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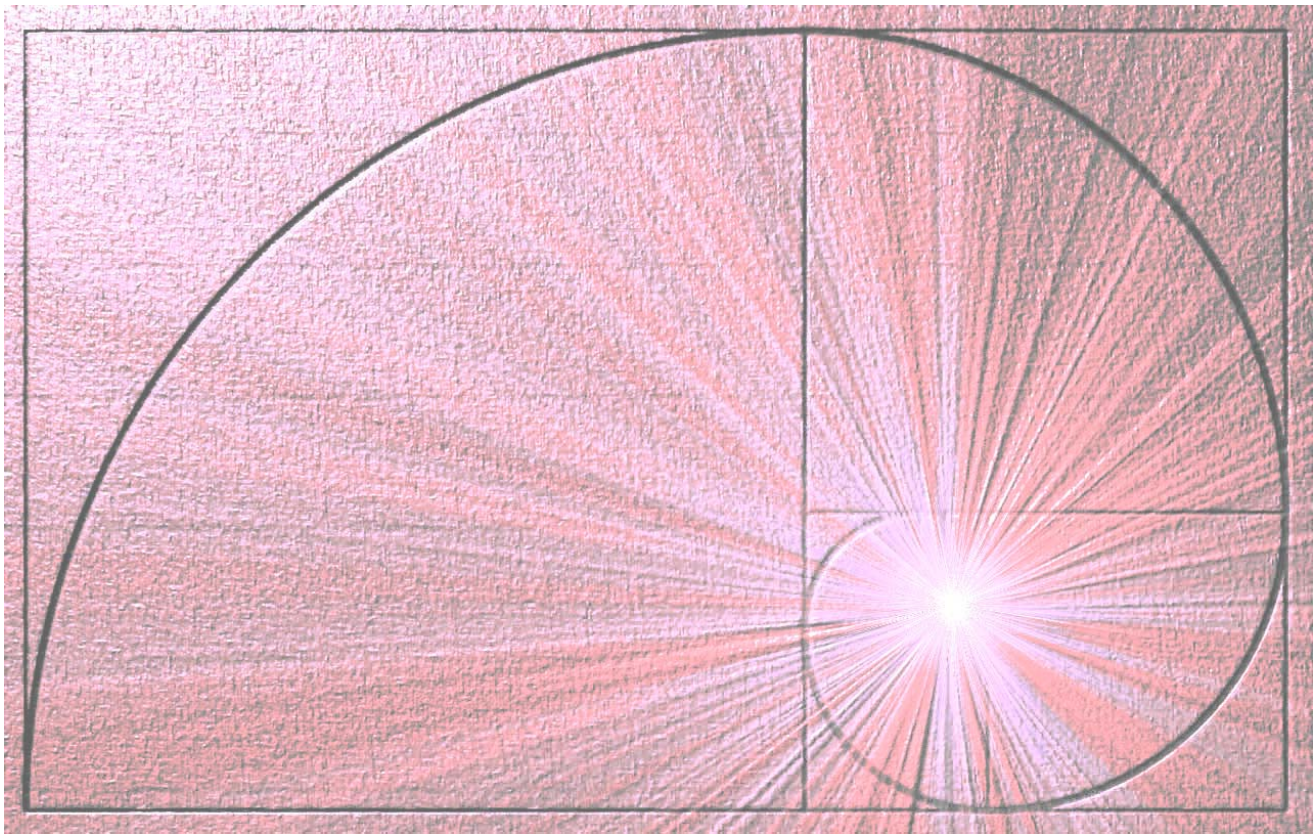

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The aim of the INTERNATIONAL JOURNAL OF EDUCATIONAL INNOVATION is to publish research papers that promote any form of educational innovation related to teaching and learning at all levels of education, as well as at any other aspects of the educational process, of school and academic life.

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EDITORIAL

The third issue of the International Journal of Educational Innovation (I.J.E.I.) of the Scientific Union for the Promotion of Educational Innovation (EEPEK), within 2024 is available, thus, reflecting primarily the great interest in it by the educational community. Particular reference is made to the colleagues-members of the reviewing committee of this journal - for their outstanding work and ongoing effort to establish this journal as a valid means of knowledge contribution to the educational communities of all levels. Colleagues' response to the journal's invitation to participate in the journal processes, as members of the scientific and editorial committee or as authors of research papers, was particularly great and provided the educational community with another form of constructive interaction other than that of conferences, training seminars and other actions implemented. In this way, we come one step closer to our central strategic aim: the creation of a large Learning Community, which will include all teachers, at all levels of education.

Therefore, once more, this issue presents a variety of topics related to education, and educational practices. The aim of every teacher is to find the best way possible to achieve the goals set in any subject taught and/or target group/s addressed. These goals include conveying knowledge, enhancing the cultivation of attitudes and values, such as self-confidence, self-esteem, or empathy, and the cultivation of skills such as interaction, communication or the ability to learn how to learn. However, the main objective of education is to help students meet challenges throughout their lives. Thus, this issue presents innovative suggestions, tools and techniques related to teaching and learning, as well as issues related to education and educational innovation, thereby highlighting both the need for research in education and the need for education to apply research results to practice. In order for teachers to achieve these goals and objectives, the importance of sharing good practices and knowledge are principal. Our goal then is to disseminate teachers' suggestions and ideas as well as their research findings.

We hope that this issue will help all those, educators and non-educators, who dream of effective education through innovation to provide ideas for a better future for all students. We will keep on with the same passion …

Dr. Charilaos Tsichouridis, Chief Editor, University of Patras
Dr. Dimitrios Kolokotronis, EEPEK President, Publishing Director

Enhancing the inclusion of all pupils: A consequence of a community of philosophical inquiry

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Abstract

This article presents the results of qualitative research conducted in a public primary school, investigating whether the formation of a community of inquiry and the work of children within it, according to its governing principles, can constitute an inclusive practice. By referring to international literature, the article attempts to clarify the concepts of Philosophy for/with Children (P4C), the Community of Philosophical Inquiry, and inclusion. The research results showed that P4C was able to promote the principles of inclusion within this sample. Students, regardless of their performance, socio-economic background, or learning profile, had the opportunity to coexist, communicate, interact, discuss, disagree, agree, and collaborate.

Keywords: philosophy with children, inclusion

Introduction

Although there has been a significant increase in educational opportunities in recent decades, the existing education system has not successfully responded to the diversity of its students and ensured their equal participation in the learning process (Petrou, Angelides, & Leigh, 2009). As a result, disadvantaged students are unable to achieve success during their schooling, and their later lives are subsequently characterized by a lack of opportunities to participate in the learning process (Petrou, Angelides, & Leigh, 2009). Within UNESCO, there is an urgent need for an inclusive orientation in educational institutions and their practices (UNESCO, 1994). According to the principle of inclusion, educational programs that contribute to the equal treatment of all students foster critical thinking, increase creativity, and promote cooperation among students (Petrou, 2012). These programs should be guided by the values of inclusion, such as equity, participation, community, caring, and respect for diversity (Ainscow, Dyson, Booth, & Farrell, 2006).

However, the cultivation of an inclusive culture in children should be carried out "in an experiential rather than proactive way" (Petrou, 2012, p. 273). One approach that seems to meet all the above prerequisites and puts the principles of inclusion into practice is the philosophy with children. In this approach, students form a community of individuals who investigate collaboratively, think together, ask questions, express their ideas, argue, listen carefully to each other, reflect, and build on the ideas of others (Camhy, 2013; Haynes, 2009). Indeed, if we consider that each class is a microcosm of the relationships that develop in the larger community, then by improving relationships within the class, we may hope for a "more beautiful society" (Dewey, 1916, cited in Kizel, 2013, p. 199).

Philosophy with / for children (P4C)

Examining the literature, one finds two terms related to this approach. The first term is "philosophy for children," which refers to the program developed by the Institute for the Advancement of Philosophy for Children (IAPC). The second term, "philosophy with children," emerged during the second generation of this movement. This change in terminology is significant as it reflects a shift from a model or guidance approach towards an ideal of analytical discourse, towards creating community reflection, contemplation, and communication (Vansieleghem & Kennedy, 2011). In this second generation of the project,

various approaches (such as the democratic-philosophical current developed by Michel Tozzi and the Socratic method of Oscar Brenefier) are included, each with its own methods and strategies. Nevertheless, the founder of this movement was Matthew Lipman.

Specifically, in the early 1970s in America, Lipman started a philosophical and pedagogical movement called "Philosophy for Children." Noting the inadequacy of the American educational system in creating critically thinking citizens and believing that children are capable of thinking for themselves, he concluded that a curriculum was needed to cultivate multidimensional thinking in students (Camhy, 2013; Tozzi, 2013; Chatzistefanidou, 2011). The concept of multidimensional thinking refers to various dimensions of thought, such as critical, creative, and caring thinking (Lipman, 2006). Drawing inspiration from Dewey and Pierce, he introduced the concept of the 'community of inquiry' as a natural environment that transforms students from passive recipients of knowledge into active, thoughtful participants (Nikolidaki, 2011; Petrou, 2013).

