improve students' creative thinking through science lessons. The question is how can we achieve this?

Possible solutions are identified by researchers (Nwazuoke, 1996; Tucker, 2001; Coleman, 1979; Șuteu & Ciascai, 2022):

- Encouraging children's curiosity about the environment;
- Listening to and respecting children's opinions even when they highlight naïve ideas or conceptions, frequently encountered in the field of science.
- Valuing children's creative thinking, through awards or awarding titles ("the little creative researcher").
- Postponing thinking about a problem or task that involves creativity, depending on its complexity (observation, exploration or experiment and problem solving).
- Encouraging creative children through constructive criticism. These criticisms must concern not only the results, the approach to solving the tasks or problems, but also the credibility of the evidence used to support the conclusions formulated by the students at the end of a documentation, exploration or experiment.

The training of teachers in the pedagogical and scientific field must be doubled by an interdisciplinary one.

- Professional culture must include in-depth scientific knowledge and skills. A teacher who is clumsy in conducting experiments or who cannot adapt an experimental approach according to the conditions in the lesson is not an example of professionalism and creativity.
- Teacher training in the field of interactive methodology.

Both teachers and students need to become familiar with problem-solving methods. The history of science, encyclopedias, visits to museums, nature and the community are an important source of solved scientific problems. Particular attention must be paid to the creation of creative environments in schools that provide students with material resources and competent support. All these materials and activities make the development of students' creativity a real challenge to help students assimilate knowledge, but "without killing creativity" (Boden, 2001).

Piaget (1976) stated that "to understand is to create". Therefore, in order to understand knowledge in a creative way, teachers can encourage students to look for new alternative examples, analogies, descriptions, and explanations of a scientific theory or concept about the topic.

Students should be encouraged to develop an interesting and diverse range of scientific observations, to make classification, to ask scientific research questions, to formulate hypotheses, to plan tests and measurement methods, to use equipment or apparatus, and to draw conclusions from empirical data (Cheng, 2011). Furthermore, teachers can encourage students to construct concepts by exposing them to conflicting ideas, engaging them in debates, trusting the opponent's evidence (Driver, 1994). According to Cheng (2011), creativity can also be generated through scientific knowledge in different forms of expression. For example, knowledge, concepts, and principles can be presented in the form of role-plays, drama, music, images, poems, and stories. Creativity in education refers not only to artistic expression, but also to the ability to create new ideas and find unconventional solutions in different learning contexts, according to Beghetto and Kaufman (2010). Natural Sciences encourages students to explore and understand the world around them through experimentation, analysis, and observation

Creativity and Assessment in the Natural Sciences

It is known that it is very difficult to evaluate creativity. That is why new and effective methods to assess this complex skill are constantly being sought.

In order to appreciate the creativity of students in natural sciences in primary education, it is necessary to resort to alternative evaluation strategies, such as group projects

and portfolios (Torrance, 1996). Portfolios, for example, provide an overview of students' progress and allow the evaluation of the creative process that led to the results achieved. Portfolios also provide a more nuanced assessment of students' creativity, as they can include qualitative and quantitative elements.

According to Treffinger (1980), open-ended inquiry is another framework for assessing creativity because it allows students to choose the methods and resources needed to investigate a scientific problem and use them to achieve their goals.

Basically, scientific creativity is the ability to find new problems and the ability to formulate hypotheses, which usually involves more knowledge than the previous ones, while artistic creation can give life to new representations and feelings, thus, there is a difference between scientific creativity and artistic creativity (Liang, 2002). Torrance (1974) considered fluency, flexibility, and original thinking to be central characteristics of creativity.

Fluency means the number of original ideas produced, while flexibility is the ability to "change", not to be tied to an established approach, in order to work efficiently. Originality is statistical interpretation. A rare response, which occurs only occasionally in a particular population, is considered original.

As a result of several observations in primary, middle and high schools, a taxonomy of questions that enhance creativity has been developed (Lubart, 1994):

1) factual questions, which can be answered by searching in a textbook.

2) questions relating to scientific principles or laws and which can be answered by a statement of a scientific law.

3) questions related to the ability to transfer or apply ideas and knowledge. This capacity refers to innovation.

4) spontaneous questions, to satisfy a curiosity.

5) questions that refer/represent real problems that need to be solved.

3.8. Creative Learning Framework in Science Lessons

Effective teaching has been defined differently by different authors. Effective teaching is defined as teaching that produces the intentional learning of students through the use of an appropriate procedure (Centra, 1993).

Creative teaching involves an open, tolerant and collaborative learning environment, where all students have the opportunity to participate in the learning process, regardless of their abilities (Johnson & Johnson, 2018), helping each other and developing team spirit (Frost, 1997).

Active learning intends to contextualise instructional materials and students are placed at the centre of the learning process (Davies & McGregor, 2017). Activation involves the student's own effort and requires the adaptation and differentiation of their activity, respectively the dosage of intensity, duration and nature of the effort in different stages of an activity.

That is why the educational approach cannot bypass the following elements (Hong, et al., 2009): *establishing in the classroom a climate based on questioning, critical and creative thinking; clearly presenting the expected results*; *systematic use of different types of activities that lead to the development of students' creativity*; providing a *positive action* plan that gives students confidence in their ability to solve the problems they are studying; *realism and patience* of the teacher.

The use of collaboration methods determines in students more spontaneity, courage to express themselves and ask various questions, they learn that teamwork gives greater results and satisfactions than individual work (Horng et al., 2005).

A creative educational environment for teaching-learning the natural sciences

The purpose of creative teaching environments is to support and stimulate students' creativity by providing them with innovative and diverse ways to learn (Merchant et al., 2014).

The creative educational environment offers students the opportunity to come into contact with new objects, which generate curiosity. From contact with them, the child comes up with ideas and gets informed (Beghetto & Kaufman, 2010).

To create an engaging learning environment, teachers can make use of technology, as it is useful in creating innovative and interactive learning environments. The implementation of interactive technology in the educational instructional process has the potential to improve students' academic performance and motivate them to learn more (Merchant et al., 2014).

The classroom as a creative learning environment in science

Research by Souza Fleith (2000) confirms the influence of the classroom environment on the development of creativity. The purpose of their research was to investigate teachers' and students' perceptions of characteristics that either encourage or inhibit the development of creativity in the classroom environment. The results suggest that both teachers and students believe that a classroom environment, which enhances creativity, gives students the opportunity to make choices, produce and accept different ideas, increases self-confidence and focuses on their strengths and interests. On the other hand, in an environment that inhibits

creativity, ideas are ignored, teachers lead and control and the learning activity has a structure that is not very flexible to the events that intervene.

Therefore, teaching science classes in dull, unwelcoming, and personality-devoid classrooms discourages students' creativity. A creative teaching-learning environment can be created by modifying learning spaces to allow for diversity and flexibility in educational activities. There is a possibility that these areas will include spaces dedicated to scientific experiments, thematic learning centers and corners of independent exploration. Flexible learning spaces, which allow students to move freely and choose the activities that interest them most, increase student engagement and motivation (Beams et al., 2012; Fisher, 2005). Teachers need to work with students to improve the environment and personalize it.

I believe there are at least three things we can do as teachers to help create a classroom where creativity can be acquired: to orient the teaching process on creative skills and attitudes, to use creative methods, and to set up a problem-solving friendly classroom.

While children find ways to play anywhere with almost anything, some environments and materials are more conducive to creative play than others. Studies of children from different types of backgrounds indicate that children engage in more creative forms of play (including fantasy and play) in "green" or "natural" areas than in more traditional or "prepared" indoor playgrounds (Louv, 2006; Moore & Cosco, 2006).

Students work in many different formats, from group projects to solo assessments, listening to presentations, and more. We can create collaborative learning layouts to keep creativity flowing between different activities. Instead of lining up the benches, we can create pods, a U-shaped layout, or separate group tables where students can work together (Hong et al., 2009).

Learning outside the classroom

Outdoor learning experiences are particularly important in the teaching-learning of natural sciences in primary education, as they provide students with unique opportunities to observe natural phenomena live, gain practical skills, and stimulate interest in the environment. When the natural science curriculum includes outdoor activities, students can better understand theoretical concepts and apply knowledge to real-world situations. Research shows that outdoor education not only encourages active and participatory learning, but also encourages students to have a positive attitude towards science and influences them to develop an ecological mindset (Starko, 2010).

Outdoor education helps develop many skills, including cognitive, social, and emotional skills. The opportunity to participate in exploration and discovery activities that

promote critical thinking and problem-solving is an essential element of outdoor education. Observing animals and plants in their natural environment, taking measurements of environmental parameters (such as temperature and humidity), and conducting simple experiments contribute to a deeper understanding of science.

Studies show that, especially for primary school students, practical activities and play are essential for the learning process. Children who participate in outdoor learning activities tend to show a greater interest in scientific fields and perform better on knowledge assessment tests (Rickinson et al., 2004). Due to the collaborative nature of outdoor projects, these activities also improve social skills such as communication, cooperation, and teamwork.

According to Dillon et al. (2006), the success of outdoor education depends to a large extent on teachers' ability to design and implement activities that are relevant and tailored to students' needs.

In order to develop students' creativity through science lessons, we can experience several changes to ensure that the learning environment can accommodate a diversity of activities that respond to learning styles, students' needs, and curricular provisions.

