BABEȘ-BOLYAI UNIVERSITY
FACULTY OF PSYCHOLOGY AND EDUCATIONAL SCIENCES
DOCTORAL SCHOOL "DIDACTICS. TRADITION, DEVELOPMENT, INNOVATION”

ABSTRACT OF DOCTORAL THESIS

THE ELECTRONIC PORTFOLIO AS A TOOL FOR REFLECTIVE LEARNING IN PRIMARY EDUCATION.

APPLICATION FOR THE STUDY OF NATURAL SCIENCES

Author: PhD Student Cosmina-Florina Șoldea

Scientific coordinator: Professor Liliana Ciascai, Ph.D

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STATEMENT

The undersigned, Șoldea Cosmina-Florina, being a doctoral student of the "Babeș-Bolyai" University, declare the following:

- The doctoral thesis entitled "The electronic portfolio as a tool for reflective learning in primary education. Application for the study of Natural Sciences" was carried out in strict compliance with 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 "Didactics. Tradition, Development, Innovation", using the Turnitin Report.
- The thesis complies with the writing standards specified in the APA Publication Manual (7th edition), except for the spacing at 1.5 lines.

Date | Signature
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ABSTRACT

This paper investigates the role of the e-portfolio as a reflective learning tool on the school performance of primary school students, so that, in the first stage of the research, teachers' perceptions of these concepts were examined. In the second stage of the research, four surveys were carried out with teachers and primary school students as participants. The first survey aimed to identify the usage level of reflective thinking in primary school teachers and it was carried out with the help of a questionnaire, interview and focus group. The questionnaire, consisting of 14 items, was voluntarily completed by the 20 teachers involved in the research through the Google Drive platform. The results show that 90% of teachers have a very good level of reflective thinking. The interview, semi-structured, consisting of 5 open questions and the focus group containing 5 questions, highlight the fact that the respondents involved in the research recognize the importance of practicing reflection and its benefits.

The second research aimed to examine the perception of primary school teachers on the use of e-portfolios and it was carried out with the help of the questionnaire-based survey, the interview and the focus group. The questionnaire, consisting of 15 items and completed with the help of the 5-level Likert scale, shows that teachers use digital portfolios in teaching because they are attractive, highlight students' progress in learning and are easy to assess. The interview, consisting of 5 open questions, and the focus group, composed of 6 open questions, conclude that the respondents recognize the importance of using the digital portfolio and the benefits of using it in teaching practice. However, regarding the last item of the focus group, the teachers' opinions are divided because some believe that learning is completed by obtaining the e-portfolio, while others believe that knowledge can be accumulated even after its completion.

The third survey measures the usage degree of reflective thinking in primary school students for the discipline of Natural Sciences. As a research tool, a questionnaire consisting of 14 items was used, which was voluntarily completed by 439 primary school students, with the help of the 5-level Likert Scale through the Google Drive platform.

The results show that 106% of students who study in the third grade have a very good level of reflective thinking compared to 99% of students in the fourth grade who also have a very good level of reflective thinking in Natural Sciences classes.

The fourth survey examines the knowledge level of the students regarding the use of electronic portfolios in Natural Sciences activities. This research was carried out on the basis of a questionnaire containing 13 items voluntarily completed by 439 students with the help of the 5-level Likert Scale through the Google Drive platform. The results show that 21% of third grade students have a very good level of knowledge on the use of electronic portfolios compared to 12% of fourth grade students.

In the third stage of the research, a formative intervention program based on these practices was implemented, which investigated the impact of the use of the e-portfolio as a reflective learning tool on the school performance of primary school students in the Natural Sciences discipline. The subjects involved in the research are 439 students who study both in the traditional educational system and in the Step by Step alternative. Of these, 227 students are in the third grade and 212 in the fourth grade. The experimental sample consists of 205 students and the control sample includes 234 students. As measurement instruments, tests were used to assess the students' knowledge in the Natural Sciences discipline in the 3 test moments (pre-test, final test, retest) for each class. In addition, for the experimental groups, self-reflection sheets were used for both teachers and students. These sheets were completed after each activity for the targeted discipline.

The results show that the students really benefited from the implemented program because they recorded high school performance in the Natural Sciences discipline regardless of the educational system they are part of (traditional and Step by Step). An analysis of gender differences shows that both boys and girls follow a similar pattern of increasing scores. In addition, the results show that there is a correlation between the level of reflective thinking and the school performance of students in the third and fourth grades.

INTRODUCTION

Against the background of the COVID-19 pandemic in 2020, the Romanian educational system has undergone transformations in terms of carrying out instructional-educational activities, so that it was necessary to use technology to ensure the continuity of the learning process. In this context, the use of electronic portfolios that cultivate reflection is an approach that responds to the educational needs of the twenty-first century. Through electronic portfolios, students organize their work, reflect on it and revise it, thus facilitating the learning process and (self) evaluation (Barrett, 2000).

This practice is in line with the theories of Dewey (1933) and Schön (1987) who argue that reflection is essential in learning because it contributes to the understanding of learning experiences. In addition, through reflection, students identify their strengths and areas for improvement by becoming aware of their learning progress (Moon, 2004).

The integration of e-portfolios as reflective learning tools in teaching activities values student-centered learning (JISC, 2008) and develops digital skills, while the reflection process encourages students to engage in the act of learning by developing critical and creative thinking. Students "must be taught how to think, not what to think" (Mead, 1928) and "should be initiated as far as possible not to become wise from books, but from the study of heaven and earth, of nature. They must know and examine things by themselves, and not only by foreign observations and testimonies" (Comenius, 1970, p.30). Precisely for this reason, we chose the theme "The electronic portfolio as a tool for reflective learning in primary education. Application for the study of Natural Sciences ".

The present paper consists of six chapters, three of which are theoretical, the next two present the research carried out and the last chapter explains the conclusions and limits of the research. The theoretical chapters deal with the issues of the study of natural sciences, reflection and the electronic portfolio. Scientific knowledge and method, the Romanian and international science school curriculum, the teaching-learning of Natural Sciences and the scientific skills that can be developed in the study of Natural Sciences are the topics explored in depth in the paper. Scientific knowledge is the basis on which science education is built (National Research Council, 1996). The scientific method, with emphasis on exploration, investigation and experiment, is a valuable tool for cultivating specific skills (Kuhn, 1962). As for the curriculum in Romania, it structures the training and development of students' skills by combining theoretical and applied knowledge. At the international level, the Natural

Sciences curriculum has differences determined by the educational priorities and resources of each country, but the vast majority of them emphasize the development of critical and creative thinking, the development of problem-solving skills and interdisciplinarity. In addition, they integrate technology into teaching activities to improve and streamline the educational act in contrast to the traditional approaches that emphasize memorization and learning through repetition.

Addressing the issue of reflection used in the teaching-learning of natural sciences in primary education required clarifications of reflection processes, critical reflection, critical thinking and creative thinking. The development of skills specific to these processes encourages exploration, experimentation, and critical evaluation of information (Bloom, 1956; Zimmerman, 2002). Their integration into the Natural Sciences curriculum enriches the student's learning experience, who can identify essential information, reasoning errors and make value judgments based on arguments. In addition, he becomes able to find innovative solutions to the problems encountered.

The portfolio was another theme of interest in our work. Addressing this topic involved clarifying the concepts of paper portfolio and e-portfolio.

The conceptual clarifications allowed to justify the need to treat the e-portfolio as a tool for reflection in the teaching-learning process in primary education. The integration of the e-portfolio as a reflective learning tool gives the student the opportunity to reflect on the knowledge gained and observe their learning progress. Personalized feedback through the digital portfolio supports the improvement of the learning process and develops digital and analytical skills. In addition, the use of e-portfolios and reflection in teaching are essential for achieving science education that meets contemporary needs.

The second part of the paper describes the preliminary research carried out, as a foundation, together with the knowledge offered by the literature in the field, of the formative intervention carried out in the third and fourth grades. At the end of the paper, the conclusions of the research and its limits are presented.

The annexes show the working materials used (guides, tests, etc.)

PART I. THEORETICAL FOUNDATIONS

CHAPTER I

STUDY OF NATURAL SCIENCES

1.1. Knowledge and Scientific Method

Knowledge in the Natural Sciences aims to understand the environment, organisms and the interactions between them and ends with a set of information assimilated by a person (Hirsch, 2019; Sweller, 2020).

The process of scientific knowledge involves the acquisition of attitudinal, contextual, declarative and procedural knowledge (Ciascai, 2006). Attitudinal knowledge is the complex set of attitudes, values and perceptions developed by students through the study of Natural Sciences, through practical activities and interactive learning experiences (Osborne, Simon & Collins, 2003). Contextual knowledge concerns the way in which scientific knowledge studied in the classroom can be applied in real-life contexts (Wellington & Ireson, 2017). Declarative knowledge in Natural Sciences involves factual knowledge regarding the topics addressed by this discipline, which students deepen within the instructive-educational process (Anderson, 1983). Procedural knowledge is defined by the capability and ability to do something, for example, the stages of investigation of environmental phenomena. Their acquisition so that students become autonomous in their explorations (Gagne, 1985). Students acquire attitudinal and contextual knowledge that stimulate interest in learning and show them how to apply this knowledge. Declarative and procedural knowledge underpin the understanding and exploration of natural phenomena and contribute to the development of critical thinking, logic, practical skills, and the establishment of causality (Piaget, 1969).

In the literature, there are two types of scientific knowledge: intuitive knowledge and formal knowledge (Sfetcu, 2022). The first type of knowledge is based on direct observations and personal experience. Through intuitive knowledge, students form preliminary ideas about the environment that may be different from the scientific ones and need to be corrected (Driver, 1983; 1989). The second type of knowledge involves learning scientific concepts by accumulating information about natural processes and the principles that govern the surrounding nature (Lederman, 2007).

The authentic evaluation of scientific knowledge implies the elimination of grid tests in favor of research projects in which students investigate a natural phenomenon and present the results obtained (Pellegrino, 2001).

Science encompasses the set of scientific knowledge and the scientific method, as a way of acquiring scientific knowledge. Science is a vast field based on research, empirical validation and theoretical development, made up of scientists who have expertise in the field (Carey, 1985; Chinn & Malhotra, 2002; Willingham, 2021). Expertise aims to develop knowledge, skills, and experiences through intense practice and storing information in long-term memory so that it can be accessed as needed (Ericsson, 2018; Kalyuga & Sweller, 2018).

The scientific method guides research through the systematic and rigorous exploration of the surrounding world with the aim of obtaining verifiable results important for the advancement of human knowledge (Fitzgerald & Smith, 2016; Klopfer, 1969). For example, in the medical field, the scientific method is used to understand the diseases from which patients suffer and to evaluate the treatments administered to patients (Pokorski, 2019). In psychology, it is essential for the development of behavioral theories and therapeutic guidance of individuals (Bakeman & Quera, 2011).

1.2. International and Romanian Natural Sciences Curricula

The term "curriculum" comes from Latin from "curriculum" (singular) and "curricula" (plural) and signifies the idea of "running", "race", "route", "road" (Harper, 2023). Ungureanu (1998) also attributes a figurative meaning to this term, namely "passage/ trajectory/ journey in life". The term emerged in education starting with the second half of the sixteenth century in the bureaucratic documents of the universities of Leiden and Glasgow (Ker, 1968). This fact underscores the idea that the term has been around since the advent of universities, but it has been used for the registration and approval of courses.

According to Bobbit (1918) and Tyler (1949), the curriculum represents the totality of learning plans and activities that are organized and evaluated by the school in order to achieve certain educational objectives. These plans are specific to school subjects and are subsumed to the purpose of the educational program, being found in the form of documents of different levels of generality (D'Hainaut, 1981; Glatthorn, 1987; Marsh & Stafford, 1988; Mialaret, 1979; Walker, 1990). In the Romanian perspective, the curriculum "*refers to the* *offer and represents the system of educational processes and of direct and indirect learning and training experiences offered to the educated and lived by them in formal, non-formal and even informal contexts"* (Bocoș, 2008, p. 21).