Regarding the philosophy with children, this approach does not focus on learning the history of philosophy or familiarizing students with philosophers' names and positions. The main aim of this program is to enable students to think for themselves by exploring questions they believe are worthy of reflection (Vansieleghem & Kennedy, 2011). Philosophy thus offers students an excellent opportunity to work together within a community of inquiry, using dialogue and philosophical reflection as their primary tools (Camhy, 2013; Splitter, 2013). This allows students to explore the boundaries of enigmatic concepts by expressing their ideas, experiences, and feelings. Through this process, they develop critical thinking skills, sharpen their judgment, enhance their creativity, and cultivate an attitude of caring for others (Lipman, 2006).

Lipman conceived of philosophy for children as transforming the classroom into a community of philosophical inquiry. To clarify this transformation, an analysis of the concept of a community of inquiry is provided below. Genealogically, the origins of the community of philosophical inquiry begin with the Socratic practice of dialogue, continue with Pierce's vision of a global scientific community, and finally with Dewey's conception of the terms 'inquiry' and 'community' (Sutcliffe, 2017).

Inclusive Dimension of Philosophy with Children

Since the early 1990s, a new movement of inclusion has emerged and developed in various parts of the world (Stasinos, 2013). According to the Salamanca Declaration, adopted in 1994, it is recognized that every child has unique characteristics, abilities, interests, and educational needs and educational programs should be designed to embrace the diversity of students. Furthermore, general schools should adopt an inclusive orientation to effectively combat discrimination, create favorable learning conditions, and provide education for all (UNESCO, 1994; UNESCO, 2005). Over the past years, various definitions of inclusion have been proposed; resulting in confusion about the term's meaning (Ainscow, Farrell, & Tweddle, 2010).

World organizations such as UNESCO declare that every child, regardless of physical, intellectual, social, emotional, linguistic, or other characteristics, has a fundamental right to succeed in education (UNESCO, 1994). In line with the philosophy for/with children, it is argued that this approach significantly impacts all pupils by developing their confidence to think for themselves and express ideas recognized as valuable (Haynes, 2009). Specifically, this approach allows students to free themselves from the stress of finding the "right" answers the teacher expects and to feel proud of their ideas (Lipman, 2006; Murris, 2013). The 'openness of philosophical thinking' does not allow for 'guaranteed, final answers,' thus giving children the freedom to explore different questions and follow their own inquiries (Marshal, 2013; Murris, 2013). In a philosophical inquiry community, the views of all children are respected, and each child's contribution is treated as valid, important, and valued (Haynes, 2009).

Another inclusive feature of this approach is that diversity is seen as a stimulus, enhancing research and learning rather than hindering it. The heterogeneity of the student population, their diverse experiences, and the plurality of their views are considered necessary and valuable in the philosophical inquiry community (Go, 2013; Gregory, 2011). According to Lipman, individual differences among students should not lead to the fragmentation of a class or create barriers between its members. Instead, he emphasizes that no one is excluded from community activities, regardless of differences in religion, ethnicity, or other factors (Lipman, 2006). Children participating in philosophical inquiry communities express pleasure in hearing various opinions, and Haynes notes that changing their opinions is a natural part of the process (Haynes, 2009). This experience allows students to engage in 'dissonance within peaceful coexistence,' listening to and respecting differences, which broadens tolerance and prevents violence (Tozzi, 2013).

In the community dialogue, all participants are equal partners, fostering a relationship of reciprocity where each individual is responsible for their own thinking and that of others (Camhy, 2013). Through their efforts to understand themselves and others and their curiosity to explore the boundaries of enigmatic concepts, students collaboratively rethink (Marshal, 2013). In other words, children learn to think together 'in terms of a collective sensibility,' realizing that the ideas, feelings, and actions that arise belong to the whole community (Kizel, 2013). The socialization of thought is a necessity and a precondition of philosophical inquiry. This community is a friendly, non-antagonistic environment where curiosity, philosophical imagination, deliberations, and cognitive products are shared. The community draws from the experiences and ideas of all children, ensuring that each member has access to the meanings produced (Lipman, 2006).

Another important element of inclusion inherent in philosophy with children is the attention and space given for children's voices to be heard. This approach opposes educational policies that perceive childhood as limited and inadequate, focusing on what the child will become in the future and providing standardized, manipulative education (Haynes, 2009). In contrast, 'doing philosophy with children means listening to their thoughts and taking them seriously' (Camhy, 2013). Students' lived experiences, subjective ideas, feelings, and explanations of things are not dismissed as invalid but serve as the starting point for philosophical dialogue. An interesting dynamic occurs when students, to support their own or others' positions, share their experiences, thus creating a valuable, collective mosaic (Lipman, 2006).This fully agrees with Article 30 of the Salamanca Declaration, which states that teaching should be based on students' experiences to enhance motivation (UNESCO, 1994).

As can be seen from the above, philosophy with children not only stimulates thinking and improves cooperation among community members but also does justice to the ethos of the community (Murris, 2013). Participation in the exploration community undoubtedly impacts the formation of children's ethos and character. This is because values such as respect, solidarity, peaceful coexistence, and tolerance cannot be taught but rather experienced and put into practice. This approach, therefore, achieves this through a process driven by the students' concerns, offering them satisfaction and helping them to give meaning to their lives (Camhy, 2013; Lipman, 2006).

Process of a Philosophical Investigation

Below is a presentation of the steps that are usually followed in the process of an investigation within the community. It is worth noting, however, that the above steps should not be seen as a rigid mechanical routine, but as a process based on the quality of the interaction and dialogue that takes place (Haynes, 2009).

At the start of a philosophical investigation, the teacher and the students together set some rules of interaction. In the second phase, it is necessary to identify the element that will motivate the investigation. The starting point for the investigation can be children's literature, a piece of music, a picture, or even an experience of the children themselves. After the

stimulus has been presented, time is allowed for the pupils to reflect and record their ideas or questions. Students can then make connections and group their questions. A question is then selected, and the investigation begins. The teacher encourages students to listen carefully, consider the answers, and explore in depth. The essential thing is that not just a mere juxtaposition of opinions or experiences takes place, but a dialogue aimed at producing meaning and understanding. When necessary, the teacher may design concept maps or histograms to help students achieve a more insightful view of the course of the discussion. The process concludes with a summary of what was said or recorded, as well as student reflection on the process itself (Trickey & Topping, 2004).

As mentioned above, for an investigation to take place, some material is required to activate students' reflection and contemplation around a topic, creating the need for further examination (Nikolidaki, 2011). This material serves as the stimulus and essentially acts as a catalyst for philosophical dialogue, as well as a reference point to which students can return during an investigation. Examples of such stimuli include the philosophical novels by Matthew Lipman and Ann Margaret Sharp, whose content focuses not on well-known philosophers but on the everyday lives of children expressing thoughts and questions that are philosophical in nature. Other stimuli can be myths, such as Platonic myths (Petrou, 2013), children's literature (Chirouter, 2013), or picture books (Murris, 2013). Finally, stimuli from the children's own experiences are particularly beneficial, as they reflect their needs and interests (Nikolidaki, 2011).

The stimulus, therefore, by presenting problematic situations and questionable concepts, encourages students' reflection and the application of mental tools such as mental operations, propositional stances, introductory questions, consolidation questions, and judgments (Lipman, 2006). This process is then reinforced through dialogue, where students internalize concepts and skills. As Lipman explains, stimuli and the community of inquiry provide an appropriate environment for the cultivation of thinking. He analogizes this to how the natural environment provides "ecological services" for the development of species, suggesting that the community of inquiry and stimuli offer similar services for the development of thinking (2006, p. 178).

Previous Investigations

It would be interesting to have evidence from research on whether or not P4C may be valuable in promoting educational inclusion. The review of the literature reveals a significant gap in research on inclusion in our country. Internationally, most research has focused primarily on the cognitive benefits arising from the approach (Ventista, 2019). However, since this research focuses on the social skills and attitudes cultivated through P4C, an attempt to present the results of relevant studies will follow below.

A seven-month study conducted by Trickey and Topping (2006) demonstrates that significant benefits in academic self-esteem can be achieved through this approach. Specifically, the study found a substantial reduction in students' dependency and anxiety and an increase in their self-confidence and self-efficacy. The results were consistent across the schools where the study was conducted. Furthermore, according to Sasseville (1994), children with low self-esteem viewed the research community as a way to value themselves, as it provided an environment where they were listened to and taken seriously by their peers.

According to Topping and Trickey (2007), collaborative philosophical inquiry enhanced the communicative interaction between children in the classroom, both in quantity and quality. Specifically, it was reported that students' participation in discussions, rational support and justification of their viewpoints, teachers' use of open-ended questions, and the student/teacher ratio of discourse increased. Another study showed that pupils who worked with the principles of P4C gained significant benefits in terms of thinking, listening, language skills, and self-confidence (Dyfed County Council, 1994, cited in Trickey & Topping, 2004). The

phenomenon of enhanced self-confidence among pupils was also observed in earlier research, which, among other things, pointed to a reduction in negative verbal interactions between pupils (Fields, 1995).

The results of another study endorsed the enhancement of attentive listening (Dyfed County Council, 1994, cited in Trickey & Topping, 2004), finding that pupils became better listeners as the P4C programme progressed, and intensifying their concentration and interest in others' views. Similarly, data from another study (Campbell, 2002) showed that P4C activated children's listening and participation in discussion groups. Students became more willing to speak up in front of the class and accept others' ideas. Data also showed that children presented more arguments when expressing their views. Furthermore, the teachers of these children argued that some of the gains made through the FMP were transferred to other contexts in the school curriculum. Finally, an improvement in the students' social skills was also observed.