In conclusion, in the instructive-educational process, creativity must be a constant from a methodological and cognitive point of view, but also a goal of the entire educational process.

CHAPTER 4. PRELIMINARY RESEARCH

4.1. Analysis of Studies on Creativity in School Practice

The analysis aimed to identify in the literature of the field ideas and methodological suggestions ***that would substantiate the studies necessary to be undertaken by the doctoral student, in addition to those already mentioned in the theoretical chapters***.

The issues analyzed were 11 in number, **covering the essential dimensions of creativity in education**: from policies and curriculum to teaching, technology, evaluation and professional training. **51 sources from the international literature were used** in the analysis, constituting a solid basis for empirical studies, case analyses or systematic reviews.

- *Creativity and educational policies.* The literature highlights a contrast between the stated intentions of educational policies to promote creativity and their real effects – often restrictive, through the emphasis on standardization and testing (Shaheen, 2010; Robinson, 2011; Hall & Thomson, 2005).
- *The relationship of creativity with the school curriculum.* Creativity develops more effectively when teachers have curricular freedom and involve students in lesson design (Cochrane & Cockett, 2007; Walling, 2009; Braund & Campbell, 2010). Rigid curriculum can inhibit creative behaviors (Schacter et al., 2006).
- *Creative teachers.* Creative teachers stand out for their long-term vision, intuition, and shaping their own creative involvement (Davies, 2006; Grainger et al., 2005). However, there is still insufficient literature on the specific skills needed by these teachers.
- *Creativity and teaching-learning practices.* Studies emphasize the role of teachers in facilitating students' creativity through flexible, student-centered and originality-centered teaching models (Jeffrey, 2006; Cheng et al., 2006; Grainger et al., 2015; Bancroft et al., 2008). Strategies such as verbal encouragement of creativity, incubation periods of ideas, and self-directed learning have been shown to be effective (Niu & Liu, 2019; Webster & Campbell, 2006; Cheung, 2012).
- *Creativity and use of technologies.* Educational technologies – from digital games to interactive whiteboards – can support creative thinking when integrated by teachers who are competent in the field (Horng et al., 2005; Jindal-Snape et al., 2011; Wood & Ashfield, 2018).
- *Collaboration of teachers and mentoring to encourage students' creativity.* Collaboration between teachers and partners (mentors, trainers, support and learning

networks, organizations, etc.) has a significant impact on promoting creativity and professional development (Sharp et al., 2005; Gkolia et al., 2009; Mullins, 2007; Wyse & Spendlove, 2007).

- *Creativity and evaluation.* A formative, process-centred assessment and constructive feedback is recommended (Davies, 2006; Heaney & Shaw, 2004).
- *Creativity and cultural differences.* Cultural differences can influence how creativity is evaluated. In their case study of two ethnically different schools in East London, Heaney & Shaw (2004) found that students appreciated opportunities to evaluate their and others' creative work as useful for learning.
- *Artistic activities and creativity.* The integration of the arts into the curriculum favors the development of creativity and self-efficacy in both students and teachers (Robson & Janniste, 2010; Cremin, 2006; Kandemir & Gur, 2007).
- *Premises of creative training.* Since the field of creativity in education tends to be somewhat nebulous and subject to a wide range of interpretations, it may be useful to present a conceptual framework dedicated to teachers to describe creative practices (Loveless et al., 2006).

In their research on creative projects carried out in 25 primary and secondary schools, Wyse & Spendlove, (2007) emphasizes the importance of bringing students up to date with the literature on creativity.

Newton & Newton's (2009) study of 16 science teachers teaching in primary education suggested that science teachers could familiarize students with the broader concept of "productive thinking," which is a combination of creative thinking and critical thinking, which is particularly relevant in science.

Braund & Campbell (2010), studying teacher training courses to teach at the age range of 11–16 years, present a variety of interventions, including lectures aimed at optimizing teaching through planning, the use of assessment, and lesson review. These interventions make the transition from conventional lessons to lessons that involve creativity and decision-making.

Howard-Jones et al., (2008) found, following a study on a development program involving 16 beginning teachers who explored their own creativity, that the ideas developed during the program could provide a useful and stimulating contribution to their teaching practices.

- *Barriers to the development of creativity*

Downing et al. (2007) identify barriers to school-level creativity, such as time and cost, school priorities, and a culture of keeping ideas rather than sharing

Wyse and Spendlove (2007) identify other barriers to change:

- organisational requirements, such as the requirements of competition imposed by the school and parents;
- such as national testing and curricula;
- regarding teachers' willingness to take risks.

Thomson and Sanders (2010) found that school leadership also faces difficulties in sustaining creativity, with staff turnover being a major obstacle that has hindered sustainable progress in this area.

Conclusions. The analysis supports the idea that promoting creativity in education – especially in primary education – requires a systemic approach, supported by flexible policies, adaptable curriculum, targeted vocational training and a collaborative culture in schools. This theoretical and empirical framework provides a solid foundation for doctoral student research on creativity in natural science teaching.

4.2. Exploring Teachers' Knowledge of Learning Styles and Their Usefulness in Developing Students' Creativity (Semi-structured interview)

Study rationale: Differences in children's learning styles and needs require educators to personalize the educational process (Mayar, 2022, p. 30). Sitar et al. (2016) emphasize the role of knowledge of learning styles in the development of creativity, both of students and teachers. by Souza Fleith (2000) emphasizes the importance of an educational environment that offers choices, accepts diverse ideas, and fosters students' confidence and strengths.

Purpose and objectives of the research. The research aims to explore the relation between learning styles and students creativity. The general obiective: to identfy how learning styles can be harnessed to stimulate students' creativity, highlighting effective methods and strategies.

Objectives of the investigation:

O1. To identify teachers' knowledge of learning styles and how to address them.

O2. Exploring the practices (techniques and methods) of the participants to stimulate the creativity of students with different learning styles.

O3. Identification of techniques and methods used by the participants for the development of students' creativity, under the conditions of the need to comply with the curriculum.

Methodology: 28 teachers from Sălaj county (17 rural, 11 urban), with various ages and backgrounds, participated in the questionnaire-based survey. Participation was voluntary, in compliance with ethical principles and informed consent. The research was conducted in September-October 2020, using semi-structured interviews (8 questions, average duration 25 min). Data collection was mainly done through notes, with only 5 respondents accepting audio recording.

Research results: Most participants are familiar with VAK/VARK learning styles and mention the difficulty of identifying individual student styles, given that many are multimodal. They do not know and/or have not used standardized inventories for diagnosis (e.g. Richard Oliver). However, teachers state that they are adapting teaching strategies to include a variety of styles: visual, auditory, reading/writing, kinesthetic, intuitive, reflective, sequential, global, activist, theoretical, and pragmatic while respecting curricular requirements.

Discussion of results and reference to the literature: the literature highlights the link between learning styles and creativity (Eishani et al., 2014), a fact also found in the survey. Jana et al. (2024) and Hidayah et al. (2024) show that visual learners score higher on creativity. Survey participants share the opinion expressed by Mukti & Soedjoko (2021) and Winiarsih et al. (2021), cited by Hidayah et al. (2024, p.202) who believe that children's learning styles have a significant impact on their creative thinking skills that is essential for flexible solving of problems in everyday life (Hashim et al., 2022; Octaviana & Kurniasih, 2020 cited by Hidayah et al., 2024, p.202). Also, the results of the doctoral student survey support the statements of Hidayah et al. (2024, p.202) and Sharp et al. (2005) who identify students with visual learning styles as those with higher levels of creativity and suggest that for the development of students' creativity, teachers must select teaching models or approaches based on students' learning styles.

Immediate implications: the relationship of teaching strategies with learning styles requires adaptations made to the strategies. Believing that learning styles can help students improve their creative thinking skills, future research should investigate the effectiveness of these strategies (Hidayah et al., 2024).

Limitations: lack of recording of interviews, which can lead to omissions in identifying participants' opinions.

Conclusions: the interviewed teachers show interest in diversifying teaching methods according to learning styles, even if they admit their incompetence or difficulties in identifying them individually. Adapting learning tasks and strategies is seen as a viable means

of stimulating creativity, provided that it is compatible with curricular requirements. Therefore, based on the present research, it can be concluded that learning styles address creativity to students in several ways: (i) direct address: learning style directly impacts creativity (Eishani et al., 2014); (ii) the selection of learning methods used in the lesson (Hidayah et al., 2024); (iii) the teacher's model: the creative teacher is a model of creativity for his students (Soh, 2017).

Future research directions. Digital technologies and software products related to individual learning styles would solve the problem of difficulties and high time consumption and would facilitate the development of students' creativity.

4.3. Teachers' Opinions on Capitalizing on the Learning Styles of Primary Education Students in Teaching

Study: Polbaci (Fazacaș) I., Pop, C. F., Ciascai, L. (2020). Exploring teachers' opinion about learning preferences of primary school students. In L. Gómez Chova, A. López, I. Candel Torres (Eds.), *ICERI 2020 Proceedings* (pp. 9157-9162), IATED. CROSS Ref. https://doi.org/ 10.21125/iceri.2020, doi: 10.21125/iceri.2020.2028. The work does not appear in another doctoral thesis. The PhD student designed, produced and processed the survey data, and co-author Pop Cristina collected the data and checked the translation.