The necessary factors to be taken into account when developing a curriculum are its purpose, curricular sequence, continuity, interest and feasibility (Hanson, 2006). In Romania, the curriculum encourages the cognitive development of students, the formation of skills and habits, the stimulation of creativity and imagination and the development of critical and creative thinking. The curricular transition in the Romanian perspective starts from known information to unknown information, from the concrete to the abstract, following the principle of information organization proposed by Ausubel (1968). At the same time, the psychological, social and individual needs of the learners are taken into account (Kuhlthau, 1987). Curricular continuity takes into account the child's evolution, so that he/ she develops harmoniously from all points of view (Gardner & Csikszentmihalyi, 2013). Regarding the feasibility of the curriculum, funds are allocated in Romania for the education of students (Vlăsceanu et al., 2007).

The curriculum specifies the competences needed to be developed by students, the learning contents and the teaching and assessment methods used in instructional-educational activities (Brockmann, Clarke & Winch, 2011). A primary element of the curriculum is represented by the educational objectives expressed clearly, precisely and appropriately in the educational context (Stufflebeam et al., 2000). Learning planning aims to organize and structure students' learning experiences according to their needs and proposed educational objectives (Decety & Jackson, 2006).

The content of the curriculum includes the knowledge that students must acquire and the skills that they must develop (Eisner, 2005). Learning methods and strategies are other important components of the curriculum with the help of which the teacher achieves and streamlines the learning process of his/ her students (Oprea, 2006; Smith, 1996; 2000). Learning assessment aims to analyze information on student performance in order to measure learning effectiveness and improve the instructional process (Gulikers, Bastiaens, & Kirschner, 2004).

The curriculum provides a clear direction on the development of students' competences, and its classification suggests how it is used in teaching (Posner, 2003; Shulman, 2005).

The multidimensional approach to the curriculum includes the structural analysis plan, the process plan, and the product (curriculum) plan (Potolea, 2002). The first plan concerns the educational purposes, the instructive-educational contents, the training strategies and the evaluation strategies. Within this plan derives the triangular model and the pentagonal model.

The triangular model focuses on educational goals, training content and learning time, and the pentagonal model emphasizes teaching strategies and evaluation strategies. The second plan aims at the design, implementation and evaluation of the curriculum, and the product plan (curriculum) includes curricula, textbooks, educational software etc. (Catalano, 2020; Potolea, 2002).

The stages of curriculum development are (Glatthorn, Boschee, & Whitehead, 2016; Scriven, 1967; Stenhouse, 1975; Tyler, 1949; Tanner & Tanner, 2007): analyzing needs and goals, planning the curriculum, implementing the curriculum, and evaluating the curriculum.

The functions of the curriculum are: projective, psychological, ensuring individual development, social, educational, cultural and evaluative (Fullan, 2015; Houle, 1961; Ornstein & Hunkins, 2018; Pinar, Reynolds, Slattery & Taubman, 2004; Schiro, 2012; Scriven, 1967; Schubert, 1986).

The curriculum is an essential part of the educational process that performs several important functions within the instructive-educational activities: it organizes the educational content, provides a clear direction of students' learning and contributes to the harmonious development of students.

Although there are a multitude of efforts aimed at improving the curriculum, we must recognize that there are also challenges. For example, most schools do not have sufficient material and technological resources through which the curriculum could be effectively implemented (Cristea, 2008). It is necessary that the evaluation of the knowledge acquired by students to be done objectively by providing constructive feedback (Vogler, 2000).

The Natural Sciences curriculum is important in the process of training students who live in a constantly changing world. Scientific literacy is a major objective both for the teaching and learning of Natural Sciences and for the development and improvement of the curriculum (National Research Council, 1996). By studying Natural Sciences, students form their scientific culture and develop their research, scientific reasoning and critical thinking skills (American Association for the Advancement of Science, 1990; Kim, 2002).

The science curricula specific to primary education abroad is designed according to the educational objectives proposed by each country. The curriculum in Pakistan emphasizes science, math, and English at the expense of arts, music, literature, and physical education (Khadim et al, 2023). Also, this type of curriculum is influenced by Islamic religious education aimed at learning Arabic and studying the Qur'an (Dar et al., 2019). In Malaysia, the curriculum offers science and vocational subjects, the latter of which are optional because they do not have mandatory credits for qualifying in the next class (Ministry of Education Malaysia, 2020). The curricula in Pakistan and Malaysia are ideologically oriented, with both countries using their mother tongues to promote national consciousness and unity (Ministry of Education Malaysia, 2013). However, in Malaysia the activities are conducted in English, while in Pakistan, Urdu is used for the teaching of non-technical subjects (Ministry of Federal Education and Vocational Training of Pakistan, 2019).

In developed countries such as the USA, Canada, Japan or EU countries, the curriculum aims to develop skills and acquire knowledge through practical activities, experiments and cooperation (Casinader & Kidman, 2018; Champagne, 1997; Connelly et al., 1985; Wamsler, 2020; Quinn et al., 2023). In contrast, in countries such as in Africa and South Asia, science curricula focus on theory through frontal lessons and the use of textbooks (Le Grange, 2012; Linn & Tsai, 2017; Oyoo, 2012; Tsai & Tsai, 2017). There must be a link between natural science textbooks constructed so that students reflect and inquiry activities (Oh & Kim, 2005).

In Singapore, the Natural Sciences curriculum reflects the importance of critical thinking through investigation, exploration, and the application of acquired knowledge in real life contexts (Yeo & Tan, 2021). For example, an activity that facilitates the understanding of scientific concepts through contact with direct experiences is the observation of the growth of the plant according to the intensity of light.

The Finnish and English Natural Sciences curricula promote holistic learning through group discussions, research, experiments, and practical activities that develop critical and creative thinking (Department for Education in England, 2013; Sahlberg, 2011). One activity in this regard is to analyze local ecosystems and identify connections between the different species that live in their natural environment.

In Hungary, Bulgaria, Portugal and Croatia, students study on the basis of an integrated Natural Sciences curriculum; later, they study biology, chemistry and physics. The emphasis is on investigation, practical experiments and the identification of connections between these disciplines, promoting the development of practical skills and critical thinking (Crato, 2020; Egri et al., 2021; Leite et al., 2019).

Although each country approaches the Natural Sciences curriculum differently, they aim to transmit specific knowledge and facilitate its understanding through experiments, investigation, virtual simulations, etc.

1.3. The Set of Methods Used in the Teaching-Learning of Natural Sciences. Application in Primary Education

The natural sciences curriculum in Romania has adapted to the many social, economic and political changes that have occurred over time. At first, the curriculum focused on the theoretical knowledge that the student had to assimilate, but now it emphasizes active, student-centered learning. The use of active-participatory methods contributes to the understanding of scientific concepts and stimulates students' interest in the learning process (Freire, 1970; Vygotsky, 1978**).** Recently, the curriculum has begun to emphasize STEM skills considered essential for the preparation of the child in an increasingly technological society (Sanders, 2009). STEM skills promote practical experiences, problem-solving, and the application of knowledge in real-world contexts (Honey et al., 2014).

The teaching of Natural Sciences is essential in education because students understand the surrounding world and natural phenomena explained through scientific concepts (Boud, Keogh, & Walker, 1985; Osborne et al., 2004). This involves the transmission of knowledge, the development of critical thinking, analytical and scientific skills through practical and direct experiences, exploration and scientific investigation (Bybee, 2013; Brookfield, 1987; Facione, 2015; Hatton & Smith, 1995; Tobin & McRobbie, 1996).

Experiential learning comprises the following stages: experience itself, observation of experience and reflection on it, abstraction of concepts and their generalization, and application of concepts in the future (Kolb, 1984). By reflecting on their experience, they understand and apply scientific concepts in reality and solve problems in everyday life (Aikenhead, 2006; Bybee & McCrae, 2011, Bybee, 2015; Schön, 1983; Stalmeijer et al., 2011). Thus, students formulate hypotheses, collect data, interpret results and draw conclusions based on observations and concrete data.

Investigation involves systematic study in order to discover something, often the object of investigation being a phenomenon or process collected from the student's familiar reality.

Ciascai (2018) shows that the investigation is close, in terms of stages, to the experiment although it does not necessarily involve carrying out an experiment: in the first stage, the question(s) to be investigated are formulated, they are studied and deepened through documentation, observations, exploration, punctual experiences and an explanatory model is built. Based on this model, assumptions are formulated (in the case of young students) or hypotheses and predictions that are then tested by confronting various facts or by experiment. The results are communicated and then the transfer of the acquired knowledge and reflection on the investigation process take place, as well as the evaluation of one's own learning. The process is cyclical and, in English literature, it is known as inquiry (US and other countries that use American English) and enquiry (UK).

Observation facilitates the acquisition of new skills and the development of cognitive abilities. The most important criteria for classifying the observation refer to intentionality, degree of independence, location, form of organization, mode of organization and the analyzer used (Dulamă, 2012). For the first criterion, we distinguish between planned observation and spontaneous observation. Planned observation involves the selection of information about the surrounding reality in accordance with the previously established objectives, and spontaneous observation involves the unorganized perception of information specific to the environment. According to the degree of independence, we find directed observation based on the indications given by the teacher and autonomous observation made by the students.

By conducting experiments, students observe the unfolding of natural phenomena and build a solid foundation for understanding the world in which they live (Hofstein & Lunetta, 2004; Hofstein & Mamlok-Naaman, 2007; NGSS Lead States, 2013). The use of this method contributes to the significant improvement of students' performance in this discipline (Roscoe & Chi, 2007).

Debates are an important source in the process of knowledge construction because ideas are presented and substantiated interactively (Tobin & Gallagher, 1987; Vygotsky, 1978).

Through these methods, students explore the environment, interpret the processes and phenomena discovered, and develop socio-emotionally (Kuo et. al., 2019; Mann et al., 2021; Ingram et al., 2019). The methods listed are integrated into the strategies applied in the activities of natural sciences.

1.4. Skills Developed by Students through the Study of Natural Sciences

According to the Online Etymological Dictionary, the term "development" comes from the Latin language "dēvolūtĭo", being the derived form of the verb "dēvolvěre". This verb consists of the prefix "de" which means separation and the verb "volvĕre" which indicates the action of spinning or rolling. In this context, the concept signifies the idea of revealing or unfolding something with the aim of highlighting it. From the perspective of social development, this process aims to learn social and moral behavioral norms in order to communicate effectively and build positive interpersonal relationships (Bronfenbrenner, 1979; Kohlberg, 1969; Rubin et al., 2018; Santrock, 2017; Shaffer & Kipp, 2013).

It is important for students to develop social skills such as negotiation and mediation because they manage conflicts and maintain harmony in social interactions (Baron & Byrne, 1984; Eisenberg et al., 2006; Maccoby, 1992). Social skills also include cooperation and collaboration to achieve common goals, active listening, and verbal and nonverbal expression (DeVito, 2009; Johnson & Johnson, 2018; Matson et al., 2013).

Social development is closely related to emotional development because individuals perceive their own emotions and those of others and adapt them according to the social context (Gross, 2015; Rivers & Brackett, 2011; Saarni, 1999; Thompson, 1994). In the case of students, social development involves identifying and solving the causes that triggered conflicts, while emotional development aims at understanding and associating emotions (Decety & Jackson, 2006; Denham, 1998; Kahneman, 2011; Shure & Spivack, 1980). As can be seen, socio-emotional development refers to conflict resolution, empathy and understanding the emotional perspective of others.

By studying Natural Sciences, students gain scientific knowledge and develop the skills necessary to understand the environment and become responsible citizens in society. Skills represent the individual's ability to put into practice the knowledge acquired during his or her educational journey in order to carry out an activity (Ericsson & Charness, 1994; Bransford, Brown, & Cocking).

Skills develop with the evolution of the child's cognitive capacity. According to Piaget's theory (1967), there are two significant stages that highlight the cognitive growth of children between the ages of 6 and 14. The first stage aims at induction-based learning in which students observe, classify and understand the elements in their environment and create connections between them. The second stage emphasizes deductive learning through which students analyze, synthesize, formulate hypotheses and apply notions in practical situations. In other words, students use their knowledge to deduce solutions in order to solve specific problems.