Research in Australian schools (Burgh, Field, & Freakley, 2006) indicated that students who participated in community research seemed less impatient with each other, more ready to discuss problems as they arose, and more willing to accept their mistakes as a normal part of the learning process. Additionally, the interaction between the children and their behavior outside the classroom reflected the collaborative environment of the research community in their classroom. It was also reported that incidents of violence and bullying were greatly reduced.

Regarding moral values, researchers Zulkifli and Hashim (2020) reported that the community of philosophical inquiry is an effective way to teach them. Russell (2002) also argued that children have a strong sense of morality, which seems to be significantly promoted through P4C. Additionally, other research has detected positive effects, including increased student participation and active listening within the philosophical inquiry community, as well as more caring and respect among the children (Commonwealth of Australia, 2008). Indeed, students seemed to experience and enjoy the mutual benefits within a school environment focused on moral values.

Finally, research by Dunlop, Compton, Clarke, and McKelvey-Martin (2015) highlighted the interest and enjoyment that students experience when participating in a community of philosophical inquiry. Specifically, students found the stimuli interesting and enjoyed the freedom to explore ideas and concepts without fear of failure. This research reported that many students tended to take their discussions beyond the classroom or were willing to share what they learned with family members.

The purpose of the research

The approach of philosophy with children, according to the literature, can offer multiple benefits to students, both instrumental (e.g., cultivation of reasoning skills, investigation, organization) and intrinsic (e.g., enjoyment, improvement of self-esteem) (Petrou, 2012). While all of these benefits are highly important for children's all-round development, this paper will focus more on the intrinsic benefits of this approach, particularly those related to the principles of inclusion. Therefore, the purpose of this research is to investigate whether the community of philosophical inquiry in the classroom contributes to the inclusion of all students.

The purpose of the research can be specified in the following research questions:

- Does student interest within the philosophical inquiry community increase?
- Can the active participation of all students in the classroom be enhanced through the approach of philosophy with children?
- Is active listening to the ideas of all children sharpened through this approach?

- Does it improve the level of cooperation between students and the quality of their interaction?
- Is students' self-confidence boosted through this approach?
- Are feelings of tolerance, respect, and care for others cultivated within the community of philosophical inquiry?

The reasoning process of the research will follow a deductive method, as the individual and more specific research questions, linked together, are intended to lead cumulatively to the general research question:

- Can the approach of philosophy with children contribute to the inclusion of all students in the classroom?

Methodology

The qualitative research method was considered the most appropriate for this study, which aims to investigate a specific case in depth, based on the assumption that "each individual is unique and worthy of study" (Papanastasiou & Papanastasiou, 2014, p. 221). This research is an example of action research, which is conducted by teachers with the aim of improving their practice (ibid.). According to Elliott, action research is "the study of a social situation with the aim of improving the quality of action within that situation" (1991, p. 69, cited in Altrichter, Posch & Somekh, 2001, p. 22).

This research arose from the recognition of the diverse educational needs of students, which sparked interest in providing a more inclusive education that respects the characteristics of all children and fosters meaningful interactions among them. However, achieving these objectives would be challenging under the current dominant educational model, which is characterized by pre-prepared curricula, a focus on covering the syllabus, strict timetables, a passive student attitude, and an emphasis on individual performance and assessment. In a context where success depends on organization, method, and expertise, there is a need for a more humane approach to education—a community where communication, cooperation, care, and joyful interactions among its members are encouraged. This vision thus drives the present research.

The identification of the problem was followed by the organization of the research process. After carefully studying both Greek and foreign literature related to inclusion and PD, the research purpose was formulated, giving shape to the "mental puzzle" (Mason, 2011, p. 36). The more specific research questions were then developed to explore the factors influencing the research purpose. The existing design aimed to ensure that the interconnected specific research questions would cumulatively lead to addressing the overall research question.

Next, the research sample was selected, and an action plan was developed, defining the methods for data collection and analysis. Observation, reflective diaries, and qualitative interviews were deemed appropriate tools for data collection. The subsequent coding and analysis of the data were to be open-ended. Initially, a letter was sent to the students' parents to obtain their signed consent for their children's participation in the study. This letter included the researcher's personal details, described the research purpose, outlined the research procedure, and explained the expected benefits. Parents were also informed that sessions and interviews would be recorded. There was a commitment to maintaining student anonymity and privacy, and participants were informed of their right to withdraw from the study at any time. Additionally, they were given the option to access the survey data if desired. After obtaining informed consent from both guardians and students, the survey was implemented.

The practical application of the research lasted three months and was conducted in a primary school classroom in Komotini. Initially, non-participatory observation was carried out to understand the students' learning profiles and their level of participation and interaction in the educational process. Discussions with the class teacher provided valuable data and

insights about the students. The researcher's implementation began shortly thereafter, with the initial sessions focused on piloting authentic data collection to refine the research questions and assess the suitability of the research methods. Participants were reminded that they could withdraw from the study at any time. Formal data collection then commenced, and the data was studied throughout the research to gain an in-depth understanding. Sessions were held twice a week, each lasting one teaching hour, as part of the Flexible Zone course.

Data collection instruments

Data collection in qualitative research relies primarily on human resources rather than measurement tools (Papanastasiou, 2014). The aim of data collection is to enable the researcher to gather all necessary information to answer the research questions. This process should be reflective, progressively guiding the researcher to solve the problem (Vrasidas, 2014). In this study, at the initial stage, the observer-non-participant observation method was applied to understand the students. The students were observed during scheduled lessons to profile them and ascertain the degree of participation and the quality of their interaction in the educational process.

Once the implementation started, the participatory observation method was carried out. Participant observers, mainly researchers, become participants in a social situation to investigate it. A necessary quality of an observer is sensitivity towards what is being observed. However, observers should avoid simplistic assumptions based on their biases (Altrichter, Posch & Somekh, 2001). In this study, a participant observer conducted observations for 9 weeks, during which 18 observations took place. During this time, students' reactions to various stimuli were observed. Each observation provided valuable feedback, which assisted in organizing and redesigning the methods to avoid forgetting information and to "capture" as much detailed information as possible. With the participants' agreement, a mechanical means of recording the teaching process was used, and transcripts were carried out as soon as possible after they were taken.

Another data collection tool was the reflective diary, one of the simplest methods of data collection. In the diary, brief notes, ideas, and reflections of the researcher can be recorded. As Altrichter, Posch, and Somekh state, the diary becomes the researcher's companion throughout all stages of the research (2001). It helps the researcher reflect on the journey, reviewing and analyzing successes or weaknesses. The diary may contain data collected by other tools, such as participant observation and interviews, and is often enriched by the researcher's comments. In this study, a reflective journal was kept, recording thoughts, ideas, fears, and concerns. This recording was usually done after leaving the research field, as it was difficult during the teaching practice, and also during the data processing. Decisions made when planning subsequent actions were also recorded in the journal. The final length of the diary kept in this research was approximately 90 pages.

Finally, another tool used for data collection was the qualitative interview, which was recorded with the consent of the participants. Interviews allow the researcher to access the way research participants see things, particularly their thoughts and opinions about their behavior (Altrichter, Posch, & Somekh, 2001). The qualitative interview typically has an informal and conversational style. It is structured with open-ended questions, having a semi-structured or loosely structured format (Mason, 2011). Questions should be characterized by clarity and help the interviewee explore their thinking. Prior to conducting the interviews, a pilot interview was conducted with two students. The pilot interview helps to avoid unforeseen weaknesses and contributes substantially to the validity of the research data (Papanastasiou & Papanastasiou, 2014). The interviews, fifteen in number, with the students were conducted during the last week of the research and lasted an average of nine minutes. They were semi-structured and included open-ended questions. At the beginning, and in order to make the interviewees feel more comfortable, the researcher applied the icebreaking

method by reminding them of the purpose of the research and assuring them of the anonymity of the interview. The aim was to formulate clear and unambiguous questions. Specifically, question one was about the students' impressions of the approach, question two was about the group climate before implementation, question three was about the group climate after implementation, questions four and five were about the benefits of the approach, and question six was about the difficulties of the approach. To facilitate data analysis, the interviews were transcribed as soon as possible after being conducted. An attempt was also made to decode non-verbal communication during them. Thus, non-verbal cues such as joy, discomfort, or skepticism were recorded and triggered further questions aimed at interpreting them.

The context of the investigation

The present study was conducted in a public primary school in the city of Komotini. This school is one of the largest in the region and has a particularly diverse student population. The research focused on a class of sixth grade, consisting of 15 students - five girls and nine boys. The academic level of the students is considered moderate, with several variations among the students, which is confirmed by the teacher of this class. The socio-economic background of the students varies. Also, the class is attended by a pupil whose mother native language is Albanian and a pupil with Attention Deficit Hyperactivity Disorder (ADHD) diagnosed by the Centre for Diagnostic Differential Diagnosis and Support.

Results

Does student interest within the philosophical inquiry community increase?