Justification of the researched problem. The literature suggests the existence of a relationship between learning styles and creative thinking skills. Alkathiri et al. (2018) point out that although the two concepts have been intensively researched separately, the relationship between them has rarely been investigated. Allison & Hayes (1996, cited by Alkathiri et al., 2018) define learning style as "a type of preferential way in which a person learns, thinks, or solves problems."

Various researches highlight contradictory results. Thus, Marzuki et al. (2019) reveal differences in creativity between students with a visual style and those with a kinesthetic style. Kassim (2013) notes the absence of significant differences between sequential and global learners, although the latter scored better on all product creativity criteria. Moradi et al. (2015) indicate differences between learning styles and creativity, also mentioning the existence of studies that deny such a correlation. However, they also note a positive relationship between learning styles and creativity in the context of math performance. Eishani et al. (2014) argue that identifying learning styles allows teachers to adapt the learning environment to achieve educational goals.

Purpose of the investigation: In addition to the results of the above-mentioned studies, the survey focused on identifying the respondents' opinion regarding the learning styles of the

majority of their students (in primary education) in order to capitalize on them in a teaching based on creativity. The research consisted of a survey conducted in October 2020.

Objectives of the investigation:

O1. Exploring the respondents' opinion on the importance of taking into account students' learning styles in the teaching process

O2. Identify respondents' opinions on the moments of the lesson when taking learning styles into account is important.

O3. Investigate respondents' opinion on VARK, sequential, global, and active learning styles.

O4. Exploring respondents' views on their students' preferences for learning a (certain type of) learning content and context.

Research methodology

Participants and research design: The survey involved 168 primary school teachers. They voluntarily agreed to answer the questionnaire and gave their informed consent. None of the participants received monetary compensation. The study protocol obtained the approval of the Research Ethics Council at the Doctoral School.

Most of the respondents are female (95.24%), most of them belonging to the age group 40-44 years old (25.60%). 62.72% of respondents work in urban areas. The distribution of participants according to seniority in the department is balanced.

The tool used. The survey was conducted using a questionnaire with 40 items, presented in Annex 4. The tool was adapted by researchers from Barbara Soloman and Richard Felder - Index of Learning Style Questionnaire (1999). The questionnaire was translated from English into Romanian by 2 PhD students with an advanced level of knowledge of English and knowledge in the field of the subject of the questionnaire, as well as by an authorized translator, with a good knowledge in the field of educational sciences. From the three translations, the optimal variant in terms of language and content was selected. Using the jury method (10 graduates of a master's program) the content validation of the questionnaire was carried out. Next, the translated and analyzed version was retroversioned.

Results

(i) Respondents' opinion on the usefulness/importance of knowing the students' learning style

Answering on a five-level Likert scale, respondents consider it mandatory to know the learning profile of students (51.19% agree completely), useful (61.90% agree totally) and necessary (63.69% agree totally).

(ii) Respondents' opinion on lesson sequences where consideration of the learning profile is important

The answers were provided on a 6-step Likert scale, where 1 means Not at all important and 6 means Very important.

The hierarchy of the importance of learning styles in relation to the steps taken in the design of the lesson, calculated by summing options 5 and 6, is as follows:

(i) Choice of learning means and materials (69.64%, m=4.92, SD=1.29)

(ii) Establishing teaching-learning strategies (66.07%, m=4.85, SD=1.30)

(iii) Choice of assessment tools (61.91%, m=4.74, SD=1.34)

(iv) Establishment of evaluation methods (61.90%, m=4.75, SD=1.31)

(v) Elaboration of textbooks/support materials (58.93%, m=4.58, SD=1.44)

(vi) Setting learning objectives (57.14%, m=4.64, SD=1.39)

Therefore, students' learning styles must be considered, consider the majority of respondents (57.14%).

Percentage of teachers who consider learning styles in relation to:

- Most students: 74.4% (m=3.92)
- Groups of students: 69.04% (m=3.79)
- individual: 63.1% (m=3.73)

The correlations between items are significant and positive (r>0.9), indicating a coherent usage pattern.

(iii)Investigating respondents' opinion on VARK, sequential, global, and active learning styles

The analysis of the responses related to visual, auditory, written/reading, reflective and kinesthetic learning styles shows that in the opinion of respondents (68.45%) most of their students understand something better about a studied object (for example, what it is and how it works, etc.) if they can touch, maneuver, try it. 97.02% of respondents believe that their students remember better things they have done (writing, drawing, assembling) than those they have just thought about. 87.50% appreciate that students prefer to participate and contribute ideas in a group, instead of listening passively. However, respondents' appreciations (68.45%) highlight their students' preference for visual learning, suggesting that methods based on images, diagrams, and graphical representations are the most effective for teaching; 94.05% appreciate that students prefer to study images in books, not text; 89.88% believe that students prefer lessons in which images are built on the board and not lessons based on verbal explanations; 83.33% believe that students prefer maps and drawings to

locate an objective and not written instructions, 75.00% appreciate that their students prefer graphs and graphs instead of written summaries.

Conclusion: Teachers should allocate a greater weight in the lesson to the construction and presentation of images, in addition to exposures or tasks that involve movement or reflection.

(iii) Respondents' opinion on their students' preferences for sequential and global learning styles

The way in which students process information must be observed by teachers (Reid, 2005). Teachers (68.45%) say that when learning something new, most students stay with the big picture. In mathematics, however, when solving problems, most respondents (80.95%) believe that students prefer to solve them step by step. 67.26% respondents believe that students prefer material structured in stages; 75.60% progressive redaction; 86.90% group brainstorming.

The global learning style registers in the opinion of the respondents the highest percentages regarding the learning of new knowledge: understanding (68.45% respondents) and memorizing it (68.45% respondents). Also, when studying scientific content, 68.45% of respondents believe that students try to understand the big picture before focusing on details

(iv) Respondents' opinion on their students' preferences for learning a (certain type of) content

98.81% respondents say their students prefer to learn facts, not definitions

(v) Respondents' opinions on their students' preference for a particular learning context

60.71% of respondents agree that most of their students prefer to learn in groups.

Most of the teachers participating in the survey (52.98%) believe that students appreciate creativity (52.98% respondents) and only 47.02% that students prefer to be guided in completing tasks. Again, the percentage of teachers who appreciate that students choose to try to meet the requirements (57.14%) is the majority, while only 42.86% of respondents believe that students prefer to reflect before acting.

The vast majority of respondents (84.52%) believe that students prefer to use known and mastered methods. 68.45% of respondents appreciate that students learn at a constant pace.

Limits: This research was conducted on teachers who teach at the primary level. Generalizing data to other levels of education faces limitations. In addition, in this research

the questionnaire was the only data collection tool. The procedure used was based on memory and self-reporting. As a result, bias could be involved in the research.

Conclusions: Identifying the students' learning preference/style allows teachers to intervene on the content studied, the materials and the learning environment. As a result, most of the teachers participating in the survey consider it very important to know the learning styles and take them into account in their teaching activities. It should be noted that the present study focused on the opinion of the participating teachers regarding the learning styles of most of their students.

General recommendations: Teachers should identify the learning style of each student. The processing of the knowledge delivered to the students, the typology of tasks, the learning materials and the training and assessment strategies should be adapted to the learning styles of each individual student. In turn, students must also be trained how to identify their own learning style in order to learn effectively. Curriculum policy and decision-makers in the field of education should provide teachers and students with materials adapted to learning styles, textbooks that capitalize on students' learning styles, tools necessary to identify learning styles and training guides for teachers.

Recommendation on formative intervention: for creative teaching and the development of students' creativity, it should be noted that most of the students taught by the teachers participating in the survey preferentially use visual, active and sequential/logical learning styles. As a result, it is advisable for teachers concerned with creative teaching and the development of students' creativity to structure the content proposed for study to students in a visual, phased and reflective manner (which is meant to remedy some of the students' tendencies to proceed to solve a task without reflecting on it). Group activities and discussions should also be encouraged.

4.4. Exploring the practices used by teachers for pre-school and primary education regarding the artisanal manufacture of products for didactic use

The study represents a deepening of the study: Polbaci (Fazăcaș), I., Pop, C.F., Ciascai, L. (2021). Exploring preschool and primary school teacher practices in making hand-made teaching products. Flax. L. Gómez Chova, A. López, I. Candel Torres (Eds.), EDULEARN21 Proceedings (pp. 5927-5932), *IATED.* CROSS Ref. https://doi.org/10.21125/edulearn.2021, https://doi.org/10.21125/edulearn.2021.2296.

The present study uses a revised version of the questionnaire used in the article published by IATED and includes a sample of preschool and primary school teachers.

The problem of research. Mayar (2022, p.30) supports the idea that craft, a term of artistic origin, contributes to the development of students' creativity: "Children's freedom of expression is the main key that supports the growth of creativity". The activity of creating children through crafts is a complex activity, which includes, along with knowledge and experiences, processes such as generating ideas, imagination, using critical thinking skills, problem solving. Mannathoko et al. (2013, p.54) show that their study highlighted that "the teachers who participated in the study had limited knowledge and skills in art, crafts and design. None of them had specialized in this subject." Steers (2006, cited by Mannathoko et al., 2013, p. 56) argues that "creative students need creative teachers who are confident in taking creative risks.", in other words, teachers who are truly competent and experienced in these areas.

Purpose of the research

This study investigated the knowledge and practices of primary school teachers involved in product-making activities.