Scientific skills are grouped into two typologies according to the age category to which the students belong (Faheem et al., 2015). Students in primary grades must possess observation and measurement skills to collect and quantify data. Equally important are the skills of classification, to group objects, data and information into categories in order to understand them more easily, but also those of communication to convey the observations made. Also, the skills of deduction and prediction respectively are essential to formulate conclusions and make assumptions about certain phenomena based on previous experience.

Primary school students are initiated, through observation, in the manipulation and control of variables. Secondary and high school students, as well as students, must possess research skills (formulating hypotheses and variables, conducting an experiment, interpreting data etc.).

Other skills that can be developed by students in the study of Natural Sciences are:

- *Creativity:* it is essential in the process of scientific discovery, although it is underestimated due to the common perception that science is based on logical reasoning. Riordon (2023) highlights the fact that the best ideas come from moments of relaxation and contemplation, but not only from the intense study of the facts. This means that being creative also involves finding innovative solutions to problems, not just generating new ideas. For example, a researcher who encounters a problem in his/ her experiment uses creative thinking to identify an appropriate solution to his problem. Creative skills are essential in generating alternative hypotheses and developing new models that help us better understand the world (Fork, 2014). Creative thinking blends with rational thinking and it is used to make meaningful discoveries.
- *Social-emotional skills:* develop when students cooperate and collaborate to solve a task. If a student does not integrate into a group because they do not have the ability to recognize and understand the emotions of others, they tend to have an aggressive and self-centered behavior. "Social maladaptability is more painful and explicit when it manifests itself in one of the most dangerous moments in a child's life: trying to be accepted in a playgroup. It is a dangerous moment because then the child is loved or hated, he feels or not that he belongs to the group and all this is made public" (Goleman, 2005, p.167).
- *Adaptability and flexibility skills:* they are essential in situations where the individual needs to adapt to new situations and think flexibly.

In conclusion, by developing scientific and socio-emotional skills in natural science activities, students:

- Analyze the causes that led to the occurrence of a phenomenon/ process.
- Learn through understanding and application.

- Move from concrete knowledge to abstract knowledge.
- Turn from spectators of the educational process into actors.
- Have the opportunity to explore the environment.
- Adopt a healthy behavior in interpersonal relationships.
- Understand what is happening around them and look for solutions to the problems they have to face.
- Argue the answers given to the teacher's questions.
- It stimulates their imagination, curiosity and creative and flexible thinking.
- Discover and deepen knowledge through intense intellectual activity.

CHAPTER II

REFLECTION IN THE TEACHING-LEARNING PROCESS OF NATURAL SCIENCES IN PRIMARY EDUCATION

2.1. Reflection. Specification of The Concept

Reflection is a key concept in the development of today's society and a constant concern of research in the field of psychology and pedagogy. Psychologically, reflection is the intellectual activity through which the individual understands his or her own behavior by examining past actions and becoming aware of his or her reactions in order to adjust them (Boyd & Fales, 1983; Mathew, Mathew & Peechattu, 2017; Moon, 1999). At the same time, through reflection, the individual develops the skills of self-control and self-regulation, forming himself or herself personally and professionally (Schön, 1983). Pedagogically, reflection is a didactic method that involves thinking focused on a subject and conducting an internal or external dialogue (Bocoș, 2013; Boud, Keogh & Walker, 1985). In addition, reflection is developed and improved both through feedback and an environment that encourages the practice of this process (Boud et.al., 1985).

Reflection involves intuition and emotion and gives meaning to the life and learning experience by creating connections between the content studied and the personal experience (Green, 1986; Șoldea & Ciascai, 2020). It is integrated into any experiential activity, internal or external, oral or written, being a way of mediation between all these experiences (Lalanne, 2000).

The reflection is classified according to various criteria, which are relevant in the context of learning, and specialists have proposed various approaches and models. From the perspective of approaches, Kolb (1984) identifies convergent reflection and divergent reflection depending on the way in which they are integrated into the educational process. Convergent reflection aims to integrate existing information and find a single correct answer, and divergent reflection involves exploring a large number of possible solutions.

The literature identifies the following functions of reflection:

1. Cognitive function: aims at understanding and analyzing one's own thoughts and actions with the aim of developing cognitive abilities and improving the way of approaching problems (Boud, Keogh & Walker, 1985).

2. Personal development function: involves the formation and development of new skills, as well as the evaluation of the individual's performance (Schön, 1983).

3. Emotional function: represents the management of one's own emotions with the aim of improving the individual's quality of life (Tryon, 2013).

4. Relational function: aims to understand one's own interpersonal relationships and improve communication with other people (Bolton, 2014).

The application of reflection has countless benefits, but we will mention the most important of them that can be found in the literature. Reflection is beneficial for the individual because it contributes to the development of the skills of introspection, self-evaluation, self-regulation, self-efficacy, self-knowledge and self-development (Zimmerman, 2011). It also leads to the development of critical reasoning, communication skills, and learning strategies, and it helps identify gaps (Gibbs, 1988; Thompson, 2021). Unfortunately, this process is associated with excessive self-criticism, self-judgment, confusion, uncertainty, and emotional overload (Schön, 1987; Khoiriyati & Sari, 2021).

2.2. Conceptual Developments Regarding Reflection

Critical reflection is the cognitive process through which the individual discerningly analyzes and evaluates information, ideas and opinions objectively and rationally (D'Cruz et al., 2005; Facione, 1990). Through this process, the individual distinguishes relevant information from irrelevant information and forms an evidence-based opinion without being influenced by distorted information (Brookfield, 1987; Ennis, 1985; Lipman, 1988; Magolda, 1992; Paul & Elder, 2018). Critical reflection involves setting goals, formulating questions, confronting biases, examining causality, integrating theory with practice, stimulating (self-) critical evaluation, and transferring knowledge (Dewey, 1910, 1938; Facione, 1990; Schön, 1983). It also includes the analysis and evaluation of multiple perspectives and reflection on learning processes (Bailin, Case & Coombs, 1999; Schön, 1983).

Critical reflection is classified according to the depth and details of this process (Boud, Keogh & Walker, 1985). Superficial critical reflection aims to describe the basic elements specific to an experience compared to the average critical reflection that involves analyzing and evaluating the experience. Deep critical reflection includes examining perspectives and sources of information, as well as evaluating one's own beliefs and values (Magolda, 1992; King & Kitchener, 1994; Mezirow, 1991). It is important to note that depth and detail is added to this process at each level (Paul & Elder, 2006).

Critical reflection influences our thoughts and actions and leads to the spiritual improvement of the individual (Foster, 1978).

Both reflection and critical reflection involve self-knowledge and focus on personal experiences. The difference between them lies in the depth and evaluative nature of the analysis process (Ciascai & Șoldea, 2024). The quoted source considers it important that critical reflection is not confused with critical thinking and creative thinking because they are three different concepts.

Etymologically, the term critical thinking comes from the Greek language (Gr. *κριτικός* = "critical") and refers to the intellectual capacity of the person to analyze and evaluate information. This concept can be found since Antiquity in the works of great Greek philosophers such as Socrates, Plato and Aristotle.

Critical thinking is the intentional judgment through which the methodological, criteriological or contextual aspects on which it is based are analyzed and evaluated (Facione, 2015). In addition, it represents the ability of the student or teacher to engage in an activity with reflective skepticism (Nieto & Saiz, 2010). This process involves using investigative strategies, establishing actions and consequences, looking for alternatives to solve the problem, respecting the arguments of others and analyzing them (Steele et al., 1998).

Technological development is changing the way we live and learn so that everything that is not technological (such as creativity) becomes an essential skill

Creativity is the individual's ability to find new solutions to problems that cannot be solved by conventional methods or to situations specific to an individual (Amabile, 1996; Cropley, 2006; Kaufman & Sternberg, 2010; Runco & Jaeger, 2012). Creativity is essential in technology and engineering for the development of innovations, in art for the creation of original works of art, and in education for critical thinking and exploration of ideas (Beghetto & Kaufman, 2014; Plucker et al., 2004; Sawyer, 2011). According to Boden (1994), creativity is based on imagination, exploration and evaluation. Imagination is the individual's ability to generate new ideas by visualizing problems from different perspectives. Exploration aims to identify appropriate solutions to solve problems and it is facilitated today by the use of online platforms such as Canva, Adobe Creative Cloud, Prezi, MindMeister or Coggle. The evaluation that validates the results continues by transforming the ideas into innovative solutions.

2.3. Capitalizing on Reflection and Critical/Creative Thinking in the Teaching-Learning Process of Natural Sciences in Primary Education

In an increasingly complex world, the natural sciences play an elementary role in understanding and solving problems in various fields. In order for these problems to be adequately addressed, it is necessary to cultivate the skills of reflection, critical reflection, critical thinking and creative thinking.

In the natural sciences, the four concepts are important processes for understanding knowledge and developing skills specific to this field. If reflection involves understanding learning and life experiences with the aim of improving the individual's personal abilities (Schön, 1983), in Natural Sciences, reflection is used to understand the results of various experiments and to apply scientific concepts (Kholid et al., 2020). Also, critical reflection analyzes and evaluates one's own thinking and the thinking of others with the aim of developing logic through deep and challenging questions (Brookfield, 1987) being useful in the study of science to develop the skills of evaluating scientific arguments (Ghanizadeh, 2017). Critical thinking aims at the critical evaluation of arguments and the development of effective solutions and alternatives, and it is used in the natural sciences to evaluate, identify model shortcomings, and improve existing theories and models (Kuhn, 1962). Creative thinking develops ideas and solutions that respond to current problems and challenges and contribute in science to the creation and development of new models (Johnston et al., 2019). Although critical thinking and creative thinking are different processes, they are still complementary in the natural sciences. Through critical thinking, errors are identified, and arguments and data are analyzed, leading to a better understanding of this discipline (Ennis, 1989; Paul & Elder, 2008; Facione, 2015). By practicing creative thinking, new and innovative ideas are created and unconventional solutions to various problems are found (Runco & Jaeger, 2012).

Teachers should encourage students to think independently and make decisions based on sound arguments, which is done through reflection. Practicing reflection in the natural sciences helps students understand complex topics, solve various problems, and develop critical thinking (Van Dijk & Kattmann, 2006). They also improve their knowledge, capitalize on their capacity for introspection and self-assess their knowledge specific to this discipline (Gunstone & Northfield, 1994; Schön, 1983). According to Hatton & Smith (1995), reflection stimulates critical, self-critical debate and cooperation among students.

In primary education, reflection-based teaching can include the following key elements:

- challenge: asking questions or referring/ presenting facts that surprise students, make them curious.

- playful approach: games are used in natural science activities that stimulate students to reflect on the information learned.

- collaboration: promotes the development of students' social skills and contributes, by substantiating critical thinking, to solving complex problems in the field of Natural Sciences (Johnson & Johnson, 1996).

- capitalizing on personal experience: it involves reflecting on students' experiences in the field of Natural Sciences and how to apply them in the context of learning (Schön, 1983).

- encouraging asking questions: students are encouraged to ask questions from the field of Natural Sciences and to express their points of view because they can learn to make well-founded decisions (Hmelo-Silver, 2004). In addition, it is an effective way to involve them in instructional-educational activities.

- continuous assessment: through continuous assessment and student reflection, teachers monitor students' progress and encourage them to become confident in the learning process (Black & William, 1998).

Reflection can be used as *a way of assessment* in the natural sciences because students reflect on their experiences and self-assess their progress (Pavlovich et al., 2009). By practicing reflection in the study of Natural Sciences, students develop their critical and creative thinking, understand scientific concepts and identify possible errors, improving the learning process (Hubbs & Brand, 2010; Goldberg, 2012).

By reflecting, students understand their thoughts, actions, feelings, and behaviors, thus developing their social-emotional skills (Güvenç & Çelik, 2012). However, there are also some possible drawbacks of reflection-based teaching in the study of Natural Sciences that need to be considered. The reflection process is longer and requires a long time to be carried out in an effective way (Moon, 1999). It can also be a too complex process for some students (Brookfield, 1987).