One characteristic of philosophy with children is the emphasis on children's own questions and experiences (Haynes, 2009). Similarly, in line with the principles of behavioral education, it is considered particularly important to involve children in activities based on their interests and needs (Booth & Ainscow, 2002). This seems to activate their motivation to learn. Through this research, it was evident that the pupils particularly enjoyed the approach we took. Among other things, they stated that they had a good time, gained new experiences, had the opportunity to talk with their classmates and thus get to know each other better, and were able to discuss age-related issues.

Can the active participation of all students in the classroom be enhanced by approaching philosophy with children?

When the learning process enhances students' interest, as shown above, and the knowledge is not theoretical but connected to children's everyday life, children who tend to be marginalized in the traditional classroom show more active participation in learning procedure (Booth & Ainscow, 2002). In line with the principles of inclusive education, learning activities should encourage the participation of all children, who should be actively involved in their own learning (Ainscow, Dyson, Booth & Farrell, 2006). Research conducted by Topping & Trickey (2007) and Campbell (2002) reports that through philosophy with children, students' participation in discussion, rational support and justification of their points of view, teachers' use of open-ended questions, and the student/teacher ratio of discourse increased. Similarly, in this study, there was also an increase in the degree of student participation.

Initially, some children were very interested and involved, while others were hesitant to speak and simply observed. This situation concerned me, and I often recorded my thoughts in my reflection diary. However, over time, there was a gradual change in participation, which was evident through their dialogues. While certain students were prominent at the beginning, others began to join in. Although some students still participated more intensely, everyone's views were heard in the dialogue. It was particularly striking that while some children noted low participation and reduced interest in their traditional classroom (according to my initial

observations and the teacher's comments), within the philosophical inquiry community, they actively participated, asked questions, and often took the floor.

Is active listening to the ideas of all children sharpened through this approach?

Active listening sets aside the teacher's tendency to bombard students with questions and avoids premature decisions by encouraging all participants to partially suspend their answers and beliefs so that everyone listens and understands others (Haynes, 2009). In this study, there was a significant improvement in active listening compared to our first sessions, as students made considerable efforts in this regard. Despite the establishment of rules from the beginning, it took several sessions for students to become attentive listeners. The change was not entirely due to the establishment of rules; the genuine interest that students developed along the way, since the discussion was guided by their questions and interests, also played a crucial role. However, it took several meetings to achieve this change, and initially, the students' listening skills were not encouraging. According to my first observations, students were disruptive, talking among themselves, not listening to the speaker, or having several people speak simultaneously.

Does it improve the level of cooperation between students and the quality of their interaction?

One of the key elements of behavioral education is to promote cooperation and encourage children to learn from each other (Booth & Ainscow, 2002). The philosophical community appears to build meaningful collaborative relationships between members in practice. Research conducted by Burgh, Field, & Freakley (2006) showed that children's interactions and behavior outside the classroom reflected the collaborative environment of the research community in their classroom. Similarly, other research (Campbell, 2002) reported that through philosophical community, students significantly improved their social skills. In this study, there was an increase in collaboration and an improvement in the quality of interaction between the children. Over time, students interacted more meaningfully. Initially, children's ideas were merely paraphrased versions of each other's ideas, but over time, they began asking each other questions, building on each other's opinions, asking for clarification, challenging arguments, analyzing opinions, and synthesizing ideas.

Is the students' self-confidence boosted through this approach?

According to the principles of behavioral education, schools should encourage children to feel good about them, and to be critical and confident thinkers (Ainscow, Farrell & Tweddle, 2010; Booth & Ainscow, 2002). Research (Sasseville, 1994; Fields, 1995; Dyfed County Council, 1994, cited in Trickey & Topping, 2004) argues that within the community of philosophical inquiry, students value themselves more highly because they are listened to and taken seriously by their peers. In this research, students' enthusiasm for the process, their increasing participation, and the quality of their ideas indicated that their confidence as thinkers was stimulated. The enhancement of students' confidence was most evident in those who appeared isolated, introverted, and insecure at the beginning of the research but became more confident and notable contributors by the end. Some children, initially described as 'invisible' and passive, developed into more cheerful, outgoing, and active participants over time.

Are feelings of tolerance, respect, and care for others cultivated within the community of philosophical inquiry?

Inclusive education promotes mutual respect among all participants and develops shared values such as justice, tolerance, acceptance of differences, and solidarity (Ainscow, 2005; Angelidis, 2011; Boyle, Scriven, Durning & Downes, 2011; Anderson, Boyle & Deppeler, 2014).

Similarly, the formation of a community of philosophical inquiry requires an atmosphere of trust and a community ethos conducive to thought and dialogue. Our attempt to form a community of inquiry began with a rather negative relational climate. Initially, there were derisive comments towards classmates' opinions, impoliteness in disagreements, tendencies to interrupt, impatience, and other disruptive behaviors. This element was also evident in other research (Burgh, Field, & Freakley, 2006), where students became more willing to discuss problems and accept their mistakes as part of the learning process.

Over time, there was a gradual change in students' behavior as they internalized the attitudes fostered by the inquiry community. While I initially regulated interactions, students eventually began to self-regulate. Incidents of disruptive behavior decreased, and students developed a community ethic. Other research (Fields, 1995; Burgh, Field, & Freakley, 2006) found a reduction in negative verbal interaction and incidents of violence through the philosophy with children approach. In this research, children's descriptions highlighted the positive change in classroom climate.

Can the approach of philosophy with children contribute to the inclusion of all students in the classroom?

Through the above attempt to answer the six specific questions of the survey, it is clear that there were significant results in these areas: student interest, active participation, active listening, cooperation and interaction between students, enhancing self-confidence, and fostering feelings of respect and care for others. Through observations, meeting transcripts, reflection journal entries, and student interviews, it was evident that students benefited in these areas during the research.

By assessing students' initial status in these areas and comparing it with the end-of-survey status, one can ascertain that the purpose of the survey has been achieved. Thus, answering the individual research questions leads to answering the general question: whether philosophy with children can promote the inclusion of all students in the classroom. In conclusion, it could be argued that the community of philosophical inquiry in the classroom effectively promotes the inclusion of all students.

Limitations of the research

The meetings with the students took place twice a week as part of the Flexible Zone course, scheduled during the seventh and last hour of the timetable, limiting the time to forty minutes. This timing often made the students anxious as the session neared its end. Since the class schedule could not be changed, the researcher adapted to this fact. Initially, the lack of time was a source of stress as it was impossible to complete activities with the students. Consequently, adjustments had to be made, which, although not ideal, were in line with reality.

Discussion

In this qualitative research, which lasted three months in a sixth-grade class of 15 students, significant achievements were observed. The students increased their participation compared to both their traditional classroom and the beginning of our sessions. They also became more attentive listeners, as discussions were guided by their questions and interests, and they strengthened their confidence as their contributions were highly valued within the community. Furthermore, they improved their cooperation and the quality of their interactions, which was evident through their dialogues. Feelings of respect and care for each other were fostered, radically changing the group's climate and the students' attitudes and relationships. These findings corroborate other relevant international research.

The sample size in this research does not allow for generalizations. However, the findings could indicate potential implications for student inclusion when working within the principles

of a community of philosophical inquiry. Despite this, we cannot assure the durability of these results over time. In other words, while the research seemed to produce results regarding student inclusion within the community of inquiry, these effects may not persist after the research ends. Inclusion is an ongoing journey rather than a destination, and the effort to overcome barriers preventing the participation of all children is a continuous struggle. Additionally, the difference between the community of philosophical inquiry and the classroom or school community makes it difficult for children to internalize the program's attitudes, challenging the maintenance of these attitudes post-research. This criterion could be explored in future research.

Another important factor impacting the benefits derived from the P4C is time. This includes the time needed for students to think, understand the investigation processes, and internalize the program's attitudes. Finding time for the sessions, which literature suggests should be weekly, also arises. Thus, while time is critical in P4C, in contemporary teaching models, it tends to become a source of stress as teachers struggle to achieve specific and measurable learning objectives imposed by the Analytical Programme.

Regarding the possible introduction of P4C in the Analytical Programme, several issues arise. First, we must ask what the purpose of such an introduction would be and whether it aligns with the program's philosophy. If the P4C resembles the dominant educational model of our times, the question of avoiding its instrumentalization inevitably arises. In such a case, P4C could become just another method or technique, thus distorting and losing its original context. Another issue is that such a transition requires adequately prepared teachers. Cultivating a conversational climate in an atmosphere of trust and forming a community of philosophical inquiry requires proper teacher training. Additionally, teachers must respect and consider each child's context and uniqueness. Otherwise, it becomes just another application rather than a meaningful practice (Theodoropoulou, 2014).

In conclusion, this research demonstrated that the P4C could promote inclusion principles in this sample, as students, regardless of performance, socio-economic background, origin, or learning profile, had the opportunity to coexist, communicate, interact, discuss, disagree, agree, come closer, and collaborate. Future studies should explore, validate, reject, or enrich these findings more thoroughly. Besides being interesting, future research on this topic is particularly important because, by uniting students through shared exploration, P4C may allow them to see differences not as obstacles but as stimuli that enrich and liberate them from the slavery of homogeneity (Petrou, Angelides & Leigh, 2009). In other words, P4C may achieve the condition of 'dissonance within peaceful coexistence, listening, and respecting difference' (Tozzi, 2013: 153).