The investigation carried out aimed to investigate the following aspects: (i) the choice of the product to be made; (ii) documentation for the realization of the product; (iii) product design; (iv) the manufacture of the product; (v) process and product reflection; (vi) the management of difficulties, optimization and use of the product made; (vii) creativity in the process of making a product.

The survey was carried out in February-March 2022, the participants being teachers from Sălaj County, Bistrița and Cluj, contacted indirectly (not personally), through the zonal online groups of teachers.

Selection of participants: Participation was voluntary. The participants were informed that their personal data will be protected, their answers will not be related to them and that during the investigation they can withdraw at any time, without repercussions. Didactic

Doctoral School. Tradition. Development. Innovation has taken steps to comply with the Informed Consent.

Demographics: 121 primary and preschool teachers participated in the research. The vast majority of the subjects involved in the research come from Babeș-Bolyai University. 116 teachers are women and 5 are male. The majority (53.72%) of respondents have bachelor's degrees and 26.45% of respondents hold a master's degree. 45.45% of respondents teach at preschool level, 54.55% of respondents teach at primary level, in institutions in urban areas (61.98%) and rural areas (38.02%). As for the experience in the department, the share of respondents decreases with the increase in seniority.

The tool used was a questionnaire designed by researchers after the stages of invention described by Badders et al. (2007, p. S13). The questionnaire was submitted to the analysis of a group of 9 teachers (professors-masters) with an experience at the department between 10 and 20 years. He was then pre-tested by a group of 23 teachers. Based on the observations and suggestions received, the necessary revisions were made. For the study included in the thesis, 21 items were selected. The questionnaire was completed voluntarily in Google drive. Subjects rated each item on a scale of 1 to 4 where 1 means Never and 4 Always. The Cronbach alpha coefficient is o.954. To interpret the results, the weighted mean (m), the Standard Deviation (SD) and the relative frequency of responses on the Likert scale levels were calculated for each item. The questionnaire is presented in Annex 5.

The research is the deepening of previous research, carried out in 2021.

Results

(i) Choosing the product to be made

In choosing the products to be made, the survey participants show, the products that they find interesting (m=3.27, SD=.76) prevail, followed by those that they find fun (m=3.53, SD=.64) and only finally those that meet a need (m=3.14, SD=.78). One explanation would be that the responding teachers choose the products thinking about their students, who must be challenged to make the product through the interest it generates and who, at the same time, must enjoy the activity of making it.

(ii) Documentation for the production of the product

Respondents take an interdisciplinary approach to documentation, using knowledge from different fields (m = 3.39, SD = .65), seek to generate new connections between knowledge (m = 3.38, SD = .63) and combine their own ideas with ideas from other sources (m = 3.47, SD = .64).

The analysis of the results also reveals the reduced use of resources such as templates and worksheets (m = 2.91, SD = .96 with 32.23% percentage of respondents choosing option 4 - always).

Learning from the experience of others has a low average score (m= 2.98, SD=.80 always: 28.10%) but respondents say they listen to experienced people: "I want to find out how others do it to be successful" (m=3.55, SD=.66, always: 63.64%).

(iii) Designing a product

Regarding product design, respondents show that they use analogy (m=3.25, SD=.74, always: 40.50%) and critical thinking (m=3.38, SD=.67, always: 48.76%). to design a product. Make a draft, mock-up or prototype of the product (m=3.20, SD=.79.)

(iv) Making the product

The respondents affirm their work autonomy by building the necessary work tools (m= 3.29, SD=.69), using various techniques and materials to make the product (m=3.27, SD=.74). At the same time, they demonstrate efficiency and concentration, paying attention to the essential aspects of the task (m=3.50, SD=.60) and keeping systematic records (m=3.40, SD=.68). Perseverance and success orientation are reflected in the willingness to fix problems immediately (m=3.25, SD=.72) and to make more attempts to achieve the goal (m=3.45, SD=.69).

(v) Reflection on the process and product

Reflection refers first of all to the realized product (m=3.39, SD=.82, always: 57.85) then to the process (m=2.97, SD=.99, always: 38.84), the two reflective activities being separated not from the point of view of the average but from the point of view of the level of agreement. At a distance from the two mentioned activities occurs the exchange of ideas (m=2.90, SD=.83, always: 26.45)

(vi) Difficulty management, optimization and use of the product made

Respondents have a predominantly positive attitude towards failure, being willing to learn from mistakes (m=3.59, SD=.66, always: 68.60%). They are also concerned with product optimization (m=3.21, SD=.75, always: 39.67%). Regarding the renunciation of product manufacturing, the respondents' options denote a greater dispersion (m=2.71, SD=1.00, always: 26.45%), which can be interpreted as a greater resilience of some respondents in the face of failure.

(vii) Creativity in the process of making a product

References to creativity were the subject of all the activities involved in the creation of the product. In the analysis of the data at the stage level, we focused less on creativity,

preferring to centralize all actions related to creativity at the end of the study and to interpret the data. By selecting the items, we identified the following dimensions of creativity used in making the products:

Dimension 1: Generating and collecting creative ideas

The item "I generate ideas but also collect ideas from books, the Web or from others" has a high average and a small dispersion of answers (m = 3.47, SD = .64, always: 54.55% respondents). The same is true of the results in the item "I seek to generate ideas for new connections between knowledge when researching, designing or making a product" (m = 3.38, SD = .63, always: 46.28% and often 45.45%). The item "I am working on different components of the product at the same time, waiting for ideas" (m = 2.60, SD = .87) denotes the awareness of incubation as a source of ideas. Idea generation is an important feature of creativity.

Dimension 2: Using Creative Strategies

The items "I use analogy to make connections between knowledge and different things" (m = 3.25, SD = .74, always: 40.50%) and "I use, to stimulate the imagination, annotated visual representations when designing or presenting a product" (m = 3.27, SD = .67, always: 39.67%) suggest basing strategies on analogical reasoning and visual learning style, both of which can lead to a wide variety of ideas.

Dimension 3: Using creativity to make products

The items "I use my creativity when designing and making a product" (m = 3.51, SD = .62, always: 57.85%) and "I seek to discover creative uses for my products" (m = 3.39, SD = .66, always 57.85%) highlight the fact that teachers perceive creativity as being present in all three stages of making a product: documentation, design and manufacturing.

Size 4. Product optimization

The item "I am looking for product optimization solutions" registers a good score (m = 3.21, SD = .75) which reflects the critical analysis of the product and the creative action to improve it.

Size 5. Recognition of the teacher's creativity by colleagues

38.84% of respondents always consider the item "My colleagues tell me that I am a creative person" (m = 3.15, SD = .80) to be true.

Findings: the groups with high experience in the department 25-29 years old and 30 years old and over 30 years old have the highest averages for items that refer to creative manifestations in the artisanal realization of a product. For most of the items (6 items) that refer to creativity in making a product, the group with experience at the department 20-24

years old registers the highest average compared to the other groups. The item "I seek to generate ideas for new connections between knowledge when researching, designing or making a product" registers the highest average (m=3.86). The group with teaching experience 30 and over 30 years old recorded the highest averages in the items "I use my creativity when designing and making a product" (m=3.76, SD.471) and "My colleagues tell me that I am a creative person" (m=3.50, SD=.814).

Conclusions

The results of the study reveal that, although handmade products made in preschool and primary education are simple, teachers perceive them as the result of a complex and creative process. They believe that their realization requires thorough documentation, designing a model based on schemas, critical thinking and integrating knowledge from several fields. The execution involves the use of various materials and techniques, a systematic approach and detailed documentation of the entire process. The teachers adopt an active and creative method, characterized by interdisciplinary exploration, adaptation and reinterpretation, thus offering a model of seriousness and creativity worthy of being followed by the students.

4.5. Teachers' Opinions on the Manifestations of Teachers' Creativity in Teaching Natural Sciences

The study included in the thesis is a revised version of the study:

Pop, C.F., Ciascai, L., Polbaci (Fazacaș), I. (2021). Teachers' opinions on the manifestations of teacher creativity in the teaching of natural sciences. In L. Gómez Chova, A. López, I. Candel Torres (Eds.), *EDULEARN21 Proceedings* (pp. 5927-5932), IATED. CROSSRef. https://doi.org/10.21125/edulearn.2021. The work does not appear in another doctoral thesis. The PhD student designed, produced and processed the survey data, and co-author Pop Cristina collected the data and checked the translation.

In Romania, there is very little research on the creative teaching of natural sciences in primary education. The research aimed to identify teachers' opinions related to the manifestation of their creativity in science classes in primary education, respectively to analyze how teachers view creativity and promote it through teaching and what kind of context and support are needed for teachers to cultivate their students' creativity.

The survey aimed to investigate the following aspects: a) respondents' opinions on creativity; b) the respondents' opinions on the role of the teacher in the development of the student's creativity; c) teachers' opinions on the relationship of creativity with the learning environment; d) the respondents' opinions regarding the sequences of the lesson in which

creativity intervenes.

The period was April-May 2021.

Research methodology

The research involved 122 teaching subjects invited online through teacher networks. The sample of respondents was random.

Selection of participants: Participation was voluntary. The participants were informed that their personal data will be protected, their answers will not be related to them and that during the investigation they can withdraw at any time, without repercussions.