The use of reflection in the natural sciences has the following advantages (Boud, Keogh & Walker, 1985):

1. Improvement of analysis skills: through reflection, one's own thoughts and actions are analyzed, optimizing the skills of analysis and evaluation of natural phenomena.

2. Development of understanding: reflection contributes to an understanding of natural phenomena by identifying patterns and connections between different phenomena

3. Improvement of analysis skills: through reflection, one's own thoughts and actions are analyzed, optimizing the skills of analysis and evaluation of natural phenomena.

4. Development of understanding: reflection contributes to an understanding of natural phenomena by identifying patterns and connections between different phenomena.

5. Improving problem-solving capacity: Reflection effectively solves problems because potential errors are identified.

Practicing critical reflection and critical thinking contributes to (Paul & Elder, 2006):

1. Improved analytical capacity: Critical reflection and critical thinking develop the skills of analyzing information and evaluating arguments.

2. Improved communication skills: Critical reflection and critical thinking develop communication between peers by evaluating and debating arguments and theories.

The practice of creative thinking in the natural sciences has the following advantages (Runco, 2019):

1. Developing innovative solutions: Creative thinking develops innovative ideas by approaching problems in a different way.

2. Improved adaptability: Creative thinking helps individuals adapt to unforeseen situations.

3. Developing collaboration skills: Creative thinking promotes collaboration with others by developing ideas and exploring different perspectives.

In conclusion, by cultivating reflection, critical reflection, critical and creative thinking, students' acquisitions go beyond the level of disciplinary knowledge and extend to the connections between the different disciplines studied and their life experienc

CHAPTER III

THE USE OF THE E-PORTFOLIO IN THE TEACHING-LEARNING OF NATURAL SCIENCES IN PRIMARY EDUCATION

3.1. Portfolio Method

Etymologically, the term "portfolio" comes from the Italian "portofoglio" made up of the Latin "portare" which refers to transport or storage and "folium" to paper (Lam, 2018). In other words, a portfolio is understood as the set of documents that can be transported/ stored.

The concept of portfolio has been present since the period of Renaissance Italy because artists and architects publicly presented their own works (Dorn et al., 2013; Goldthwaite 1980). An example of a portfolio is Leonardo DaVinci's notebooks in which notes and drawings of his studies, ideas and inventions can be found (Dorn et al., 2013). There are currently about 7000 pages available, the best known being the Codex Arundel produced in 1550. In 1440, in Montepulciano, the architect Michellozzo presented to the whole city his portfolio containing the specific projects for the construction of a hospital in the hope of their approval (Goldthwaite, 1980).

The transition from the art and architecture portfolios to the educational one was possible in the early 1970s, being influenced by countless factors. Among these factors, we mention the abandonment of standardized tests, the emphasis on quality assurance of the instructional-educational process and the emergence of new theories of learning (Elbow & Belanoff 1997; Farrell, 2017; Habib & Wittek 2007; Lam 2018). On a didactic level, the portfolio represents the collection of works made by the student that exposes his effort, progress and achievements and demonstrates the knowledge acquired and the skills developed (Arter & Spandel, 1992; Barrett, 2000; Paulson, Paulson & Mayer, 1991; Wolf, 1989). Such a tool documents students' learning process and progress over time and, as Tierney, Carter & Desay (1991) point out, it promotes collaboration between teachers and students.

This educational approach also aims to use the portfolio as a tool of documenting the learning process. The presentation portfolio can become an extended curriculum vitae presented to future employers (Habib & Wittek 2007; Syzdykova et al., 2021). This use of the portfolio is based on Meizrow's theory of transformational learning, Kolb's experiential learning, Flavell's metacognition, and Lava's theory of situated learning (Batson, 2011; Eynon & Gambino 2017; Penny Light, Chen, & Ittleson 2012; Reynolds & Patton 2014). At the same time, the theories mentioned above emphasize the development of learning and reflection on this process.

Regarding the classification of portfolios, the literature offers a multitude of typologies.

According to Pandya, Slemming & Saloojee (2017), the portfolio can be classified into two categories according to its content. Thus, we have the working portfolio and the reflective portfolio. The working portfolio includes the students' works, and the reflective portfolio aims at their reflections and observations on their own learning process. Barrett (1994) adds two other categories to the working portfolio: the presentation portfolio and the evaluation portfolio. The presentation portfolio contains the most successful works in the portfolio providing information for a specific audience (Wade & Yarbrough, 1996). In teaching practice, it is done by selecting the best works from the student's work portfolio. The assessment portfolio is used to assess the performance (Michelson & Mandell, 2004) and the level of development of students' competences in a field because it highlights the learning process and the final outcome (Barrett, 2000). Both the learning process for portfolio development and the final product are equally important (Harrison et al., 2007; Joyes, Gray, & Hartnell-Young, 2010). All categories of portfolios involve reflection either for the selection of portfolio components or on them (Șoldea & Ciascai, 2020). All the categories of portfolios mentioned above highlight the student's abilities and competencies in a certain field (Stiggins, 1994).

Nastas (2013) also provides information on the materials contained in the portfolios (Table 3.1).

Table 3.1.

Materials of the school portfolio (after Nastas, 2013 ***citation taken in full with the author's permission****)*

	Paper	Hybrid	Electronic/ digital/ E-Portfolio
Description *What?*	Most of the products are essays, problem sets, the journal/ notebook with notes and tests.	In addition to paper products applicable in the classroom, hybrid portfolios can include photos, videotapes, audio cassettes.	The works are made by students in electronic format: video, audio and graphic images etc. (all materials are in digital format)
Requirements (Volume) *How much?*	The physical storage requirements of classic portfolios are difficult and limited.	Physical storage requirements can be difficult depending on materials and the number of students in the classroom.	Can be stored on a hard drive or platform
Accessibility of materials/ Access restrictions *How?*	Only accessible to one person at a time.	Multiple media formats can make accessibility difficult. Only accessible by one person at a time.	Portfolios are accessible online to multiple individuals/ groups, at any time and at the same time. It is easier to disseminate materials than hybrid ones.
Time/ moment or duration *When?*	It requires time for the realization of materials, storage (transcription on sheets, printing, etc.). Correction is difficult and most of the time errors are not reversed. Duration has a quantitative and qualitative impact.	Working with multiple forms of media requires a lot of time for storage, analysis. Corrective interventions require additional time, even duplication of time. Duration has a quantitative and qualitative impact.	It allows a storage time for materials accessed from multiple sources of information. The corrections are multiple and immediate. Creating a qualitative and quantitative product in a limited time frame.

Storage and security	Space must be provided for storage in a closet or office. The number of portfolios depends on the number of students and requires storage space. Copying is difficult	Space must be provided in a cupboard or office, respectively on a platform. The number of portfolios is equal to the number of students. Storage time is dependent on the physical or electronic space available Copying is difficult for paper documents and easy for digital ones.	Can be password protected limited class, group or individual. Copying is easy.

According to Barrett (2000), the structure of a portfolio contains the following elements:

1) Introduction: comprises a short written presentation by the student, the learning objectives and a general description of the content of the portfolio.

2) Selected papers: Papers are selected in such a way as to target the student's strengths, weaknesses, and progress in learning

3) Reflections and self-assessment: these are diaries or documents in which students write down their reflections on their own learning process (Boud & Falchikov, 2007)

4) Learning plans: these are the documents in which students write down their own learning plans for the development of skills and competencies specific to a field of study.

5) Evaluation and feedback: during this stage, teachers give grades to the student's portfolio and describe the feedback provided in the form of comments or notes (Carraway, 2019).

The first to adapt portfolio-based assessment by mentioning that it involves the appreciation of the student's work were Ford and Larkin (1978). This approach was seen as an alternative to standardized quantitative tests (Elbow & Belanoff 1997; Habib & Wittek 2007; Lam 2018).

There are two ways to assess the portfolio:partial evaluation and final evaluation. The partial evaluation involves the grading of a theme in the portfolio or the awarding of a grade that is obtained by the arithmetic average of the grades awarded for each task. The final evaluation of the portfolio is made by noting each component of the portfolio (Davis & Ponnamperuma, 2005). A very important aspect regarding the use of the portfolio is, as highlighted above, its evaluation by awarding ratings or grades based on certain criteria.

These criteria refer to the achievement of the learning objectives, the quality of the materials, the number of works carried out, their complexity, the way of working, the correctness of the materials and personal reflection (Zubizarreta, 2009; Prendes Espinoza & Sánchez Vera, 2008).

The use of the portfolio has numerous benefits, including illustrating student performance, increasing student motivation, encouraging self-reflection and providing useful feedback (Gilsenan, 2011) Also, difficulties may arise in identifying the degree of originality in solving tasks, especially if the portfolio was done in a group (Ball et al., 1995).

In conclusion, the use of the traditional portfolio has advantages and disadvantages that must be taken into account so that student performance is correctly evaluated (Friedman & Pinnegar, 2011).

3.2. From the Paper Portfolio to the Electronic Portfolio

After 1990, with the advent of the web, educational technology facilitated the creation of e-portfolios an achievement that illustrates the Web 1.0 digital revolution (Eynon & Gambino 2017; Weller, 2018). The first electronic portfolios were aimed at digitizing the classic versions of the portfolios that appeared in 1980. These were created using computer intranets with Mac-based folders called Docex, Apple II, document servers, and Storyspace software (Campbell, 1996; Purves, 1996; Wall & Peltier 1996). Research carried out in 1990 on e-portfolios focuses on digital tools, platforms and the technology needed to put them into practice. It also captures the experiences of early adopters experiencing a new paradigm (Yancey, 1996).

In the literature, the first reference to electronic portfolios was made by Campbell (1996). He said that, in 1989, he used electronic portfolios in an elementary school in Wyoming to create a historical archive of students' work. The collection included written texts, drawings and video sequences with his students. The approach is similar to that of the year 1980 in which the portfolio is used to record students' progress and achievements over time.

An important role in the development of electronic portfolios was played by Helen Barrrett who, in 1994, wrote an article entitled "Evaluation of the portfolio with technological support". In this, article he presented his vision of digital portfolios as an alternative form of evaluation. In addition, it considered that they offered teachers, parents and students the opportunity to quickly view the numerous works made by students during their schooling.

Although the article focuses on creating and storing a portfolio, Barrett proposes an interesting pedagogical conception of electronic portfolios. In other words, Barrett classifies digital portfolios into two categories: the working portfolio and the formal portfolio. The first category of portfolios records the students' progress, while the second category contains the students' most beautiful works. He also argues that the portfolio is seen both as a process and a product, thus unifying the two theoretical conceptions of portfolios from the 1980s. Therefore, the portfolio seen as a process is based on the constructivist approach, and the one seen as a product being based on the competency-based approach. Over the course of a decade, Barrett (1998) develops his theories on the electronic portfolio by providing one of the first definitions. Thus, in his opinion, electronic portfolios digitize and store the collections of works made by students with the help of various technologies and multimedia elements. Also, in the same year, Barrett initiated a portfolio list server, creating a community of teachers who shared ideas about the digital portfolio.

Purves (1996) advances the idea of a portfolio as hypertext comprising texts or artifacts created and arranged by the student. The oldest reference in the literature with reference to an electronic portfolio placed on a website is given by Watkins (1996).

The portfolio is defined as a collection of electronic texts of a student, hypertextually interconnected and published on the World Wide Web (WWW). They are geared towards online audiences, including the portfolio evaluator.

Selwyn (2014) argues that the years 2000-2010 represent the period in which technology becomes part of society, being an integrated component in education. Teachers and students adopt virtual learning environments, blogs, open educational resources, and use the e-portfolio in the teaching and learning process (Weller, 2018). Batson (2002) highlights the fact that electronic portfolios have a greater potential to transform the educational process compared to technological applications known to him. In addition, the e-portfolio is multifaceted, which means that it is a technology, a pedagogical approach, a process, but also a product (Chen & Black, 2010).