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Factors of resilience of mothers with children with Autism Spectrum Disorder

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Abstract

In this study, the resilience of mothers with children diagnosed with Autism Spectrum Disorder (ASD) was investigated and compared to the resilience of mothers with typically developing children. The factors "mother's age", "educational level" and "number of children" were examined to determine if they influence the resilience of the two groups of mothers. Resilience was assessed using the Resilience Scale (RS) by Wagnild & Young (1993). The study involved 172 mothers of children with ASD and 153 mothers of typically developing children. The results showed that mothers of children on the autism spectrum are less resilient than mothers of typically developing children. Additionally, the effect of mother's age and educational level on resilience was confirmed only for mothers with children with ASD. The number of children in the family did not differentiate the results. In conclusion, the need for psychological empowerment of mothers with children with ASD was identified.

Keywords: resilience, Autism Spectrum Disorder, mothers, children

Introduction

Resilience has been a field of intensive research in recent years, both in the general population and among populations facing adversity, such as refugees, prisoners, parents of individuals with special needs, etc. It is a multidimensional concept, which has evolved through various phases of research, starting with its measurement and definition, progressing to understanding the processes that contribute to it and ending up with integrated approaches that combine genetic, neurobehavioral and statistical analyses (Bonanno & Diminich, 2013). It refers to an individual's ability to maintain or restore their mental health and to adapt positively to difficult and stressful situations (Singh & Kumar, 2022). It is not a trait one is born with, but rather something that can be developed throughout a person's life.

Often, resilience is "built" after experiences of intense emotional pain, but this does not mean that someone who has developed it will not feel discomfort and sadness or will not face other difficulties (American Psychological Association [APA], 2020). The development of resilience has multiple benefits. It increases a sense of optimism, self-perception and self-confidence, allowing individuals to better cope with life's challenges. Resilient people have more energy and are less prone to stress and depression. Additionally, it helps develop self-efficacy and self-control, mentally empowering individuals to overcome past traumatic experiences. Finally, resilient people create positive and constructive relationships with others, do not hesitate to seek and offer help, develop empathy and view changes as challenges for developing new skills, rather than fearing failure (Komseli et al., 2022; Reivich & Shatté, 2002).

Resilience is particularly studied in populations of people with special needs or their families, such as mothers of children on the autism spectrum. Autism Spectrum Disorder (ASD) is a lifelong developmental disorder, usually becoming apparent in the early years of a

person's life (Savvidou, 2020), with uncertain causes, possibly originating from a combination of genetic and environmental factors. Some studies link autism to chromosomal abnormalities, such as fragile X syndrome (Antoniou & Daliana, 2017; Reddy, 2005), while others point to abnormalities in areas of the brain, such as the hippocampus and amygdala (Bachevalier & Loveland, 2006; Bauman & Kemper, 1985; Happé, 2003; Tuchman, 2003). Additionally, exposure to chemicals during pregnancy has been examined as a possible factor influencing the development of autism (Talbott et al., 2015). According to Sevaslidou (2020), a study with surveys from every continent showed that ASD ranges from 1-189/10,000 individuals and autism specifically from 2.8-94/10,000 individuals, with the majority being male.

Individuals with ASD primarily face difficulties in social interaction, communication, and creative imagination. They find it difficult to understand others' expressions and emotions, they avoid eye contact and they have difficulty forming friendships (Mavroupoulou, 2011). Communication difficulties include delayed speech development, problems with articulation and language use, difficulty understanding figurative language (Galanis, 2015; Loukusa & Moilanen, 2009), or unusual characteristics such as echolalia (Prizant & Rydell, 1993, as cited in Mavroupoulou, 2011). Regarding creative imagination, they exhibit stereotypical behaviors, obsessions and resistance to changes (APA, 1987; Wing, 1996). Finally, individuals with ASD sometimes show unusual reactions to sensory stimuli. Nevertheless, not every person with ASD exhibits all of the above characteristics or to the same degree, and there are some who display exceptionally high performance in specific areas ("islets" of skills), such as mathematical calculations or art (Mavroupoulou, 2011).

The diagnosis of ASD is now conducted by DSM-V (Diagnostic and Statistical Manual of Mental Disorders, 2013), according to which three subcategories are defined based on the intensity and severity of the manifestation of the deficit behaviors of the respective disorder. Specifically, level 1 includes individuals who simply require support, level 2 includes individuals who require enhanced support, and level 3 includes individuals who require very substantial support. However, for many years, the DSM-IV (1994) was also widely used, which defined five diagnostic subcategories: autistic disorder, Asperger's syndrome, pervasive developmental disorder not otherwise specified (PDD-NOS), childhood disintegrative disorder, and Rett syndrome.

The presence of a child with ASD in the family can cause significant stress for parents and affect their resilience due to the child's substantial cognitive limitations and behavioral management challenges, which create an imbalance in the family environment (Khawar et al., 2016). A literature review by Kotera et al. (2021) found that families of children with ASD are at greater risk of developing mental health problems compared to families of typically developing children. But in general, parents of children with neurodevelopmental disorders experience higher levels of parental stress and burnout compared to parents of typically developing children (Craig et al., 2016; Alrahili, 2023). Similarly, the research by Van Bourgondien et al. (2014) showed that the levels of anxiety, depression, and burnout are higher in parents of individuals with ASD compared to parents of typically developing children or parents of children with other disabilities or chronic illnesses. On the contrary, the study by Flores-Builes and Andrés-Roqueta (2022) in Spain found that parents of children with neurodevelopmental disorders overall exhibited greater resilience than parents of typically developing children, with parents of children with ASD being more resilient compared to parents of children with Attention Deficit Hyperactivity Disorder and parents of children with Developmental Language Disorder. However, the research by Pastor-Cerezuela et al. (2021) did not find statistically significant differences in the resilience of mothers of children with ASD and mothers of typically developing children.

Specifically for mothers of individuals with ASD, research by Smith et al. (2010) showed that the levels of negative impact on their daily lives are greater than those of mothers with

typically developing children. The results of the study by Malla and Taha (2022) indicated that mothers of children with autism experience higher levels of psychological burden (anxiety, stress, depression) compared to mothers of typically developing children, and lower levels of hope and resilience.

The finding of many studies that parents of children with ASD exhibit lower resilience has led to further investigation of factors that may differentiate their resilience compared to mothers of typically developing children. One such factor is the parents' age (Kliewer & Sandler, 1992). Specifically, in the case of parents of children with ASD, some studies have found that older parents of children with ASD are more resilient (Buchholz, 2022; Malla & Taha, 2022) and exhibit a more positive disposition (Smith et al., 2010), while others have shown that the parents' age is not significantly correlated to their resilience (Flores-Builes & Andrés-Roqueta, 2022; Ghanouni & Eves, 2023; Şanlı, 2023; Sinha et al., 2016). Another factor is the parents' educational level. The research by Campbell-Sills et al. (2009) found that a higher educational level is associated with greater resilience. The same conclusion was reached by Kavalioti (2017) in a study with parents of children with autism in Greece. On the contrary, the studies by Dey and Amponsah (2020) and Şanlı (2023) showed that parents of children with special needs who have a higher level of education exhibit lower levels of resilience. Koziarz et al. (2021) concluded from their research that parents of children with autism with higher educational levels reported worse experiences in family life compared to those with less education. Additionally, Buchholz's (2022) study, which involved mothers of children with ASD, showed that the positive correlation between subscales of resilience is stronger in the group of parents without a high level of education compared to those with higher education. Another factor that has been studied in relation to resilience is the number of children in the family. The research by Flores-Builes and Andrés-Roqueta (2022), with a sample of parents of children with neurodevelopmental disorders (half of whom were parents of children with ASD), showed that the number of children in the family does not affect parents' resilience. The research of Alrahili (2023) also led to a similar result. However, the research by Smith et al. (2010) showed that a larger number of children in the family leads to more effective control of negative emotions and better adaptability (Greeff & van der Walt, 2010).

The observation that in recent years the number of individuals with ASD has increased, as well as the fact that the diagnosis of a child on the autism spectrum affects the family's life at psychological, social and economic levels, requiring the maintenance of good mental health especially for the mother to meet the caregiving demands of the child with ASD, makes it imperative to study factors that enhance resilience. The investigation of factors such as maternal age (Buchholz, 2022; Malla & Taha, 2022; Smith et al., 2010), educational level (Buchholz, 2022; Campbell-Sills et al., 2009; Dey & Amponsah, 2020; Kavaliotis, 2017; Koziarz et al., 2021; Şanlı, 2023) and the number of children in the family (Greeff & van der Walt, 2010; Smith et al., 2010) led to conflicting results, necessitating further study of these factors. It is also worth noting that in the majority of studies that refer to parents, the sample was mainly mothers of children with ASD, as they primarily shoulder the demanding caregiving role for these children (Kavaliotis, 2018). In this direction, this study, based on previous ones, aims to further explore findings related to maternal resilience among Greek mothers of children with ASD, comparing it with that of mothers of typically developing children. Specific research questions refer to the impact of mother's age, her educational level and the number of children in the family on maternal resilience.