Demographic profile of respondents. The vast majority of the subjects involved in the research come from Babeș-Bolyai University. 94.26% of respondents are women, 47.54% of respondents have bachelor's degrees and 47.54% of respondents hold a master's degree. 48.36% of respondents teach at primary level, 22.95% at preschool level and 19.67% at secondary school level. The experience at the department is varied, with relatively balanced weights. The respondents work as teachers for primary education (48.92%), preschool (25.42%) and secondary education (19.67%).

The instrument used was a questionnaire adapted by researchers after D. Aishe (2014), Morais and Azevedo (2010) from which, for the present study, 33 items were selected. The questionnaire was completed in Google Drive, on a voluntary basis.

The participating teachers rated each item in the first three groups (tables 1, 2, 3) on a scale from 1 to 5 where 1 means total disagreement and 5 means total agreement. Cronbach's Alpha coefficient is .918.

Research procedure

To interpret the results, the mean response to each item and the Standard Deviation (SD) were calculated. The subjects' answers were also analyzed according to their experience at the department, seen from the perspective of teaching degrees: no definitive, definitive in education, grade II and grade I.

Results

(i) Respondents' views on creativity

The percentage of respondents who consider creativity to be an innate talent (30.33%) is lower than that of respondents who dispute the statement (41% respondents). This result is in relation to the percentage of respondents who support the statement "Anyone can be creative" (81.14% respondents). The majority of respondents express their total agreement with reference to the items: "Creativity can be developed in any person" (54.92%) and "Creativity is a skill that can be developed in each object of study" (60.66%).

The analysis by groups of teaching experience shows that the 8 respondents without a final degree appreciate at a higher level the item "Creativity is an innate talent, not acquired" (m=3.06, SD=1.25). The highest average for respondents with experience in the department between 2 and 6 years is obtained for the item "Anyone can be creative" (m=4.35; SD=1.10 respectively m=4.36; SD=.66). For the respondents with the second teaching degree, the highest averages are obtained for the items "Creativity can be developed in any person" (m=4.45; SD=.96), "Creativity is a skill that needs to be developed in school" (m=4.64; SD=.49) and "Anyone can be creative" (m=4.36; SD=.66). Respondents with high teaching experience (first-grade students) value the items "Creativity is a skill that needs to be developed in school" (m=4.14; SD=1.14), "Creativity can be assessed" (m=4; SD=1.12), "Creativity is an innate talent, not acquired" (m=3.06; SD=1.25) and "The development of students' creativity must be a goal of current education" (m=4.44; SD=.75).

(ii) Respondents' opinions regarding the role of the teacher in the development of students' creativity

90.16% of respondents say that teachers should be concerned with the development of students' creativity, and 71.31% admit that the teacher can inhibit creativity. Only 37.71% agree that teachers need to be specially trained to recognize creative students, which indicates a possible underestimation of the importance of professional training in the field of creativity. Teachers with grades II and I appreciate the teacher's role in stimulating creativity the most (m over 4.5 in the item about the teacher's involvement in the development of creativity).

(iii) *Results related to the characteristics of the environment that favor the development of the student's creativity*

Respondents are skeptical that students have enough time in class (only 31.15% agree) and that school is the most appropriate place for educating students' creativity (38.52%). However, 81.15% agree that some disciplines favor creativity more than others and 77.87% support the inclusion of creativity in the curriculum. Only 63.93% believe that students have creative opportunities in any lesson, which suggests unevenness in the application of teaching strategies. The highest percentage of respondents appreciate with total agreement the item "In some subjects, students can be more creative (than in others)" (53.28% total agreement, m=4.31; SD=.85) and "The school curriculum must provide for the development of students' creativity" (51.64% total agreement, m=4.23; SD=.96). The analysis by groups of teaching experience highlights the fact that, in the case of respondents with the first grade, the highest averages are obtained for the items "At any lesson/teaching activity, students have many opportunities to manifest themselves creatively" (m=3.87; SD=1.12), "In some subjects,

students may be more creative (than in others)" (m=4.32; Sd=.82) and "The development of students' creativity forces the teacher to design his lessons in detail" (m=4; SD=1). For the rest of the items, the respondents with the second teaching degree register the highest averages.

(iv)Results related to the application of the teacher's creative skills to the design and implementation of the lesson

Cronbach's Alpha calculated for the category of items related to the application of creativity in the design and realization of the lesson is .957. The lowest percentage of agreement is recorded with reference to the use of creativity in defining competences.

The highest percentage of respondents who express the option of *Completely agree* is recorded with reference to the items: "Development of assessment tools" (43.44% respondents), "Adaptation of teaching strategies to the concrete conditions of application in the classroom" (39.34% respondents), "Choice and application of strategies" (36.07% respondents) and "Selection of necessary educational means" (35.25% respondents).

Conclusions

The study reveals that teachers recognise the potential of creativity in education, most agreeing that it can be developed and harnessed in any field. The results highlight negative perceptions related to the available time and the adequacy of the school environment, which indicates the need for structural and curricular reforms. Creative teachers are a model of creativity that can be transferred to students through the right teaching-learning strategies.

4.6. Teachers' Opinions on the Manifestations of Students' Creativity in Natural Sciences Study Activities

Stan (Fazacaș), I. (2023). Opinions of teachers on the manifestations of students' creativity in the study of natural sciences. *Educational Alternatives, 21*, (1314-7277). *Journal of International Scientific Publications*. https://doi.org/10.62991/EA1996164654

The purpose of this study is to identify the teachers' opinions regarding the development of students' creativity in teaching practice, in general and through the study of natural sciences, in particular.

Objectives:

a) identifying the respondents' opinions regarding the development/stimulation of students' creativity;

b) exploring the respondents' opinions on the characteristics of the creative student;

c) identifying the respondents' opinions regarding the barriers encountered by students in the development of creativity;

d) exploring teachers' opinions on the relationship of creativity with the study of natural sciences.

Research Methodology

The research carried out consisted of a questionnaire-based survey. The period was October-December 2023.

Participants. The research involved 112 teachers from all over the country, from educational institutions in rural and urban areas. The vast majority of the subjects involved in the research come from Babeș-Bolyai University. 88.5% of respondents are women, 41.6% of respondents have bachelor's degrees and 47.8% of respondents have a master's degree, the rest of the participants being doctoral students. 61.9% of respondents teach at primary level, 17.7% at preschool level and 8% have the specialty of teachers, 2.7% educators and 9.7% in secondary and high school education.

Selection of participants. Participation was voluntary. The participants were informed that their personal data will be protected, their answers will not be related to them and that during the survey they can withdraw at any time, without repercussions.

Tool used

The questionnaire was applied online, participation being voluntary. Responses were collected using a 5-step Likert scale from 1 to 5, where 1 means total disagreement and 5 means total agreement. The investigation was carried out over a period of two months in the second semester of the 2022-2023 academic year.

Results

(i) Respondents' opinions on the development of creativity in general and in teaching practice, in particular

The answers received appreciate the role of the teacher (Q14: m=4.56; SD=.655 and Q17: m=4.44; SD=.720) and interactive methods (Q16: m=4.42; SD=.743) in the development of students' creativity. Respondents appreciate that students' creativity can be developed through natural science lessons (Q12: m=4.21; SD=.821), but they do not have an essential role.

Table 1.4.

Statistical indicators (mean and standard deviation) related to the scores recorded in the general questions on the acquisition of creativity, Q11->Q17, depending on teaching experience

Experience at the department	Respondents	Q11. Creativity can be learned	Q12 Students' creativity can be developed in natural science classes	Q13. Natural sciences are essential subjects for the development of students' creativity	Q14. A teacher should help his students develop their creativity	Q15. The school where I teach focuses on stimulating students' creativity	Q16. I use several interactive methods in my class/group to stimulate	Q17. I am an example of a creative person for my students
	/ (f)	m/ SD	m/SD	m/SD	m/SD	m/SD	m/SD	m/SD
Under 5 years old	11.61 (13)	3.77 1.301	4.00 .913	3.62 .961	4.69 .480	3.77 1.013	4.46 .660	4.54 .660
5-9 years	9.82 (11)	3.36 1.206	3.82 1.250	4.27 1.272	4.45 .820	4.27 1.009	4.55 .688	4.45 .934
10-14 years	13.39 (15)	4.13 .640	4.53 .640	3.87 .516	4.67 .724	3.87 1.187	4.33 .724	4.47 .737
15-19 years old	16.99 (19)	4.00 .816	4.11 .737	3.79 .976	4.37 .684	3.95 .911	4.21 .976	4.32 .582
20-24 years old	20.54 (23)	4.26 1.096	4.39 .722	4.04 .928	4.74 .449	4.22 .951	4.61 .656	4.48 .846
25-29 years old	12.50 (14)	4.07 .917	4.50 .760	3.79 .893	4.57 .646	4.29 .726	4.64 .633	4.64 .497
30-34 years old	9.82 (11)	4.00 1.000	4.18 .751	3.82 1.079	4.55 .688	4.45 .522	4.18 .603	4.37 .674
Other value	5.36 (6)	3.33 1.211	3.67 .516	3.50 1.049	4.17 .983	4.17 .983	4.17 .983	4.17 .983
Total	112	3.96 1.026	4.21 .821	3.87 .944	4.56 .655	4.11 .933	4.42 .743	4.44 .720

The highest average scores in *the general questions about the acquisition of creativity* were recorded in the category of respondents with a seniority in education of 20-24 years, followed by the category of seniority 25-29 years. The lowest average scores appear in the case of those who have a seniority in education exceeding 34 years in relation to all the questions asked. The seniority categories 15-19 years and 5-9 years respectively rank next two in terms of the relatively low average score expressed in relation to *the general questions about acquiring creativity*. The same method shows that there are no statistically significant differences between the average scores obtained in the *general questions about the acquisition of creativity* according to the teachers' experience.