As e-portfolios pread, researchers begin to define them so that we find seventeen different definitions for the period 2000-2010. The most common sources are those cited by JISC (2008), Abrami & Barrett (2005), Lorenzo & Ittleson (2005) and Hartnell-Young (2007). According to Jisk (2008), the electronic portfolio comprises the collection of digital artifacts that present the student's achievements and learning. It is based on the skills of planning and synthesizing information, as well as reflection and feedback. Documents are organized and archived online and can be accessed at any time from anywhere (Barrett, 2000;

Hartnell-Young, 2007; Lorenzo & Ittleson, 2005). Among the materials in the portfolio, we mention video, audio, text and image content that support the pedagogical and evaluation processes while illustrating the student's performance (Abrami & Barrett, 2005; Jafari, 2004).

E-portfolios have the following advantages: a) they allow joint work in the same portfolio and b) they allow access to individual portfolios, as a result, they facilitate personal reflection, exchange of ideas, identification of strengths, weaknesses, feedback and lead to the improvement of the learning process.

In order to develop an electronic portfolio, the student must have a series of digital skills necessary to help him in his work (Dabbagh & Kitsantas, 2012). Competences include the use of Word, PowerPoint, Excel and searching for information using the Internet (European Commission, 2008). By creating an electronic portfolio, students develop skills such as adaptability, decision-making and efficient time management. They also improve their creativity, active listening, and cognitive flexibility that optimize collaboration, independence, and critical thinking (Riverón Portela, 2001). In addition, they develop their reflective skills, by collecting information from various sources and presenting the contents of the portfolio in an attractive manner (Bower et al., 2015; European Commission, 2006). Linguistic and social skills are improved (Williams, 2015), as well as digital skills, such as editing texts, images and graphics, developing concept maps, making a video and using learning platforms (Bower et al., 2015).

The evaluation of electronic portfolios is done through e-learning platforms based on previously established criteria according to the educational objectives and the level of development of the students (Barrett, 2010; O'Neil & Conzemius, 2006). These criteria refer to the degree of achievement of the learning objectives, the number and degree of complexity of the works carried out, their correctness, the diversity of materials, creativity and originality (Barrett, 2010; O'Neil & Conzemius, 2006). It also takes into account the assessment of students' self-assessment and self-regulation skills developed during the creation of the digital portfolio (Barrett, 2010). Digital portfolio-based assessment allows students to integrate their learning and make connections between modules in an authentic and meaningful way (Eynon & Gambino 2017).

The advantages of using the electronic portfolio are the inclusion of a large number of multimedia materials, the development of digital skills, the correct understanding of a message and the provision of rapid feedback (Barrett, 2000; Chen & Light, 2010). It also emphasizes stimulating creative thinking and artistic talent, increasing motivation for learning and involving all students in the learning process (Karami, 2020).

The differences between the electronic portfolio and the traditional one are aimed at including audio-video materials and quickly modifying texts without wasting information or time. In addition, there are no spatial and cost constraints because the works do not have to be printed (Chen & Light, 2010; Kebritchi et al., 2010). The materials are attractively presented, the student's personal expression is encouraged, portfolio management is easy, and the rigidity of assessment is eliminated (Chen & Black., 2010; Jafari & Kaufman, 2004).

3.3. Integration of the e-Portfolio and Reflection in the Teaching Learning Process in Primary Education

In the current era, the rapid advancement of technology has brought significant changes in the field of education (Johnson & Johnson, 2016). One of these advances is represented by the use of the e-portfolio which is the effective way to monitor, highlight and evaluate the progress of students (Barrett, 2007; Chang, 2019; Zhang & Tur, 2022).

One of the most common theoretical approaches in the period 2000-2010 is the practice of reflection through electronic portfolios (Barrett 2007; Brandes & Boskic 2008; Yancey, 1996; Zubizarreta, 2008). Several empirical studies have investigated the role of reflection in the making and use of the portfolio and in connection with the impact of reflection on student learning. The researchers' findings showed that (1) the value of the e-portfolio lies in the processes and methods of its realization (Chen & Penny Light, 2010); (2) the portfolio structure shapes the nature of student reflection, and (3) the e-portfolio encourages and supports reflection (Paris & Ayres, 1994). Ciascai (2023) shows that this reflection can also be done by using electronic reflection journals, as an annex to the electronic portfolio. In these journals, students write down their self-assessment and teacher's feedback, their reflections on the learning process, their thoughts, emotions, their knowledge of the materials they have produced, and their significant learning experiences (Boud, Keogh & Walker, 1985; Moon, 1999; Gonzalez, 2008).

Reflection, stimulated through the electronic portfolio, involves establishing learning objectives and strategies and making them explicit in dedicated sections (Chen & Penny, 2010; Chou & Chang, 2008). In other words, by reflecting on the materials that students are going to include in their portfolio, they express their creativity and individuality and contribute to the achievement of learning objectives (Eynon & Gambino, 2017; Papanthymou

& Maria, 2019). The structuring of the portfolio materials based on reflection, critical reflection, critical and creative thinking provides a deep insight into the students' reflection and learning process and their learning progress (Yancey, 2015).

By sharing materials and providing constructive feedback from the teacher individually, students' school performance is improved (Jafari & Kaufman, 2004; Shulman, 2005). It should be noted that it is important to take measures to protect students' information, therefore, it is necessary for teachers to have the essential knowledge about online safety and personal data protection (Chen et al., 2021).

The integration of the e-portfolio into teaching activities is a complex process that requires planning, implementation, reflection, evaluation, revision and improvement (Bower et al., 2015).

The integration of the electronic portfolio in teaching activities can be done according to several criteria such as:

1) Purpose of integration: the e-portfolio is integrated as an additional tool in teaching activities or as a tool for assessing students' school performance (Barrett, 2007).

2) How to use: The e-portfolio can be used as an independent learning tool or integrated into classroom projects (Wu & Lin, 2019).

3) Level of complexity: the e-portfolio can be simple, with limited functions or with a multitude of functions and options (Kim & Ryu, 2020).

4) Technology used: the e-portfolio is created and managed based on special software or on the basis of general applications such as Google Drive.

5) Purpose of assessment: the e-portfolio is used to evaluate students' performance with reference to a specific topic or to evaluate their progress (Alcaraz Salarirche, 2016).

6) Interaction with students: the management of the e-portfolio can be done only by the teacher or students can also be involved by providing the necessary access (Ismail, 2023).

7) Degree of personalization: the e-portfolio can be adapted according to individual needs, such as pace and style or learning needs (Tondeur, Van Braak & Valcke, 2007).

8) Flexibility: the e-portfolio can be adapted according to changes that take place in the curriculum or according to the teacher's options (Kim & Ryu, 2020).

The integration of the e-portfolio into teaching activities has multiple benefits such as documenting students' practical activities, illustrating their performance and results, facilitating communication with parents, creating a sense of belonging to a community and collaboration between students studying online (Bolliger & Shepherd, 2010; Bower et al., 2015; Chen et al., 2021). In an e-portfolio, stored teaching materials are accessed at any time, digital skills and critical thinking are developed, and the learning process is personalized (Chen et al., 2021; Farrell & Seery, 2019; Zubizarreta, 2009). In addition, students identify the knowledge acquired, their strengths, weaknesses and develop the necessary strategies to overcome them (Green et al., 2013; Paolini, 2015; Yancey, 2015). At the same time, students objectively self-evaluate their own work and become aware of their successes and failures (Biswas-Diener et al., 2011).

The e-portfolio can be used in STREAM education and technology (Șoldea et. al, 2021; Șoldea et. al, 2021; Pop and. al. 2021) and it is a valuable resource in learning as long as teachers and students have the necessary knowledge to access this technology effectively (Ertmer & Ottenbreit-Leftwich, 2010).

PART II. EXPLORATORY AND EXPERIMENTAL RESEARCH

CHAPTER IV

EXPLORATORY RESEARCH ON THE USE OF REFLECTIVE THINKING AND THE E-PORTFOLIO IN THE LEARNING PROCESS IN THE NATURAL SCIENCES

The research was carried out in two stages: the preliminary stage and the formative intervention stage.

Structure of the research carried out

In the preliminary stage, a system of observational research was applied on the use of reflective thinking by teachers and students, teachers' perception of the e-portfolio and the level of students' knowledge of the e-portfolio (Table 4.1).

Table. 4.1.

Structure of the research carried out

Typology of the Interventions	Participants in research	Investigations	Methods
Exploratory Research I Professor Exploratory Research II teacher	20 teachers who teach at the third and fourth grades.	The level of use of reflective thinking	Inquiry - Tool 1 Individual Interview - Tool 2 Focus group 1 – tool 3
		Perception of the e-portfolio.	Inquiry - Tool 4 Individual Interview - Tool 5 Focus group 2 – tool 6
Exploratory research III students	439 students from the third and fourth grades.	The level of use of reflective thinking	Inquiry – Tool 7
Exploratory Research IV Students		Level of knowledge on the use of the e-portfolio	Inquiry – Tool 8
Formative experimental research		Level of school performance of students in experimental groups following the application of the intervention based on the practice of reflection in the context of portfolio use Electronic	The formative experiment

Note: The use of survey, individual interview and focus group for teachers involved in exploratory research followed the need to refine the results. In fact, the number of teachers is small (20 teachers) and the teachers' perceptions regarding the practice of critical reflection and the use of the portfolio, as evidenced by the written survey, are at high values, which raised questions for us. As a result, the researcher wanted to clarify the results obtained through the written survey.

4.1. Preliminary Research on the Knowledge and Use of Reflection and the E-Portfolio by Teachers and Students in Primary Education Involved in Research

4.1.1. The Problem and Objectives of the Preliminary Investigations

Problem: The preliminary research carried out aims to identify aspects regarding the types of portfolios used in primary education, the frequency of their use, the practice of reflection in the creation of a digital portfolio, as well as its use as a reflective learning tool.

The objectives of the preliminary research carried out:

Objective 1. To investigate teachers' perception of the practice of reflection in primary school teachers.

Objective 2. Investigating the perception of primary school teachers on the use of e-portfolios.

Objective 3. Examining the self-perceived level of use of reflective thinking in natural science classes in primary school students.

Objective 4. To investigate the self-perceived level of knowledge on the use of e-portfolios in natural sciences classes in primary school students.

Objective 5. To investigate gender differences in the level of use of reflective thinking and knowledge on the use of e-portfolios in natural science lessons in primary school students.

The results obtained in the preliminary research were used as a starting point in the formative research. Thus, the preliminary research allowed the identification of a profile of primary school teachers, involved in the research, with reference to the practice of reflection and the use of the electronic portfolio. At the same time, the investigation of the level of reflective thinking and the students' knowledge/ skills regarding the use of the e-portfolio facilitated the design of learning activities based on the digital portfolio and reflection and the direct relationship with children during the teaching activity.

4.1.2 Illustration of the Composition of the Batch of Students Participating in the Preliminary Research and Formative Intervention

The participants in the preliminary research are also those who were involved in the formative intervention. Their selection in the experimental (205 students) and control (234 students) classes was based on:

a) the willingness shown by teachers to participate in the activities carried out in the experimental groups;

b) school results in the subjects Environmental Knowledge and Natural Sciences obtained in the previous year of study by students in the third and fourth grades;

c) tests on digital skills applied to students in the third and fourth grades. It should be noted that the students selected in the experimental and control classes did not differ significantly either in terms of their scientific knowledge or their digital skills.

439 students participated in the research, of which 234 were assigned to the control group and 205 to the experimental group. Of these, 227 students are in the third grade and 212 in the fourth grade.

In the third grade, the control group consists of 121 students, and the experimental group consists of 105 students, compared to the fourth grade, in which 112 students are in the control group and 100 in the experimental group.

The effect of the students in the experimental group is smaller than that of the control group; the differences between the number of students in the third and fourth grades are less than 5%. In the third grade, the percentage of female students is slightly higher than that of male students, this difference being maintained in terms of the number of students in the control group, which is higher than that of the experimental group. The students in the Step by Step form of education represent only a quarter of the total number of third-grade students involved in the research. The same proportion is maintained for students in the fourth grade of the Step by Step program. In the third grade, there are 13 students in simultaneous classes, and in the fourth grade there are 15 students.