Method

In the present study, the quantitative research method using a questionnaire was preferred for the quick and at no cost collection of data from a large sample of mothers (Papanastasiou & Papanastasiou, 2021) and because people responding to a questionnaire share the same frame of reference, allowing for free and anonymous expression. However, a

disadvantage is that the sample may not necessarily be representative, not all the questionnaires that are sent out may be completed, while at the same time respondents' answers may not always be entirely truthful as they strive to provide socially acceptable responses. Another negative aspect is that the motivations for completing the questionnaire by each participant are unknown, which prevents verification of the validity of the responses (Papanastasiou & Papanastasiou, 2021).

The questionnaire was completed by 325 mothers in total, 172 mothers of children with ASD and 153 mothers of typically developing children. Detailed presentation of the demographic characteristics is provided in Table 1, including information on mothers' age, mothers' educational level and overall number of children for each participant, with or without a child with ASD, as well as their family and financial status. Additionally, there is information about the age and gender of the child with ASD and their diagnosis. From Table 1, it emerges that the majority of mothers are educated (have at least one degree), with a moderate annual income, married with two children. Regarding children with ASD, almost 60% of the sample, mostly children over 7 years old, were diagnosed with DSM-IV because this manual was used in the assesssment centers during the last decades, while the younger children were diagnosed with a DSM-V: autism level 1 and level 2 (level 3 is not included because only two children were diagnosed in this level) . The majority of the children were boys.

Table 1. Demographic characteristics of the participants and their children with ASD

		Mothers of children with ASD (172 in total)		**Mothers of typically developing children (153 in total)**	
		N	%	N	%
Age groups	25-40	78	45,3	86	56,2
	41-61	94	54,7	67	43,8
Number of children in the family	1	42	24,4	47	30,7
	2	95	55,2	82	53,6
	3 and above	35	20,4	24	15,7
Education level	Graduate of Secondary Education	45	26,1	43	28,1
	University graduate	67	39	57	37,3
	Master's/PhD holder	60	34,9	53	34,6
Marital status	Married	131	76,1	134	87,6
	Divorced	26	15,1	12	7,8
	Widow	8	4,7	2	1,3
	Unmarried	7	4,1	5	3,3
Income	High	21	12,2	17	11,1
	Moderate	110	64	111	72,5
	Low	41	23,8	24	15,7
Age of the child with ASD	3-7	60	34,9		
	8-12	55	32		
	13-17	32	18,6		
	18 and above	25	14,5		
DSM-IV & DSM_V diagnosis	Autistic Disorder level 1	27	15,7		
	Autistic Disorder level 2	42	24,4		
	Autism Disorder (DSM-IV)	29	16,8		

	Asperger´s syndrome	40	23,3
	Rett's syndrome	0	0
	Childhood Disintegrative Disorder	1	0,6
	Pervasive developmental disorder not otherwise specified	33	19,2
Gender of the child with ASD	Boy	140	81,4
	Girl	32	18,6

For the study of resilience, the Wagnild and Young (1993) resilience scale was chosen, which has been translated into Greek and consists of 25 statements, in which the respondents are required to indicate their level of agreement or disagreement (from 1 = strongly disagree to 5 = strongly agree). Scores are summed, with higher scores indicating higher resilience of the respondent. According to Neill and Dias (2001), this scale demonstrates concurrent validity, supported by significant correlations between its scores and those of other scales measuring morality, depression and life satisfaction. Regarding reliability, it is high with Cronbach's a=0.91 (Wagnild & Young, 1993). The questionnaire for mothers of children with ASD included additional demographic questions related to their child with the disorder.

The administration of the questionnaires and the collection of the answers took place from April to September 2023. The questionnaire was sent electronically to parent and guardian associations of children on the autism spectrum from all over Greece, as well as to mothers of children with typical development, through parent and guardian associations and schools from various regions of the country, and Facebook pages with mothers. It was distributed to individuals of both genders. There were 325 female respondents and only 12 male respondents, so the research could not be generalized for both sexes. Therefore, men's responses were not included. The message accompanying the questionnaire emphasized that participation was voluntary, responses were anonymous and that they would be used only for research purposes.

Statistical analysis of the data was conducted using IBM SPSS Statistics 28 software. The Cronbach's a reliability test in this study is 0.94, ensuring the internal consistency of the questions. Before conducting inferential statistical tests, the normality of the response distributions was checked using Kolmogorov-Smirnov test, which indicated normal distributions with values of 0.56, df=144, p=0.2 for mothers of children with ASD, and similarly 0.60, df=144, p=0.2 for mothers of typically developing children. To compare the mean resilience scores of mothers with children with ASD versus those with typically developing children, a multivariate analysis of variance was applied, considering factors such as maternal category (with or without a child with ASD), maternal age, educational level, and number of children in the family (2x2x3x3). Independent samples t-test was used for comparing mean scores between two groups, while one-way analysis of variance (ANOVA) was used for comparisons involving more than two groups. The statistical significance of the differences was tested at a significance level of α=5%.

Results

The main objective of the research is to compare the resilience of mothers of children with ASD and those with typically developing children. The results of the multivariate analysis of variance revealed that the average resilience of mothers with children with ASD differed statistically significantly from that of mothers with typically developing children, F(1.289) = 4.15, p = 0.042. Mothers with children without ASD had a higher average resilience (M = 3.93,

SD = 0.45) than mothers who have to take care of a child with an autistic disorder (M = 3.72, SD = 0.49).

The factor maternal age also differentiated the results to a statistically significant degree, with F(1.289)=4.11, p=0.043, where the older mothers scored a higher mean than younger ones (25-40 years old M=3.83, SD=0.48 and 41-61 years old M=3.93, SD=0.48). From the study of the averages of the two age categories of mothers and after applying an independent samples t-test, it was found that this difference only concerned the category of mothers of children with ASD and not those with typically developing children, with t(170)=2.55, p=0.011 (25-40 years old M=3.72, SD=0.46 and 41-61 years old M=3.91, SD=0.51).

Another factor that noted statistically significant differences was that of educational level. Mothers of secondary education showed higher resilience scores compared to those with university or postgraduate studies, with F(2.289)=3.32, p=0.037 (secondary education graduate M=3.98, SD=0.45, University education M=3.81, SD=0.49, master's/PhD holder M=3.88, SD=0.49). In the case of this factor as well, the statistically significant differences only concerned the category of mothers of children with ASD, as measured by one-way ANOVA, with F(2.169)=5.73, p=0.004. University graduate mothers and those with master's/PhD degree who have a child with autism scored lower resilience (secondary education graduate M=4.03, SD=0.37, University education M=3.74, SD=0.52, master's/PhD holder M=3.76, SD=0.51).

Finally, the factor number of children in the family did not lead to statistically significant differences in either of the two groups of mothers, and similarly, no statistically significant interaction emerged among the studied factors.

Conclusions

From the analysis of the research results, it emerged that mothers of children with ASD are less resilient than mothers of typically developing children. This finding agrees with previous studies (Alrahili, 2023; Craig et al., 2016; Kotera et al., 2021; Malla & Taha, 2022; Smith et al., 2010; Van Bourgondien et al., 2014) and may be due to the fact that mothers of children with ASD often face greater social life limitations, more conflicts within family and social environments, financial difficulties due to increased needs of their child and increased challenges and difficulties in daily life (Alrahili, 2023). Other possible reasons include lack of structures and limited support from the state and the community, lack of free time and denial of acceptance of the situation by themselves or other family members (Santoso, 2022). All of the above burden the lives of these mothers and lead to high levels of anxiety, negative thoughts and feelings, mental and physical fatigue and consequently a decrease in resilience. This current finding disagree with the study by Flores-Builds and Andrés-Roqueta (2022), which reached the opposite conclusion, namely that parents of children with neurodevelopmental disorders, particularly parents of children with ASD, are more resilient compared to parents of typically developing children, as well as with the study by Pastor-Cerezuela et al. (2021) that did not find significant differences in resilience between the two groups of mothers.

Age is a significant differentiating factor among all mothers, regardless of whether their children have ASD or not. However, it plays a larger role among mothers of children with ASD, with older mothers being more resilient. This finding is also confirmed by findings of other similar studies (Buchholz, 2022; Malla & Taha, 2022; Smith et al., 2010), which attribute it to the fact that older individuals exhibit greater emotional stability, have more experience in managing difficult situations and have found ways and strategies to cope with these challenges. However, other research has shown no statistically significant correlation between resilience and parental age (Flores-Builds & Andrés-Roqueta, 2022; Ghanouni & Eves, 2023; Şanlı, 2023; Sinha et al., 2016).

Another statistically significant factor influencing resilience is the educational level of the mothers. Specifically, this difference is significant among mothers of children with ASD, with secondary education graduates being more resilient compared to those with a university or a

master's/PhD degree. This finding aligns with the results of other relevant studies (Buchholz, 2022; Dey & Amponsah, 2020; Koziarz et al., 2021; Şanlı, 2023), which attributed lower resilience levels of degree-holding parents to feelings of shame or to higher expectations for their children's education and progress, which, due to their cognitive limitations, make it almost impossible to meet their parents' expectations. In contrast, Kavalioti's (2017) research conducted on a Greek population reached the opposite conclusion, namely that more educated mothers are also more resilient.