Table 2.4.

Statistical indicators (mean and standard deviation) related to the general questions about the acquisition of creativity according to the factor of the respondents' studies

Respondents' studies	Respondents / N	Q11. Creativity can be learned m/SD	Q12 Students' creativity can be developed in natural science classes m/SD	Q13. Natural sciences are essential subjects for the development of students' m/SD	Q14. A teacher should help his students develop their creativity m/SD	Q15. The school where I teach focuses on stimulating students' creativity m/SD	Q16. I use several interactive methods in my class/group to stimulate students' creativity m/SD	Q17. I am an example of a creative person for my students m/SD
Secondary school	7.1 8	3.88 .641	4.13 .835	3.88 .641	4.50 .765	4.13 .641	4.00 .535	4.13 .835
License	41.6 47	4.02 1.093	4.13 .824	3.79 .999	4.51 .655	4.11 .983	4.45 .775	4.49 .718
Master	47.8 53	3.94 1.008	4.32 .803	3.91 .946	4.62 .657	4.09 .986	4.47 .723	4.45 .637
Doctorate	16.99 19	3.50 1.291	4.00 1.155	4.25 .957	4.50 .577	4.25 .957	4.25 .957	4.25 1.500
Total	112	3.96 1.026	4.21 .821	3.87 .944	4.56 .655	4.11 .953	4.42 .743	4.44 .720

The recorded responses emphasize the fact that Natural Sciences is considered an essential discipline for the development of students' creativity by doctoral students (m=4.32; SD=.803). All categories of respondents appreciate that the teacher has an important role in the development of students' creativity (m≥4.50).

The highest average scores in the *general questions about creativity development* were recorded in the category of master's degree respondents, followed by the doctoral and bachelor's degree category. The lowest average scores appear in the case of those who have graduated from high school.

Components of creativity. Cronbach's Alpha coefficient for the category of items describing the components of creativity is 0.868. The highest average scores are recorded for items that relate creativity to imagination (m=4.66; SD=.594) respectively inventiveness (m=4.65; SD=.581) and the lowest average score is recorded for the item "Creativity involves linguistic products" (m=3.88; SD=1,063). Items that refer to common traits of creativity and scientific knowledge have high average scores: divergent thinking (m=4.46; SD=.734), original ideas (m=4.49; SD=.735). The exception is the resolution of problems for which the lower average score (m=4.23; SD=.920). The component "Creativity involves imagination" registered the highest percentage of agreement from respondents, 72.3%.

ii). Respondents' opinions on the characteristics of the creative learner

According to the teachers' answers, the profile of the creative student includes a rich imagination (m=4.60; SD=.592), creative thinking (m=4.57; SD-.694), open-minded (m=4.46; SD=.721), curiosity (m=4.45; SD=.757), intuition (m=4.32; SD=.738) and flexible thinking (m=4.30; SD=.826). Most of these traits are valuable for the study of the natural sciences. It should be noted, however, that there are two important traits for the study of science: risk-taking (m=4.11; SD=.904) and deep thinking (m=4.09; SD=.916) who do not register high average scores as characteristics of creativity. Cronbach's Alpha for the category of items that present the traits of the creative student is 0.915.

As for the respondents' students, they record average scores in the range [4.13-4.31] regarding the capacities of knowledge transfer and deepening, concentration, identification of new solutions or their adaptation, etc.

The highest percentage of respondents, 51.8%, fully agree with the option "My students have the ability to identify new solutions". At the same time, teachers agree that in the Natural Sciences class their students have the ability to creatively adapt known solutions (m=4.31).

(iii) Respondents' opinions on the barriers encountered by students in the development of creativity

The highest percentage of respondents, 23.2%, consider *the lack of resources* and the rigidity of teachers (17%) a barrier encountered by students in the way of capitalizing on

creativity. The lowest percentage of respondents, 2.7%, consider *the Internet and Limited Vocabulary* a barrier faced by students to capitalize on creativity.

Conclusions

The study confirms the perceived importance of creativity in education and the recognition of the active role of the teacher and interactive methods in stimulating it. The natural sciences are considered a valuable discipline in this regard, but not essential. Seniority in the department and level of education slightly influence perceptions, but not statistically significant. The research provides a relevant foundation for the development of teaching strategies that harness students' creative potential, especially through active, interdisciplinary and student-centered methods. However, some evidence suggests that teachers who are more creative find student characteristics associated with creativity more desirable in the classroom (Kettler et al., 2018).

General conclusions on preliminary investigations

The preliminary research is based on a review of the literature in the field and a number of over 50 articles describing research conducted on the creativity of teachers and students. On this basis, investigations were carried out regarding:

- *Learning styles of teachers and students* surveyed (subchapter 4.2) and exploratory study (subchapter 4.3) for which the target group was teachers. It should be noted that teachers are to a small extent knowledgeable about their students' individual learning styles. As a result, they use in their teaching practice learning styles: VAK/VARK, sequential, global, intuitive and convergent that address the class group or groups of students. Resorting to these learning styles is useful in science lessons because it facilitates the acquisition and practice of the methods of scientific knowledge and, consequently, the development of students' creativity through science lessons.
- *The process of making a hand-made product* is representative of the learning activities of primary school students because it includes documentation, knowledge relating, (staged) design of the approach and the product, imagining the product as a whole, formulating explanations, developing schemes, drawings, divergent and critical thinking, imagination and problem solving. In addition, hand-made products made by students in various disciplines are often used later in science learning.
- *Teachers' opinions on the manifestation of teachers' and students' creativity in science lessons* represent two investigations that complement each other and which, together with the other researches, guide the formative intervention.

CHAPTER 5. RESEARCH ON THE DEVELOPMENT OF SCHOOL PERFORMANCE OF STUDENTS IN THE PRIMARY CYCLE – THIRD GRADE THROUGH A CREATIVE TEACHING-LEARNING PROGRAM

5.1. Introduction to the research issue

There is evidence that involving educators in creating new resources in the classroom is beneficial. For example, after their involvement in the design of game-based learning, 21 teachers in Spain became more inventive (Frossard et al., 2012).

With all this in mind, we have structured the lessons in such a way that creative teaching-learning methods are included as often as possible. Some of them I used frontally, individually or in groups of students, depending on the teaching tasks pursued.

In organizing the experiment, we started from the knowledge of the psycho-physiological age particularities of the students and we ensured the adaptation of the activities to the students' learning rhythm, respectively the use of didactic strategies that respond to the individual learning styles of the students.

5.2. Research objectives and assumptions

Preliminary research has shown that primary school teachers practice creative teaching in teaching activities, but not systematically, i.e. they are not concerned with the creative training of students.

The aim of this research is to study the development of school performance (in two components: creativity and achievement in science) among third-grade students within the context of a creative teaching-learning activity system. The research aimed to verify the contribution of a creative teaching-learning program implemented in the subject of Natural Sciences to the level of creative abilities and school performance in Science.

The program includes methods and techniques to stimulate students' creativity, identified in the context of preliminary research.

Research objectives:

O1: Develop a creative teaching-learning model for science lessons.

O2: Application of the intervention program in experimental classes.

O3: Identify the levels of creativity and school performance in the applied tests.

O4. Interpretation of the results regarding creativity and school performance, from the point of view of their evolutions in the three tests for the experimental group.

General hypothesis of the research: The implementation of a creative teaching-learning program in the Natural Sciences discipline, in the third grade, contributes significantly to the development of students' creativity and their school performance.

Secondary hypotheses of the research:

Hypothesis 1: The teaching-creative learning program in the Natural Sciences discipline third grade contributes significantly to the development of students' creativity.

Hypothesis 2: The teaching-creative learning program in the Natural Sciences discipline third grade contributes significantly to the development of students' school performance

Hypothesis 3: There are significant post-test differences between the experimental and control groups by gender, if the creative program is applied.

Hypothesis 4: There is a statistical correlation between creativity and school performance.

Research variables

a) Independent variable:

* Intervention program focused on the development of students' creativity;

b) Dependent variables: *the level of*

* Students' creative abilities;
* Students' performance in the natural sciences;

c) The controlled variable:

* School discipline;
* Age of students.

5.3. Methodology (pair sampling)

Research design:

Study with paired sampling and comparison between experimental groups and control groups. The participants were selected through convenience sampling, with the agreement of the Ethics Commission, the School Inspectorate, the school management and parents.

Experimental group: 85 students from the third grades A, C, D – "Simion Bărnuțiu" Secondary School Zalău; Control group: 80 students from third grades A, B, C – "Corneliu Coposu" Secondary School in Zalău. The classes are heterogeneous, balanced in terms of age, gender and background. The level of classes is balanced in terms of age, gender and background, which is good to very good.

During the experimental approach, the students were observed and aspects related to the methods used and the involvement of the students in the lesson were noted, the development of the educational activities carried out traditionally versus those carried out by applying the active-participatory methods of stimulating creativity was observed.

Tools used in research

Tool 1. The Wallach-Kogan creativity test. This test was used in the pre-test and post-test stage. The Wallach-Kogan test is used to measure creativity in children, especially in terms of divergent thinking. The ease of its application makes it preferred and used in many studies (Wallbrown et al., 1975).