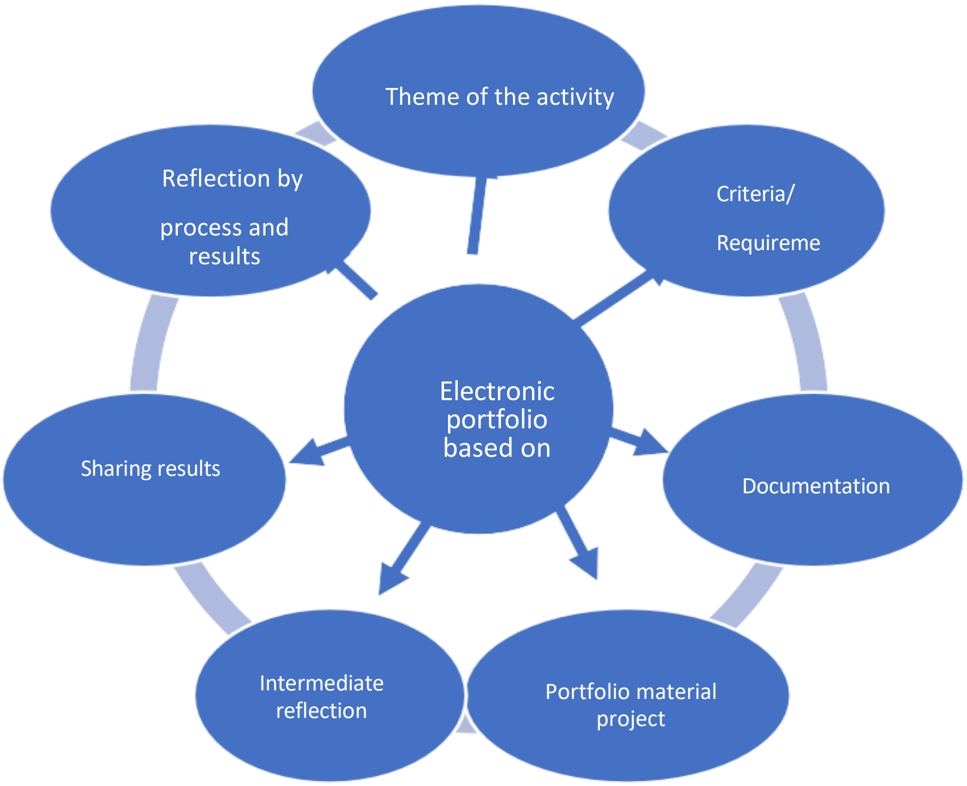
Conclusions on preliminary investigations

The results of the preliminary investigations allowed the following findings to be formulated:

- the tools (questionnaires) applied to teachers and students in the third and fourth grades have good internal consistency;
- both the teachers (20 teachers) and the students (205 students of the third and fourth grades included in the experimental group, as well as the 234 students of the third and fourth grades in the control group) have a good and very good self-perceived level of reflective thinking and the use of portfolios;
- the students in the control and experimental groups do not significantly differ statistically with reference to the self-perceived level of scientific knowledge, the practice of reflection and the use of electronic portfolios and regarding the level of digital skills.

Based on the results obtained, the formative investigation approach applied to the experimental group (third and fourth grades) was projected in a unitary manner. We mention that the distribution of students in the experimental and control group was random. Also, the results obtained through individual interviews and focus groups carried out additionally with the teachers of the experimental groups allowed the outlining of the model of learning activities based on electronic portfolio and reflection, meant to give the unitary character to the activities carried out in the experimental groups.

Figure 4.1.
The Learning Activities Model Applied in Formative Intervention



CHAPTER V

FORMATIVE RESEARCH ON THE USE OF THE E-PORTFOLIO BASED ON REFLECTION AT THE THIRD AND FOURTH GRADES IN THE DISCIPLINE OF NATURAL SCIENCES

5.1. Research Objectives, Hypotheses and Variables

The general objective of the research is to investigate the impact of the use of the e-portfolio as a reflective learning tool on the school performance of students in the discipline of Natural Sciences.

Specific objectives:

Objective 1. Analysis on the impact of the implementation of the portfolio at the end of the school year on the knowledge of natural sciences of students in the third and fourth grades.

Objective 2. Analysis of gender differences according to the control and experimental groups in the knowledge tests of the Natural Sciences discipline.

Objective 3. Analysis of the relationship between the level of use of reflective thinking and school performance in the Natural Sciences discipline in primary school students.

Additional questions

In order to deepen the research, a set of complementary questions were formulated focused on the existence of statistically significant differences, with reference to scientific knowledge, between (i) the third and fourth experimental groups; (ii) experimental groups in traditional education and Step by Step, (iii) experimental groups in traditional education and simultaneous traditional education, (iv) experimental and control groups in Step by Step education, and (v) experimental and control groups in simultaneous traditional education. These questions are exploratory in nature because we have not found dedicated studies in the international literature.

Hypotheses formulated

General hypothesis: The integration of the reflection-based digital portfolio into the science learning process, in experimental classrooms, as a training strategy, will have a positive impact on learning performance in the Natural Sciences discipline.

Specific hypothesis 1: There are significant differences between the school performance of students in experimental and control classes in the final assessment and retesting stage, without these differences being present in the initial assessment, under the implementation of a learning program based on the digital portfolio and integrating reflection as a training method.

Null hypothesis: There are NO significant differences between the school performance of the students in the experimental and control classes in the final evaluation and retesting stage, without these differences being present in the initial evaluation, under the conditions of implementing a learning program based on the digital portfolio and integrating reflection as a training method.

A study conducted on a sample of 7305 students from different grades, including the third grade of primary school, shows that there are gender differences in science performance (Hsin-Hui, 2015). The quoted source shows that boys, starting with the third grade, record better results in sciences that are maintained during secondary school studies, compared to girls. As a result, we formulate the following hypotheses:

Specific hypothesis 2. There are gender differences between school results in science in the three stages of testing.

The null hypothesis. There are no gender differences between school results in science in the three stages of testing.

The literature debates the existence of a relationship between reflective thinking and performance in science. Thus, Nurhayati (2023), citing Bassachs et al. (2020), García-Carmona (2021), Vogelsang et al. (2022), shows that reflective thinking is essential in science learning. Lew and Schmidt (2011) deny the existence of a relationship between reflection and academic performance, but refer in their research to students. Since there are few data-supported references to early school age in the literature, for our research, we formulated the following exploratory hypothesis:

Specific hypothesis 3. There is a positive relationship between the level of reflective thinking use and performance in science.

The null hypothesis. There is no positive relationship between the level of reflective thinking use and performance in science.

Based on the results of the study conducted by Nițulescu (2014) with reference to the school results, including creative-reflective thinking, of students, in traditional education and

Step by Step, the following hypotheses were formulated:

Specific hypothesis 4. There are significant differences between the science results of students in the traditional form of education and the Step by Step form of education.

The null hypothesis. There were no significant differences between the science results of students in the traditional form of education and the Step by Step form of education.

Specific hypothesis 5. There are significant differences between the science results of the experimental group in traditional education and simultaneous traditional education.

The null hypothesis. There are significant differences between the science results of students in traditional education and simultaneous traditional education.

Specific hypothesis 6. There are significant differences between the third and fourth experimental grades in terms of results in science.

The null hypothesis. The experimental grades III and IV do not significantly differ statistically in terms of results in science.

Variable

Independent variable: Intervention program based on the use of the electronic portfolio in natural sciences classes and the time of testing (pre-test, post-test, retest).

Dependent variable: The level of school performance in the natural sciences discipline in primary school students (third and fourth grades).

Controlled variable: students' digital skills.

5.1.2. Methodologies

Design and variables. The present study is one that implements an experimental design in which the manipulated independent variable is the implemented program (the electronic portfolio). The independent variable has two modalities, with two groups (control vs experimental). The dependent variable in our study is the score on the knowledge test, measured in three time points (pre-test, post-test, retest). The score was calculated by adding up all the items that measure the level of knowledge. A higher score signifies a higher level of knowledge, with a value of 100 being the maximum possible score.

The strategies applied within the learning activities aimed at a variety of methods such as problematization, problem solving, modeling, questionnaires, experiment, investigation, but also forms of student organization (individual work, group work and frontal activities).

Table 5.1.1.

Experimental design

Time of assessment / Group	Pretest	Formative intervention	Posttest	Retest
Experimental Group	The test for the evaluation of school performance in the discipline of natural sciences	Integrating the e-portfolio into learning	The test for the evaluation of school performance in the discipline of natural sciences	The test for the evaluation of school performance in the discipline of natural sciences
Control group	The test for the evaluation of school performance in the discipline of natural sciences	The traditional method	School performance evaluation test at Natural Sciences Discipline	The test for the evaluation of school performance in the discipline of natural sciences

5.1.3 Participants

This study involved 20 female primary school teachers and 439 students. Of these, 234 students were assigned to the control group, while 205 students were included in the experimental group. Most of the subjects study in traditional education, 111 in the Step by Step alternative, and 28 students are in a simultaneous group (third and fourth grade students learn together). The participants are between 9 and 10 years old, and their distribution was made following the application of tests to verify the level of their digital skills.

The experimental groups were constituted according to the level of schooling and include four third grades, four fourth grades and a simultaneous third and fourth grade. The experimental groups of the third grade comprise two traditional classes from the "Mihai Eminescu" Secondary School in Năsăud, with C.I. and T.S. as teachers, and two classes from the Secondary School No. 4 in Bistrița with a Step by Step class and a traditional class. The traditional class was coordinated by the C.D.E. teacher, while the Step by Step class was guided by the B.M.F. and C.A. teachers.

The experimental groups of the fourth grade included two traditional classes from the "Mihai Eminescu" Secondary School in Năsăud, with teachers on R.I.M. and V.I.A., a class of Step by Step from the Secondary School No. 4 in Bistrița, with the teachers D.C.B. and

D.A., and a traditional class from the "Tudor Jarda" Music High School in Bistrița, with the teacher B.D.M. In addition, there was another simultaneous class of the third and fourth grades from the Secondary School "George Coșbuc" Coșbuc coordinated by P.A.O.

The control groups were organized in a similar manner, with four classes of the third grade, four classes of the fourth and one simultaneous class of the third and fourth grades. The control groups in the third grade included a traditional class from the "George Coșbuc" National College in Năsăud, with an R.I. teacher, and three classes (two classes with traditional education and a class in which students study in the Step by Step alternative) from Secondary School No. 1 in Bistrița. The two traditional classes at this school had L.I.C. and T.N. teachers, while the Step by Step class was guided by the S.A.T. teacher. The fourth-grade control groups included a traditional class from the "George Coșbuc" National College in Năsăud, with a teacher named M.Ş., two classes (one traditional and one Step by Step) from the "Liviu Rebreanu" National College in Bistrița. The traditional class was coordinated by B.A.M., and the Step by Step class was led by S.S.V. From Secondary School No. 4 in Bistrița, there was another class of the fourth traditional education was coordinated by N.M. In the control group, there was also a simultaneous class of the third and fourth grades from the Telciu Technological High School (Bichigiu Secondary School) led by Z.S.

The inclusion criteria are:

- students from the third and fourth grades of traditional education and Step by Step;
- students from the third and fourth grades, traditional education and simultaneous traditional classes.

5.1.4. Measuring Instruments

The measuring instruments used to achieve the objectives of the formative intervention are the tests applied to classes that measure the level of knowledge of students in the discipline of Natural Sciences in the 3 moments (pre-test, final test, retest).

Table 5.1.2.