The number of children in the family did not differentiate the mothers' resilience, a finding that agrees with the researches of Alrahili (2023) and Flores-Builes and Andrés-Roqueta (2022). Mothers may experience increased challenges and pressure and feel anxious about the "burden" that their typically developing children might bear having a sibling with ASD. However, other studies link a larger number of children in the family with greater adaptability and control of negative emotions (Greeff & van der Walt, 2010; Smith et al., 2010), which was not found in the present study.

In summary, the findings of the present study, in agreement with the majority of studies, showed that mothers of children with ASD are less resilient compared to mothers of typically developing children. The factors "mother's age"' and "educational level" influence the resilience of mothers with children with ASD, with older mothers and less educated mothers being more resilient. The factor "number of children in the family" did not appear to affect either group of mothers. However, the results of our study are in contradiction with the findings of some other similar studies, indicating that further research is necessary to accurately determine the resilience of mothers of children with ASD and to identify the influence that the above factors may have on their resilience when raising a child with ASD.

As the sample in the present study was limited to mothers, it would be beneficial to include a larger sample with corresponding representation of fathers of children with ASD and fathers of typically developing children and also with diagnosis of the same diagnostic and statistical manual. Factors such as the severity of the disorder, the age and the gender of the child with ASD would also be important to include in future research. Additionally, it would be interesting to examine the resilience of siblings of individuals with ASD, as these children have to manage situations and relationships different from those with typically developing siblings. Furthermore, future research could focus on other protective factors of resilience, such as counseling support for parents from health professionals, strong family bonds and good couple communication. Finally, the extension of the research to parents of children with ADHD, intellectual disabilities, learning difficulties and other educational needs would shed more light on the issue of resilience among parents of children with disabilities. Focusing research on the resilience of these parents, who often need psychological support, would greatly contribute to this population group which is vulnerable not only psychologically but also economically and socially.

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Supporting the Understanding and Memorization of Advanced Chemistry Concepts in Third-Year Junior High School Students through Narrative Techniques

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Abstract

The applications of Science Communication (SciComm) can support teaching by making it more productive by engaging the audience's interest. One tool of SciComm is the narrative technique, which has tangible results. If designed appropriately, it can assist in a fuller understanding of concepts and in their memorization. In this section of our research, we studied the effectiveness of four narrative approaches to advanced Chemistry concepts in twenty 3rd-year Junior High School students at Anavryta Model Junior High School. The students were divided into two groups. Subsequently, the techniques were alternately applied, and the results were compared regarding both the understanding of the thematic subject and the duration of the educational imprint. Statistically significant positive results were confirmed.

Keywords: Science Communication, narrative technique

Introduction

Science Communication (SciComm) is defined as the use of appropriate means and approaches for the interaction between scientists and the non-scientific public, aiming to promote scientific knowledge (Burns et al., 2003).

SciComm refers to the process and techniques by which scientific knowledge, ideas, and discoveries are communicated from scientists and research institutions to a less specialized audience. The goal of science communication is to inform, educate, and enhance public understanding and participation in the scientific process. The available means that can now be utilized for this purpose are numerous and include the internet, print media, radio, television, and museums.

During the phase of doctoral research, we studied the parameters of SciComm (Asimellis et al., 2020; 2021a; 2021b; 2022a) and the effectiveness of its educational parameter in both face-to-face applications (Asimellis et al., 2021c; 2021d) and online approaches (Asimellis et al., 2022b). In the context of our postdoctoral research focused on SciComm, we further explored the possibility of educating someone more effectively, faster, and with a more extended educational imprint through its applications. This part of our research focused on a specific audience observed over a long period. The aim of the research was to test the educational value of specific narratives as a tool for a fuller understanding of scientific concepts and as a supportive tool for the memorization of the taught material over a longer period. Our sample consisted of twenty 3rd-year middle Junior High School students from the

excellence, creativity and innovation group of the Model Junior High School of Anavryta. The students who participated in the group generally showed particular interest in the scientific field of Chemistry, achieved high performance, and adopted laboratory behavior consistent with safety rules. The application and investigation were carried out in the 2023-2024 academic year.

The teaching narrative, i.e., the inclusion of short stories in teaching, is a means of SciComm and has scientifically proven benefits in education, as it can enhance understanding, memorization, and knowledge transfer. The use of appropriate teaching narratives increases audience attention and concentration, enhances understanding, facilitates memorization (Haven, 2007), promotes critical thinking (Schank, 1995), strengthens emotional engagement (Green et al., 2003), creates multicultural sensitivity (Dahlstrom, 2014), and connects scientific knowledge with everyday life (McEwan & Egan, 1995). Narrative is a fundamental human process for understanding the world and organizing knowledge, making it particularly effective in the educational process (Bruner, 1991).

Methodology

In this research, short stories were used to help understand:

- *Catalyst Concept*: Understanding how a catalyst remains unchanged in quantity and quality during a chemical reaction.
- *Surface Area's Role in Reaction Rates*: The effect of surface area on the rate of reactions involving solids or pure liquids.
- *Energy Degeneration*: The concept of energy degeneration and the specific amount of energy required to excite an electron within an atom.
- *Appropriate Energy Amount for Exciting an Electron in an Atom.*

The technique used was as follows: the students of the group were divided into two equal groups, A and B, of ten individuals each. When Group A was taught the first thematic, the same worksheet based on guided inquiry technic was used as that of the other group, with the only difference being that the corresponding story was included in it. The same approach was used for the third thematic. In the second and fourth themes, the worksheet was again common for both groups, but the narrative technique was applied only to Group B. After completing each unit, there was a written individual examination with closed-type questions common to all students. Subsequently, the performances of the two groups were studied separately, and an analysis was conducted to see if statistically the average performance differed significantly between them when the specific story technique was utilized. Additionally, a corresponding written examination was repeated three months after the teaching to observe whether the taught material remained active in memory. The structure of each evaluation test was examined for content validity and internal validity, ensuring that the assessed elements are representative. Additionally, the reliability of internal consistency was tested using Cronbach's alpha as a criterion. The measured value in each case ranged between 0.868 and 0.886, leading to the conclusion that good internal consistency reliability was achieved. Statistical testing was conducted using an independent samples t-test with the SPSS software at a 95% confidence interval.

Results and Discussion

Catalyst Concept

Catalysis is a field of Chemistry with particular importance. The idea of a material involved in the reaction mechanism, making it faster—thereby solving the problem of the slow rate of its occurrence—while remaining qualitatively and quantitatively unchanged, is difficult for students to grasp. To better understand the regeneration of the catalyst after accelerating the reaction in which it was used, the following story from mathematics was used:

"Once upon a time, there was an Arab father who had three sons. When he died, he left his property, i.e. his 17 camels, to his children. The condition of the will was that the eldest

son would receive half of the herd, the second a third, and the third a ninth. Obviously, the problem arises because the number of 17 camels is not divisible by any of the numbers 2, 3, or 9. The children had fallen into despair until one day a friend of theirs, riding his camel, met them by chance. When the three sons told their friend what had happened, he replied, 'No problem! Take my camel!' Now the children had 18 camels. The first son took half of them, i.e., 9. The second took a third, corresponding to 6 camels. The third took a ninth, thus 2 camels. Therefore, the sum of the camels they divided was 9+6+2=17. Subsequently, they returned the extra camel to their friend. Problem solved. Just as the friend's camel 'entered' the problem and was 'regenerated' qualitatively and quantitatively unchanged, so too can a catalyst engage in a reaction, modify the path the reactants take to become products, and ultimately regenerate after speeding up the reaction."

The results of the written examination obtained from the two groups were tested with an independent samples t-test using SPSS software to determine whether statistically the mean scores differed significantly at a 95% level. In each case, prior to the use of the t-test, the normality of the distributions was tested, and through the Kolmogorov – Smirnov test, it was determined that at a 95% significance level, they do not statistically significantly differ from a normal distribution. The average score of Group A was 18.0, while that of Group B was 14.4.

Table 1. Mean and Standard Deviation of Scores for the Two Groups

Group	N	Mean	Standard Deviation
A	10	18.0000	2.10819
B	10	14.4000	3.86437

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.009 < a$. This means we reject the null hypothesis and conclude that the mean score of Group A is significantly higher than that of Group B at a 95% confidence level.

Table 2. t-test for Independent Samples

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
2.586	18	0.009	0.019	3.60000

The written examination was repeated—this time with different closed-type questions—on the same topic after three months. The results were tested to see if the mean score statistically differed significantly both between the different groups and between the individuals who were members of the same group. The first test aimed to check the effectiveness of incorporating the specific narrative into the teaching unit, and the second to assess the possibility of extending the memorization of knowledge over a more extended period.

The average score of Group A was 17.2, while that of Group B was 13.2.

Table 3. Mean Scores of the Two Groups After Three Months

Group	N	Mean	Standard Deviation
A	10	17.2000	2.69979
B	10	13.2000	2.69979

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.002 < a$. This means we reject the null hypothesis and conclude that statistically the

mean score of Group A remained significantly higher than that of Group B at a 95% confidence level.