Tools 2,3,4. Knowledge tests. These tests were applied to students in the three test stages and were also based on the Wallach-Kogan Creativity test.

Data processing procedure.

For the statistical processing of the survey data, the IBM SPSS Statistics for MacOS software, version 29.0.0.0(241) was used. The continuous variables were characterized using the statistical indicators listed below: mean value, standard deviation, minimum value and maximum value. Categorical variables were analysed as both absolute frequency and percentage.

Research period: the research was carried out during the 2023-2024 school year in the Natural Sciences discipline.

Formative intervention program

During the experiment, the following steps were completed: pre-test, post-test and re-test. The knowledge tests used are described in the content of the paper but also in Annexes 8-12.

The questionnaire was also used as an important tool through which one can receive real, in-depth feedback.

5.4. Results in the Pre-experimental Phase

The pre-experimental stage included an initial test to detect the level of creativity of students in the third grade, applied to both experimental and control classes and took place in December, the 2023-2024 school year. The Wallach-Kogan creativity test was applied.

Creativity and school performance analyzed in the pre-experimental phase

The paper presents the mean values and standard deviations of the scores describing the quantified creativity in the pre-experimental phase (at the initial test), differentiated

according to the group of respondents (experimental group/control group) and the analyzed item (I16, I17, I18). The Cronbach's alpha coefficient for the items used in this study is 0.272.

Items of the creativity test initially applied:

I16 - Present the types of natural resources through a drawing/diagram/story.

I17 - Name actions to protect the environment

I18 - How would you use natural resources to provide shelter for your pet?

The *single-factor Anova method* shows that there are no significant differences between the *experimental and* control *groups in* terms of students' creativity quantified through items I16 (F=1.193, p-value=0.276), I17(F=2.736, p-value=0.100) and I18(F=0.679, p-value=0.411), respectively, in the pre-experimental stage. In the initial test, the group does not influence the creativity of the 3rd grade students in the subject *of Natural Sciences*. The highest average score, 3.79, was recorded in the experimental group for the question "*Name actions to protect the environment*", which demonstrates interest and responsibility for the future of the planet, aspects cultivated since primary school.

The tests applied, through the specificity of their items, simultaneously measured the creativity and school performance of the students. As a result, there were no significant differences between the experimental group and the control group in terms of school performance in the natural sciences either.

5.5. Description of the training intervention

The training intervention took place between January and June 2024.

The guide used in the formative intervention was built on the basis of the models proposed by Șuteu and Ciascai (2024) and Hong et al., (2009) and totals 120 pages.

Șuteu & Ciascai (2024) describe the creative teaching-learning approach and Hong et al. (2009) specify five strategies for developing creativity recommended to be used by the teacher in the teaching process:

- Multiple perspectives in solving tasks and problems. Guilford (1967), characterizes creative thinkers as generators of new, multiple, and divergent ideas. Runco (2003) who looks at creativity as a problem solving that leads to the construction of new meanings.
- Knowledge transfer and strategies. This transfer capacity is characteristic of students who are able to flexibly use knowledge, skills and strategies.
- Commitment to pregnancy (Renzulli, 2002 cited by Hong et al., 2009).
- Use creative skills in as wide a variety of situations as possible.

- Collaboration, as a way of facilitating and maintaining the creative process (Hong et al., 2009).
- Capitalizing on learning styles in the learning strategies used.

Strategies included: experiment, project making, questioning and explanation, questioning based on open-ended questions; solving problems that require the imagination; composing problems with various solutions (by surplus data or by less data); creating a product from surplus items (more than would be needed); problematization; artisanal production of some products; completing some incomplete texts, completing a story, composing a poem; composing a story about a situation or character; creating a game; participation in games, mobile learning.

The model that is the basis of the formative intervention program was created following the research of the literature in the field, preliminary research, consultation with the methodists of the methodical center in Zalău, with the teachers who teach in the third grade. The model is adapted to the age of the students and is flexible, allowing the choice of strategies according to the learning objectives, the learning content and the skills needed to be developed as well as the particularities of the class of students. It was proposed to the professors of the online experimental group and analyzed and reviewed with fellow teachers, fellow master's students and fellow doctoral students, in the context of 3 meetings.

The following are the topics that were the subject of the experimental research: 1) Growth, development and multiplication in plants and animals. 2) Characteristics of living things. Basic needs. 3) Ways of adaptation and defense to plants. 4) Ways of adapting and defending animals. 5) Insects, fish, amphibians. General characteristics. 6) Reptiles, birds, mammals. General characteristics. 7) Activity and rest. 8) Maintaining health. 9) Living bodies and lifeless bodies. Properties of bodies. 10) The states of aggregation of bodies. 11) Metals. Properties and use. 12) Magnets and their uses. 13) Movement and rest. Features of movement. Duration. Distance.Velocity. 14) Forces that cause interactions between bodies. The effects of interactions between bodies.

For each theme, the set of operational objectives and tasks required of students was indicated, in the context of teaching for the development of creativity.

5.6. Results in the Post-Test Stage

Results of the knowledge tests: At the final test, the means of the experimental sample for the items of knowledge recall (memorization) and knowledge comprehension & application MGr Exp recall = 25, SD = 5.175 and MGrExp understanding and application = 31.74, SD = 4.846l are statistically differentiated t = -11.622, p = .001. For the knowledge in the recall

category, the means Mmale=24.27, SD=6.509 and Mfemale=26.02, SD=5.038 do not differ significantly: t=-1940, p=0.054. On the other hand, in the category of understanding and application Mmale=30.91, SD=6.171 and Mfemale=32.90, SD=4.133, t=-2.450, p=0.015 differ significantly.

Creativity analyzed in the post-test phase

Wallach-Kogan creativity test: The average of the experimental group is 11.28 and the control group is 9.22. t(164)=3.604, p=.000. There are significant differences between the averages of the two groups at the final test.

The Cronbach's alpha coefficient for the items used in this study is 0.757.

The items analyzed in the posttest are:

I14 - Three friends went to a café. The first left by bus, the second on foot and the third by bicycle. Who got to the café first? Why?

I15 - To get to the café, the three decided to turn their way into an adventure. Describe the route of each one according to the chosen means of transport. Which of the three ended up last?

I16 - In what order did the three friends arrive?

What recyclable materials would you use to make a means of transport that will help you get to the café faster than on foot. Describe/draw its manufacturing process.

I17 - Describe in a creative way measures to protect the environment. (Solution 1)

I18 - Describe in a creative way measures to protect the environment. (Solution 2)

I19 - Describe in a creative way measures to protect the environment. (Solution 3)

The *single-factor Anova method*, the Welch test applied in the case of unequal variances shows that there are significant differences between *the experimental group* and the *control group* relative to the scores obtained in the final test in terms of students' creativity quantified respectively by means of items I14 (W=11.541, p-value<0.01), I15 (W=26.504, p-value<0.01), I16 (W=27.658, p-value<0.01), I17 (W=4.471, p-value<0.01), I18 (W=53.122, p-value<0.01), I19 (W=135.255, p-value<0.01).

As for **the science knowledge test**, the averages of the two groups are: Mexp= 56.74, SD=8.481 and Mcontrol=57.66, SD=11.176. The means of the experimental and control groups do not differ statistically: t=.594, p=.553, but the results are in favor of the control group.

The means of the experimental group at the initial and final tests differ statistically: t=2.387, p=0.019.

We explain the result obtained in the knowledge items by the fact that the teachers in the experimental classes allocated more time to the development of the students' creativity than the teachers in the control classes who focused their activities only on the development of

scientific knowledge. We remind you that the curriculum and textbooks do not pay attention to the development of students' creativity.

5.7. Results in Remote Testing

The retest took place in the fourth grade (the former third grades involved in the research) at the end of September of the 2024-2025 school year.

Upon retesting, the averages of the experimental group in the two categories of knowledge MGrExp recall = 24.35, SD = 5.763 and MGrExp understanding and application = 33.06, SD = 3.865 are statistically differentiated according to the categories of knowledge t = -15.657, p = .001

The t-test for independent samples shows that there are no significant differences between the total scores recorded in the final test respectively at the retest (t=0.231, df=168, p>0.05) by the experimental group. This result can be interpreted as follows:

Learning was reinforced and retained in the long term: students did not regress in knowledge and skills, which means that the methods applied helped them assimilate and retain information;

The possible capping of progress after the post-test can be explained by the fact that the methods applied had the maximum effect in the period between pre-test and post-test, and then the progress stabilized. It is also possible that students have reached an optimal level of learning in relation to the methods applied, and new strategies may be needed for further improvements.

The retest confirmed that the creative methods did not negatively affect the learning of other types of knowledge:

- If the creative methods focused on the development of critical thinking and creativity, but the scores on all types of questions remained stable, this means that **there was no imbalance** between the types of skills developed.
- Sometimes, creativity-centered methods can lead to decreased performance in more structured areas of memory, but in this case that didn't happen.

The need for a more detailed analysis - for a deeper understanding, the teacher could:

- Analyze the types of questions -individually (e.g. memory, logical reasoning, practical application) to see if some categories were more affected than others.
- He studied whether there were individual variations between students, that is, whether some continued to progress and others maintained the same level.
- Investigate students' motivation for retesting, as sometimes they don't make the same effort as they did in the post-test stage.