Tools used in formative research

Formative research	Third grade	Knowledge tests in the discipline of Natural Sciences	Pretest Tool 1
			Final Testing – Tool 2
			Retest – Tool 3
	Fourth grade	Knowledge tests in the discipline of Natural Sciences	Pretest-Tool 4
			Final Testing – Tool 5
			Retest – Tool 6
	Grades III and IV	Self-reflection sheet Teacher	Tool 7
		Student self-reflection sheet	Tool 8
		Portfolio evaluation grid	Tool 9

5.1.5. Working procedure

In order to implement the formative intervention based on the use of the e-portfolio as a reflective learning tool in the Natural Sciences discipline, it was necessary to sign collaboration agreements between Babeș-Bolyai University Cluj-Napoca and the school institutions involved in the research. The first step was therefore to inform the partner schools about the objectives and conduct of the research and to obtain their agreement. After obtaining the collaboration agreement from the school institutions, the parents of the students involved were informed about the purpose of the research and voluntary participation in the activities related to the formative intervention. Thus, the students' relatives signed the participation agreement through which they expressed their consent for the students' works or some photos of them from the activities to be attached, if necessary, to the present work.

Once the participation agreements were obtained, the application of digital tests (ANNEX 18) followed in order to assess the students' skills and knowledge and to set up experimental and control groups. The participants involved in the research (students and teachers) received and completed the questionnaires designed by the researcher through the Google Drive platform. The applied scales/ questionnaires assess the knowledge and skills of students and teachers regarding reflection and the electronic portfolio in learning in the Natural Sciences discipline (ANNEX 1, 4, 7, 8). Also, interview sessions and focus groups were organized on the theme of the research in which the 20 teachers involved in the research participated (ANNEX 2, 3, 5, 6). At the same time, the initial knowledge assessment tests were applied to the Natural Sciences discipline (pre-test), in October, for the experimental and control groups (ANNEX 9, 12). The teachers in the experimental groups were trained by the researcher in the use of the SeeSaw platform based on the guidelines published by the platform administrators. The guides were translated from English into Romanian by the researcher and verified by an expert in the field of teaching exact sciences (ANNEX 19, 20, 21, 22). After the training of the teachers, the training and use of the platform with the students followed. Teachers in the experimental groups trained students in the use of the SeeSaw platform and used the platform during the intervention period. Next, the teachers from the experimental group received both the indicative homework carried out in accordance with the school curriculum for the Natural Sciences discipline (ANNEX 23) and the self-reflection and reflection sheets for teachers and students in order to be used in the teaching activity (ANNEX 15,16). They also received the evaluation grid of the electronic portfolio (ANNEX 17).

The research ended with the application of the knowledge assessment tests in the Natural Sciences (post-test – ANNEX 10,13) in March followed by retesting in May (ANNEX 11,14). These tests provided valuable data to assess the impact of the educational intervention. The results indicate a significant improvement in the students' school performance following the application of the intervention program based on the use of the electronic portfolio to the Natural Sciences discipline.

5.1.6. Data analysis

Statistical processing used in formative intervention

- Means and standard deviations of the experimental and control groups III and IV at the three tests.
- Differences between the averages of the students in the third and fourth grades in the control and experimental groups in the three tests.
- Values and confidence intervals for the three tests applied to groups III and IV.
- Frequencies of scores for the three tests in groups III and IV.
- Tests of intra- and inter-subject effects in groups III and IV, normal program and Step-by-Step.
- Tests of intra- and inter-subject effects in groups III and IV, normal and

simultaneous schedule.

- Anova Mixta Analysis for Traditional Education Classes (3rd and 4th).
- Gender differences control group – experimental on natural science tests.
- Gender differences according to control vs. experimental group.
- The matrix of correlations between the level of use of reflective thinking and school performance - third grade.
- Matrix of correlations between the level of use of reflective thinking and school performance - fourth grade.
- Qualitative study of teachers and students on the practice of self-reflection

Objective 1. Analysis of the impact of the implementation of the portfolio at the end of the school year on the knowledge of natural sciences of students in the third and fourth grades.

For data analysis, we used the IBM SPSS 21 statistical program. For descriptive analysis, we used means and standard deviations, and, for inferential statistics, we used the Anova test and the T test.

Differences between the averages of the students in the control and experimental groups (grade III)

In the following table, we have presented the averages for the control group and the experimental group in all three test moments (pre-test, post-test and retest). We can see that the control group has a higher average than the experimental one in the initial evaluation, but in the post-test and retest phase the situation changes, the experimental group having a higher average.

Table 5.1.3.

Descriptive statistics on the three tests for the experimental and control groups

	Group	Intercede	Standard deviation	Number
Pre-test score	Control	80.8852	13.98180	122
	Experimental	78.5905	18.68344	105
Post-test score	Control	81.9098	12.55204	122
	Experimental	85.8190	13.76854	105
Retest score	Control	80,0492	11.81108	122
	Experimental	84.3619	13.47942	105

Table 5.1.4 shows the same mean values, as well as the confidence intervals (95%). They show us with 95% confidence where the average is at the population level.

Table 5.1.4.

Values and confidence intervals for the three tests applied to the third grades

Group	Testing	Media	Standard error	95% confidence interval	
				Lower lim	Upper limit
Control	Pretest	80.885	1.478	77.973	83.798
	Posttest	81.910	1.189	79.568	84.252
	Retest	80.049	1.142	77.800	82.299
Experimental	Pretest	78.590	1,.93	75.451	81.730
	Posttest	85.819	1.281	83.294	88.344
	Retest	84.362	1.231	81.937	86.787

To inferentially test the differences between the means, we used the bifactorial Anova test in which the time of testing is a dependent sample variable (with the 3 levels), and the group is a variable with independent samples (control vs. experimental). We can see that both testing and the interaction between testing and the group are statistically significant, with the partial square eta indicator showing a large effect.

Table 5.1.5.

Differences between the averages of students in the third grade

Source	F	Say.	Partial Eta Squared
Testing	10.221	.000	.043
test * Grup	8.130	.000	.035

Next, we performed two separate Anova analyses, in the first case, considering only the pre-test and post-test, and, in the second case, the post-test and retest evaluation.

We also performed an Anova test at the post-test and retest.

The following tables show the standard averages and deviations for each specific exercise within the post-test and retest.

Table 5.1.10.

Averages and post-test standard deviations in the third grade groups involved in research

Group		Ex. 1-Posttest	Ex. 2-Posttest	Ex. 3-Posttest	Ex. 4-Posttest	Ex. 5-Posttest	Ex. 6-post-test re
Control	Media	15.9508	27.0656	16.4098	8.8525	10.7049	3.0984
	N	122	122	122	122	122	122
	Standard deviation	4.15575	6.0102	3.81981	2.64629	4.09735	4.81803
Experimental	Media	15.0476	28.4476	16.6571	9.1810	10.9143	5.3524
	N	105	105	105	105	105	105
	Standard deviation	6.20233	3.39111	3.62902	2.28196	3.12593	5.06493
Total	Media	15.5330	27.7048	16.5242	9.0044	10.8018	4.1410
	N	227	227	227	227	227	227
	Standard deviation	5.21082	5.00496	3.72662	2.48446	3.67368	5.04997

Table 5.1.11

Averages and standard deviations: retesting in the third grade groups involved in the research

Group		Ex.1-Retest	Ex.2-Retest	Ex. 3-Retest	Ex. 4-Retest	Ex. 5-Retest	Ex. 6-Retest
Control	Media	11.5410	11.5574	15.6885	11.3033	21.7541	8.0984
	N	122	122	122	122	122	122
	Standard deviation	1.63205	1.57485	3.11775	2.25223	6.15813	7.10768
Experimental	Media	11.8286	11.9619	14.9810	11.2571	23.5810	10.3524
	N	105	105	105	105	105	105
	Standard deviation	1.64934	2.09360	5.17015	2.87238	2.71315	8.58552
Total	Media	11.6740	11.7445	15.3612	11.2819	22.5991	9.1410
	N	227	227	227	227	227	227
	Standard deviation	1.64273	1.84004	4.19881	2.55207	4.95221	7.88902

Table 5.1.12

Descriptive statistics

Descriptive Statistics

	N	Minim	Maximum	Mean	Std. Deviation	Skewness		Kurtosis	
	State.	State.	Statistic	Statesmen c	Statistic	Statesmen c	Std. Error	Statesmen c	Std. Error
Pre-test score	227	16.00	100.00	79.8238	16.32834	-1.233	.162	1.366	.322
Post-test score/ Final evaluation	227	39.00	100.00	83.7181	13.24413	-.871	.162	.497	.322
Retest score	227	48.00	100.00	82.0441	12.76499	-.478	.162	-.535	.322
Valid N (listwise)	227								

Differences between control-experimental students (fourth grade)

In the following table, we have presented the means for the control group and the experimental group in all three test moments (pre-test, post-test, and retest). We can see that the control group has a higher average than the experimental one in the initial evaluation, but, in the post-test and retest phase, the situation changes, the experimental group having a higher average.

Table 5.1.13

Averages in the control and experimental groups of class IV in the 3 test moments

	Group	Media	Standard deviation	N
Pre-test score	Control	81.42	14.631	112
	Experimental	76.55	15.559	100
Post-test score	Control	77.92	14.519	112
	Experimental	85.88	13.375	100
Retest score	Control	78.96	15.203	112
	Experimental	90.09	10.303	100

Next, we performed a bifactorial Anova test in which we included the time of testing as an independent variable with repeated measurements, and the group (experimental vs control) as an independent variable with independent samples, the dependent variable being test performance. The testing, the group, and the interaction between the two have a statistically significant effect.

Our hypothesis that the experimental group has a higher average in the knowledge test, post-test and retest test (compared to the control group) is confirmed. At the time of pre-testing, however, the control group has a higher average than the experimental one. Thus, the results obtained support our hypothesis and we can conclude that the intervention does indeed have an effect on the students' knowledge.

Differences between grades III and IV

The analyses suggest that the effect of the intervention is different for the third grade compared to the fourth grade. To test this hypothesis, we performed an ANOVA analysis in which we also included the class as an independent variable.

The results are presented in the following table.

Table 5.1.16

Tests of effects in subjects

Measure: MEASURE_1

Source	Sum of squares	degrees of freedom	Variance	F	P	eta square partially
Testing	4169.333	2	2084.666	24.608	.000	.054
test * grup	8061.913	2	4030.957	47.583	.000	.099
Test * Clasa	1063.322	2	531.661	6.276	.002	.014
Testing * group * class	1272.255	2	636.127	7.509	.001	.017

Table 5.1.17

Tests of effects between subjects

Measures: MEASURE_1

Transformed variable:

Mean

	Sum of squares	degrees of freedom	Variance	F	P	eta partial square
Group	3693.808	1	3693.808	8.647	.003	.019
Class	5.836	1	5.836	.014	.907	.000
group * class	626.300	1	626.300	1.466	.227	.003

We can see that the class interacts with testing and group with testing. These interaction effects suggest that the effect of the intervention is greater in one of the two classes. An analysis of the differences in the averages does indeed confirm that the fourth grade benefited more from the intervention. For example, in the post-test the difference between the experimental and the control is 7.96 points in the fourth class, and, in the third class, it is 3.91 points.

Sex differences according to control vs. experimental group

Next, we tested the differences between the sexes and according to the group (control vs experimental). For this, we performed a mixed Anova analysis with 3 variables (time of assessment, sex and group). The interaction between all three variables is not significant, meaning that boys and girls follow a similar pattern of increasing scores. An analysis of the graphs, however, shows that, in boys, there is a progressive increase from the initial to the final evaluation and to the retest.

In girls, however, there is a significant increase from the initial evaluation to the final evaluation, but from the final evaluation to the retest there is no change.

Assumption of normality:

We can see from the graphs below that the distributions of the 3 variables are slightly asymmetrical, but it should be noted that the values of the asymmetry and vault indices do not have extremely high values. Also, the t-tests and Anova are robust to violations of the assumptions of normality, especially in the case of large samples these violations are not a problem (Cohen, 2001).

Objective 3. Analysis of the relationship between the level of use of reflective thinking and school performance in the Natural Sciences discipline in primary school students.