Analysis of the results according to the gender of the students:

Table 1.5

Descriptive statistics of the average creativity score obtained in the experimental group according to the gender of the respondents

Descriptive statistics

	Test Type	*N*	*Mean*	*Standard deviation*
Average creativity score	Girls	49	4.45	0.95
	Boys	36	4.21	0.71

Table 2.5

Results of the t-test comparing the average creativity score recorded by the respondents in the experimental classes in the retest stage, in the girls/boys group

t-test for independent samples

	t-test for equality of means		
	t	Df	p
Average creativity score	0.129	83	>0.05

The t-test for independent samples indicates that there are no significant differences between the average creativity scores recorded in the retest stage, between girls and boys (t=0.129, df=83, p>0.05). The same situation is found with regard to scientific knowledge. Thus, at the initial and final testing, the averages of the students involved in the research do not differ statistically according to gender:

At the initial testing, the sample of students involved in the research did not statistically differentiate at the initial testing according to gender: Mmale = 57.21, SD=12.97 and Mfemale=58.98, SD=11.56, t=-.918, p =.360. The same observation is valid for the post-test: Mmale = 55.62, SD = 9.936 and Mfemale = 57.66, SD = 18.265. The sample of students involved in the research is not statistically differentiated according to gender t=-1.088, p =.280

The fact that *there are no significant differences between boys and girls* at retesting suggests that the strategies applied were *inclusive, that* they did not favour a particular group (experimental or control), and that *they were balanced and accessible* to all, and equally supported the learning of all students.

This result cannot be generalized at the microgroup level. Thus, if in the knowledge category the averages of the male and female groups do not differ significantly, in the category of understanding and application the averages of the two groups differ significantly.

In some contexts, boys and girls may have different learning styles (e.g. boys often prefer more active methods, and girls may have a greater inclination towards collaborative or detailed activities).

Similar results suggest that creative methods have been able to integrate *diverse approaches* that meet the needs of all students.

5.8. Limits of research

The limitations that influenced/affected the results of the research, without having particular influences on the conclusions, were:

- Time limits: the short period (six months) of the training intervention.
- Limiting the investigations to the Sălaj area.
- Focusing preliminary research on teachers' opinions, explainable if we take into account the age of the students;
- Number of subjects involved in preliminary research. Most research has involved a number of subjects between 100 and 150. The conclusions of the research are valid for the population (teachers and students) investigated, but cannot be representative for the majority of primary school teachers and students. If the investigations had lasted longer and there had been the availability of some teachers to be involved in the research, the formulated findings would increase their credibility.
- The attitude of some teachers who did not want to collaborate in the formative intervention, neither as teachers of the experimental classes nor as teachers of the control classes. This attitude affected (delayed) the implementation of the training intervention program.
- Other limitations of the research, mentioned by the teachers involved in the research, are the time and the lack of financial resources and work materials.
- The subjectivity of the answers provided to the surveys by the teachers.
- The students' limited ability and difficulties to express their opinions about the creative tasks assigned to them in the context of the formative intervention.
- The small body of evidence on which research is based. The preliminary investigations carried out, consisting of questionnaire-based investigations, did not result in facts, materials, etc.

CHAPTER 6. CONCLUSIONS AND RECOMMENDATIONS

6.1. Research conclusions

The chosen research theme aimed to improve the results of third-grade students in the Natural Sciences discipline in the context of an educational intervention program based on creative teaching.

The first part of the paper is a documentary research.

In three chapters, the issues of creativity, scientific knowledge and creative science teaching in the third grade are analyzed.

The analysis of the literature in the field has allowed, as a main finding, the fact that science teaching and creativity are not related in teaching activities or in the respective school curriculum in science textbooks, in general and in school curricula for primary education, in particular. Thus, in the teaching process, the emphasis is placed on the regularities in the development of phenomena and processes and elements of creativity are not highlighted to the students, e.g. the variety of questions, experimental alternatives and alternative hypotheses, the creative behaviors of scientists faced with various problems, etc. (Ciascai, 2022).

The documentary research and the review of the literature of the field were based on a rich literature, its reading allowing a clarification of the concepts and the appropriate design for the level of the third grade students of the formative intervention program.

The preliminary research, six in number, responds to a need to enrich research on creativity. Studies 4.1-4.3 concern the relationship of creativity with the learning styles of young school age students, still insufficiently treated in the literature of the field.

Study 4.4: Exploring the practices used by teachers for pre-school and primary education regarding the artisanal manufacture of products for teaching use. Learning through the artisanal construction of products (objects, materials) is a study introduced in this thesis due to its potential in developing students' creativity. The study covers, like the previous ones, a gap in the literature in the field.

Studies 4.5 and 4.6: Teachers' opinions regarding the manifestations of teachers' and students' creativity in teaching natural sciences. The results of these two surveys reveal that respondents appreciate the role of the teacher and interactive methods in developing students' creativity. He also believes that students' creativity can be developed through natural science lessons without them having an essential role. The analysis of the data obtained through the

two studies allows the identification of a profile of the creative student with concerns in the study of science. He has a rich imagination, creative thinking, open mind, curiosity, intuition, and flexible thinking.

The penultimate chapter presents the formative intervention carried out: the results of the Wallach-Kogan creativity test and the knowledge tests applied to students in the 3rd grade.

At initial testing, there were no significant differences between the experimental and control groups. At the final test, the experimental group recorded significant improvements in creativity (ANOVA: $F=53.711$, $p<0.01$; mean=3.66 vs. 2.60). The performances were maintained over time, with no significant differences between the final test and the retest ($t=0.104$, $p>0.05$).

This aspect indicates the effectiveness of the creative methods implemented.

As a result, we can conclude that:

1) Creative methods have had a positive impact on learning (knowledge and creative development). The students recorded significant improvements in knowledge and creative skills after the application of the formative intervention program.

2) The learning was sustainable. The fact that the high scores were maintained even on retesting shows that students not only learned in the short term, but strengthened their knowledge, which demonstrates effective information retention.

The first hypothesis was confirmed, the level of creativity of the experimental group being clearly higher than the control group, there are significant differences between the experimental group and the control group at the final test.

The second hypothesis is supported. Thus, the average of the total scores at the final test differs significantly between the experimental and control groups.

The third hypothesis is confirmed, in terms of gender differences of the experimental group, in the category of understanding and application, thus the averages of the girls in the experimental group at the final test differ significantly from those of the boys. This result can be interpreted in the basis (Eliasson et al., 2017) which states that girls develop longer answers than boys, which ensures that they are more likely to give the correct answer.

The students' results and creativity correlate statistically, the grades of the students in the experimental group being higher than those in the control group.

6.2.General conclusions

Regarding our research, the result that the experimental group, where creative teaching methods were applied, obtained a significantly higher creativity score than the control group, suggests some important conclusions regarding:

The importance of creative teaching methods. Creative teaching methods, by stimulating the development of students' creativity, are much more effective for learning than traditional methods. This can be explained by the fact that creative methods encourage intuition. divergent thinking, originality and exploration of new ideas.

Stimulating involvement and motivation. Integrating creative teaching methods into teaching can generate a more dynamic and engaging learning environment for students, which increases their motivation for active engagement in the learning process. This increased engagement leads to deepening learning, free expression of ideas, communication and collaboration, etc., and increasing the score of knowledge, creativity and innovation.

*Impact on cognitive processes.*The use of creative learning methods requires complex cognitive processes such as analysis, synthesis and evaluation, which helps to develop more sophisticated thinking skills. The experimental group, being exposed to an environment that values these processes, was able to develop more creativity than the control group.

Flexibility in learning. Creative teaching methods provide students with opportunities to explore and express their ideas, to learn in a personalized way, which leads to the diversification of ways of thinking and acting. Unlike traditional methods, creative methods do not limit students to predetermined ways of thinking and acting, which may explain the difference in school performance

The relationship of teaching methodology with creativity. The significant difference between the scores of the two groups validates the hypothesis that the teaching methodology directly influences the development of creativity. This result can serve as an argument for the adoption of innovative methods in education, in the context of the development of 21st century skills.

6.3. Recommendations

Given the importance of the topic, there is a need to deepen it, respectively to approach it on new levels. The in-depth studies can focus on the role of emotions/emotional intelligence and motivation in the creative process; appreciating the impact of creativity on students' school performance in various subjects; long-term academic performance and creativity-based teaching-learning; the impact of technology and virtual reality on students' creative processes and creativity development.

However, important issues remain such as the revision of the curriculum and textbooks for their orientation towards creativity and the training programs for teachers to use creative methods.

This thesis joins the research carried out at international and national level, aiming to improve the educational climate and support the harmonious development of students. A valuable aspect of the thesis consists in the integration of the issue of creativity in school practice, in primary education, approaching it in a unitary, and not fragmentary, way. A rigorous analysis of the factors, manifestations and dimensions of creativity in the school environment, even in restricted contexts, can significantly contribute to the prevention and reduction of school failure.

6.4. Directions of Valorization and Continuation of Research

New topics of interest can be added to these directions of deepening the issue of school creativity: gamification and the development of students' creativity; creativity and its role in reducing school stress; the role of artificial intelligence in the development of students' creativity, STEM education, etc. STEM education has been a continuous concern of the PhD student, therefore in Annex 28 an activity project illustrating the integrated creative STEM approach is presented.

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