To determine whether there is a relationship between the ***level of use of reflective thinking*** and ***school performance*** in the discipline of natural sciences in primary school students, we made a correlation between the two variables with the help of the Pearson correlation coefficient. The results are presented in the tables below.

Table 5.1.29.

Matrix of correlations between ***the level of use of reflective thinking*** *and* ***school performance*** - *third grade*

Correlations

		grtotal	points_ev_init
Grtotal	Pearson Correlation	1	.159*
	Sig. (2-tailed)		.016
	N	227	227
punctaj_ev_init	Pearson Correlation	.159*	1
	Sig. (2-tailed)	.016	
	N	227	227

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

There is a significant positive correlation between ***the level of reflective thinking use*** and ***school performance*** in children in the third grade ($r = 0.159$, $DF = 225$, $p < 0.05$), which means that increased levels of reflective thinking are related to increased levels of school performance in children in the third grade.

Table 5.1.30

Matrix of correlations between ***the level of use of reflective thinking*** *and* ***school performance*** - *fourth grade*

Correlations

		Grtotal	points_ev_init
Grtotal	Pearson Correlation	1	.279**
	Sig. (2-tailed)		.000
	N	212	212
punctaj_ev_init	Pearson Correlation	.279**	1
	Sig. (2-tailed)	.000	
	N	212	212

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

There is a significant positive correlation between ***the level of reflective thinking use*** and ***school performance*** in children in the fourth grade (r = 0.279, DF = 210, p< 0.01), which means that increased levels of reflective thinking are related to increased levels of school performance in children in the fourth grade.

5.1. Teachers' qualitative study on the practice of self-reflection

At the end of each activity within the intervention program, the teachers from the experimental group had to fill in a self-reflection sheet.

After each activity, the set of worksheets was analyzed and the data were included in a qualitative analysis of how the teachers perceived various aspects of the activity

5.2.1 Conclusions of the qualitative study of teachers on the practice of self-reflection

In order to stimulate students to get involved in the learning activity, it is necessary to use a wide variety of homework and teaching strategies in the classroom and to diversify homework (Acatrinei & Opriș, 2023; Opriș, D. & Opriș, M., 2024). The use of the e-makes it easier for students to confront this variety of learning activities (Opriș, 2024).

The teachers involved in the research carried out numerous educational activities, including the organization of games according to the theme of the lessons addressed, the organization of debate sessions in which the information presented was discussed, as well as the creation of posters, drawings and experiments in relation to the planned lessons. Also, visits to various locations were organized in order to consolidate the students' theoretical knowledge and combine it with the practical ones, short educational films were watched and various products were made in relation to the topics addressed in the Natural Sciences discipline.

The teachers listed a series of difficulties encountered, among which we specify the students' lack of interest in terms of the theoretical part, the identification of multiple ways by through which they initiated the students in the activity and mentioned their curiosity, finding films that would present the notions as correctly as possible and solving technical problems. For the various difficulties, teachers reported that they provided clear and practical examples, explained the concepts in an accessible and attractive manner, and assigned each student a role in each teaching activity. As suggestions from teachers, we mention creating their own educational films, organizing debate/ practical sessions within each lesson, using interactive simulations, diversifying learning resources, asking for constructive feedback, as well as encouraging students to carry out their own investigations. As for the aspects that the teachers liked, we mention the interaction of the students during the activities, the explanations given by the students, the creativity of the students, the products and experiments carried out and the games carried out. In the case of unpleasant aspects, teachers reported the lack of time management, the vast volume of theoretical information, the lack of a laboratory equipped with the necessary resources and the lack of electronic devices for students.

5.3. Qualitative study of students on the practice of self-reflection

At the end of each activity within the intervention program, the students in the experimental group had to fill in a self-reflection sheet.

After each activity, the set of worksheets was analyzed and the data were included in a qualitative analysis of how the students perceived various aspects of the activity.

5.3.1. Conclusions of the Qualitative Study on the Practice of Self-Reflection by Students

The students involved in the research carried out numerous educational activities, including participation in games in accordance with the theme of the lessons addressed, participation in debate sessions in which the information presented was discussed, as well as experiments. They also visited various locations in order to consolidate their theoretical knowledge with practical knowledge, watched short educational films and made various products using different techniques in relation to the topics addressed in the Natural Sciences discipline. Numerous materials from various categories were used to make the products, including paper (white, cardboard, crepe), glue, scissors, watercolors, pencils, plasticine, tempera, brushes, as well as various recyclable materials.

The students listed a series of difficulties such as handling small decorative elements, cutting out drawn elements, assembling materials, drawing certain parts of a mammal/reptile, but also correcting and finishing some products. For the various difficulties, the students reported that they made the products in stages, tested the functionality of the products, replaced some materials and collaborated. As suggestions, the students specified experimenting with various materials to see which one blends best from an aesthetic point of view, assigning a different role to the product, writing poems or stories about the product made, getting involved in various campaigns and creating films and exhibitions with and about the products made. As for the pleasant aspects, the students mentioned the products made, the freedom to explore and make the products and their presentation. In the case of unpleasant aspects, the students specified the resumption of the manufacturing process, breaking the materials while handling them and making decisions regarding the design of the products.

CHAPTER VI

CONCLUSIONS OF THE RESEARCH

Specific conclusions

Professors involved in research have a high self-perceived level of reflective thinking and the use of the e-portfolio in teaching. The same situation can be found in the case of students in the third and fourth grades, involved in the research.

Following the formative intervention carried out, the following conclusions can be drawn regarding the hypotheses formulated:

Specific hypothesis 1: There are significant differences between the school performance of students in experimental and control classes in the final assessment and retesting stage, without these differences being present in the initial assessment, under the implementation of a learning program based on the digital portfolio and integrating reflection as a training method.

The results obtained show that in the retest and post-test stages, the results of the experimental group differ significantly from those of the control group, being superior to them, from which we conclude that the experimental group really benefited from the intervention. The distributions of the scores in the three moments of the test are elongated to the right (being more students with high scores than students with low scores). The analyses carried out suggest that the effect of the intervention is different for the third grade compared to the fourth grade. An analysis of the differences in the means does indeed confirm that the fourth grade benefited more from the intervention.

Specific hypothesis 2. There are gender differences between school results in science in the three stages of testing.

The t-tests with independent samples applied in the three stages of the test show that there is a significant difference only in terms of the initial assessment ($p=0.005$), boys having higher scores than girls. However, these differences disappear in the final assessment and in the case of the retest. As a result, the hypothesis is only partially verified. It should also be noted that the analysis of the results shows that in boys there is a progressive increase from the initial to the final evaluation and to the retest. In girls, however, there is a significant increase from the initial evaluation to the final evaluation, but from the final evaluation to the retest there is no change.

When interviewed, teachers attribute boys' results to the predominantly practical themes of their portfolios and their interest in technology, aspects that are less attractive to girls.

Specific hypothesis 3. There is a positive relationship between the level of reflective thinking use and performance in science.

The results show, for both grades (third and fourth grades), that there is a significant positive correlation between the level of use of reflective thinking and school performance, which means that increased levels of reflective thinking are related to increased levels of school performance.

Specific hypothesis 4. There are significant differences between the science results of students in the traditional form of education and the Step by Step form of education.

The results show us, regarding the students' knowledge, that there is no difference between the step-by-step program and the traditional one (p=0.129), and the type of program does not interact with the time of testing (p=0.842), which means that there are no differences between the two types of program in any of the three moments of testing. So the null hypothesis is supported by the experimental data.

Specific hypothesis 5: There are significant differences between the science results of the experimental group in traditional education and simultaneous traditional education.

Regarding the simultaneous classes of the third and fourth grades, there are no significant differences at the time of pre-testing, but there are in the other two moments, which means that the experimental group has maintained its score, and the control group has registered a decrease. The analyses by classes show us that only at the level of the third grade there is an interaction between the group and the time of testing. For grade III, however, the difference is large at the level of post-testing, but this is reduced at the time of retesting, and, for grade IV, there is a small difference between control and experimental at the time of retesting, but not at the time of post-testing.

Specific hypothesis 6. There are significant differences between the science results of students in the third and fourth grades.

The analyses suggest that the effect of the intervention is different for the third grade compared to the fourth grade. We can see that the class interacts with testing and group and testing. An analysis of the differences in the means does indeed confirm that the fourth grade benefited more from the intervention, compared to the experimental third grade group.

To the question whether the two experimental and control groups in traditional simultaneous education differ significantly in formative intervention, the answer is affirmative. Thus, we can see that there is an interaction effect between the time of testing and the group. If at the time of pre-testing there is no significant difference between the control and experimental groups, within the post-test and retest the difference exists. However, it should be noted that the post-test score is lower than the pre-test score. Thus, we can conclude that the experimental group maintained its score and the control group recorded a decrease.

In the case of the Step by Step curriculum, there are no statistically significant differences between the experimental and control groups.

General conclusions

The present work had as a benchmark multiple researches in the specialized literature, including those carried out by Hamdan and Yassine-Hamdan (2022), Hammrich et. al. (2000), McLeod and Vasinda (2009), Pennington (2011), Theodosiadou and Konstantinidis (2015).

The analyzed studies present similar conclusions to those of the present paper, showing the benefits of implementing and using the e-portfolio in the learning process. These benefits are manifested by improving students' school performance, developing reflective and critical thinking, (self-)evaluating their progress, identifying areas that need improvement, increasing self-esteem and involving students in their own learning process. In addition, also through the use of digital portfolios, students' metacognitive skills such as planning, monitoring and evaluating learning strategies are developed. At the same time, a stimulating environment is created in which students collaborate and learn from each other, also developing skills necessary for their long-term school success because they are provided with the tools to help them become autonomous and effective learners. It is important to mention that the use of e-portfolios and the development of reflection are necessary in promoting quality education tailored to the needs of students.

6.1. Discussions

The present study demonstrates that the intervention carried out (portfolio) has an effect on the knowledge of children in the third and fourth grades. Moreover, the effects are maintained over time, which means that the research methodology is solid, and the consistent results provide stable and repeatable evidence that can be used to strengthen, revise or build new theories in the field, being a valuable benchmark for future research.

These results are especially important for practitioners (primary school teachers, teachers, school counsellors) in that they provide an effective way to improve teaching by introducing self-reflection sheets for pupils and teachers. These worksheets facilitate the reflection process and encourage both teachers and students to engage in the act of learning.

In future research, these worksheets can be used to reflect on difficult situations and share the knowledge gained, encouraging collaboration and communication.

In order to comply with the requirements of research ethics (Opriș, 2024), the involvement of students in the research carried out had the consent of the parents, the agreement of the school institution and the agreement of the students. As the case may be, in response to some requests, the students were anonymized, but these situations were reduced numerically. In all situations, they have the products of the students' activity uploaded to their electronic portfolios.

6.2. Limit

The present study has a number of limitations. First of all, the randomization was done by classes and not by subjects. Thus, each class was assigned to a group (control vs. experimental). Randomization on the subject would have brought a higher level of control, but this would have been very difficult to implement. Another limitation is that a large part of the implementation of the portfolio was done by the professors, thus, the researcher having limited control. Also, the process of measuring knowledge was not a comprehensive one, but rather a simplified one, and the questionnaires were not validated on the Romanian population. In addition, the number of subjects has been reduced.

Future studies could also study other types of portfolios. It would also be important to see if the results of this study apply to other classes. Last but not least, the mediating mechanisms should be investigated in future research, in order to understand how exactly the intervention produced the given effect.

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WEBOGRAPHY

Original user guides of the SeeSaw platform after which the translation into Romanian was made with the consent of the owner of the platform.

1) SeeSaw: a guide for language teacher
https://ppli.ie/wp-content/uploads/2020/11/Seesaw.pdf

2) How to guide for SeeSaw
https://balgowlaht-p.schools.nsw.gov.au/content/dam/doe/sws/schools/b/balgowlaht-p/remote-assistance-learning/3-april/How_to_Guide_for_Students_See_Saw.pdf

3) Parent guide to SeeSaw
https://www.calwellps.act.edu.au/data/assets/pdf_file/0009/467127/Seesaw_Parent_Guide. pdf