Table 4. t-test for Independent Samples After Three Months

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
3.313	18	0.002	0.004	4.00000

Additionally, we conducted a paired-samples t-test for each group separately at a 95% significance level to determine whether the mean score significantly decreased or not, to assess the improvement or otherwise of the long-term memorization of the taught material. For Group A, we obtained $p = 0.084 > a$, while for Group B, we calculated $p = 0.041 < a$.

Table 5. Paired-Samples t-test Separately for the Members of the Two Groups

	t	df	Significance	
			One-Sided p	Two-Sided p
Group A	1.500	9	0.084	0.168
Group B	1.964	9	0.041	0.081

This leads to the conclusion that in the case of Group A, the mean performance score did not significantly decrease, while in Group B, there was a significant decrease in the mean score. Thus, the educational significance of the specific narrative technique was confirmed both in terms of understanding the concept it concerned and for improving its memorization.

Surface Area

The reaction rate is a subject of study in chemical kinetics. One of the factors that affect the speed of a reaction is the surface area of the pure liquids or solids reacting with other reactants. However, this factor is often taught briefly without confirmed educational outcomes. To better understand how the reaction rate is affected by the surface area of the pure liquids or solids involved in the reaction, the following historical narrative was used:

"The Battle of Thermopylae took place in 480 BC between the Persians and the allied Greek army. The specific location was chosen due to the strategic importance of the narrow passage. Thermopylae was a narrow path between the mountains and the sea, limiting the movement of the numerous Persian troops. King Leonidas of Sparta and his 300 Spartan warriors, along with other Greek forces, chose to defend this passage to halt the advance of the Persians, giving the rest of Greece time to organize its defense (Pressfield, S. 1998)".

"The Battle of Salamis took place between the Persians and the Greeks in 480 BC. The Persian fleet had a clear numerical superiority. However, it was won by the Greeks mainly due to the clever strategy of Themistocles. The Greeks managed to lure the Persian fleet into the narrow straits of Salamis, where the numerically superior Persian fleet could not deploy its full strength. On one hand, the Persian ships were lined up in three rows, so they fought few at a time; on the other hand, the smaller and more agile Greek ships took advantage of the confined waters and successfully attacked, causing great confusion and destruction among the Persians, leading to their defeat (Strauss, B. 2004)".

These historical events were chosen to highlight the importance of the surface area between the "reactants." Specifically, we observe, that the Persian superiority did not help them because, ultimately, what played a crucial role was the interface area between the two fleets, which was small in the narrow straits of Salamis. Similarly, solid reactants interact only through the surface that comes into contact with the other reactants in the reaction. Therefore, breaking them down into smaller pieces increases the interface area and accelerates the reaction, as the internal portion of the solid is now exposed to the other reactant.

A written examination followed, and the results obtained from the two groups were tested with an independent samples t-test using SPSS software to determine whether the mean scores differed statistically at a 95% significance level. In each case, prior to the use of the t-test, the normality of the distributions was tested, and through the Kolmogorov – Smirnov test, it was determined that at a 95% significance level, they do not statistically significantly differ from a normal distribution. It should be noted that the narrative technique was applied to Group B. The average score of Group A was 16.0, while that of Group B was 18.0.

Table 6. Mean and Standard Deviation of Scores for the Two Groups

Group	N	Mean	Standard Deviation
A	10	16.0000	2.66667
B	10	18.0000	2.10819

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.040 < a$. This means we reject the null hypothesis and conclude that statistically the mean score of Group B is significantly higher than that of Group A at a 95% confidence level.

Table 7. t-test for Independent Samples

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
-1.861	18	0.009	0.040	-2.00000

The written examination was repeated—with different closed-type questions—on the same thematic after three months. The results were tested to see if statistically the mean score differed significantly both between the different groups and between the individuals who were members of the same group. The first test aimed to check the effectiveness of incorporating the specific historical narrative into the teaching unit, and the second to assess the possibility of extending the memorization of knowledge over a more extended period.

The average score of Group A was 14.4, while that of Group B was 16.8.

Table 8. Mean Scores of the Two Groups After Three Months

Team	N	Mean	Standard Deviation
A	10	14.4000	2.79682
B	10	17.2000	3.29309

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.028 < a$. This means we reject the null hypothesis and conclude that the mean score of Group B remained statistically significantly higher than that of Group A at a 95% confidence level.

Table 9. t-test for Independent Samples After Three Months

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
-2.049	18	0.028	0.055	-2.80000

Additionally, we conducted a paired-samples t-test for each group separately at a 95% significance level to determine whether the mean score significantly decreased or not, to assess the improvement or otherwise of the long-term memorization of the taught material. For Group A, we obtained $p = 0.041 < a$, while for Group B, we calculated $p = 0.084 > a$.

Table 10. Paired-Samples t-test Separately for the Members of the Two Groups

	t	df	Significance	
			One-Sided p	Two-Sided p
Group A	1.964	9	0.041	0.081
Group B	1.500	9	0.084	0.168

This leads to the conclusion that in the case of Group A, the mean performance score significantly decreased, while in Group B, there was no significant decrease in the mean score. Thus, the educational significance of the specific narrative technique was confirmed both in terms of understanding the concept it concerned and for improving its memorization.

Energy Degeneration

A significant part of the curriculum covered in the group concerned modern atomic theory. In the section on electronic structure, the concept of energy degeneration was taught. To make this concept more fully understood and retained for a longer period, the narrative technique was utilized.

"Two mathematician friends who had studied together in Thessaloniki meet by chance after many years. During the conversation, one mentions that he now has three sons. The other asks him about their ages.

'Look, we are mathematicians. I will answer you with a riddle.'

'I don't mind.'

'If you multiply the ages of my three sons, the product is 36. If you add their ages, the sum equals the number of the building where we lived in Thessaloniki when we were students.'

'That's nice, but it is not enough for me. I need one more piece of information.'

'Fine. My eldest son has blue eyes.'

How can we determine the ages of the children based on this information? We consider the ages of the children as natural numbers and list all the possible triplets that give a product of 36 (Table 11). Additionally, the last column of the table provides the corresponding sum of the ages.

Table 11. Combinations of Ages with a Product of 36

Age 1	Age 2	Age 3	Sum
1	1	36	38
1	2	18	21
1	3	12	16
1	4	9	14
1	6	6	13
2	2	9	13
2	3	6	11
3	3	4	10

If they lived in a building with the number 21 as students, the first two pieces of information would have been sufficient to determine the children's ages. Since a third piece of information was required, it means they lived in a building with the number 13, as it is the only sum that appears twice. Thus, two different situations lead degeneratively to a common characteristic. Two combinations of ages remain: 1, 6, 6, and 2, 2, 9. The correct choice is 2, 2, 9 because, in the other combination, there is no eldest son, as the two older children are twins!".

Just as two different combinations of ages led to a common characteristic—the same sum—degeneracy similarly involves different orbitals of the same subshell that have equal energy.

A written examination followed, and the results obtained from the two groups were tested with an independent samples t-test using SPSS software to determine whether the mean scores differed statistically significantly at a 95% significance level. In each case, prior to the use of the t-test, the normality of the distributions was tested, and through the Kolmogorov – Smirnov test, it was determined that at a 95% significance level, they do not statistically significantly differ from a normal distribution. It should be noted that the narrative technique was applied to Group A. The average score of Group A was 18.8, while that of Group B was 16.0.

Table 12. Mean and Standard Deviation of Scores for the Two Groups

Group	N	Mean	Standard Deviation
A	10	18.8000	1.93218
B	10	16.0000	3.26599

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.016 < a$. This means we reject the null hypothesis and conclude that the mean score of Group A is statistically significantly higher than that of Group B at a 95% confidence level.

Table 13. t-test for Independent Samples

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
2.333	18	0.016	0.031	2.80000

The written examination was repeated—with different closed-type questions—on the same thematic after three months. The results were tested to see if the mean score differed statistically significantly both between the different groups and between the individuals who were members of the same group. The first test aimed to check the effectiveness of incorporating the specific historical narrative into the teaching unit, and the second to assess the possibility of extending the memorization of knowledge over a more extended period.

The average score of Group A was 14.4, while that of Group B was 16.8.

Table 14. Mean Scores of the Two Groups After Three Months

Group	N	Mean	Standard Deviation
A	10	18.4000	2.06559
B	10	14.8000	3.79473

Assuming the null hypothesis (H_0) that statistically there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.008 < a$. This means we reject the null hypothesis and conclude that the mean score of Group B remained statistically significantly higher than that of Group A at a 95% confidence level.

Table 15. t-test for Independent Samples After Three Months

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
2.635	18	0.008	0.017	3.60000

Additionally, we conducted a paired-samples t-test for each group separately at a 95% significance level to determine whether the mean score significantly decreased or not, to

assess the improvement or otherwise of the long-term memorization of the taught material. For Group A, we obtained $p = 0.172 > a$, while for Group B, we calculated $p = 0.041 < a$.

Table 16. Paired-Samples t-test Separately for the Members of the Two Groups

	t	df	Significance	
			One-Sided p	Two-Sided p
Group A	1.000	9	0.172	0.343
Group B	1.964	9	0.041	0.081

This leads to the conclusion that in the case of Group A, the mean performance score did not significantly decrease, while in Group B, there was a statistically significant decrease in the mean score. Thus, the educational significance of the specific narrative technique was confirmed both in terms of understanding the concept it concerned and for improving its memorization.

Appropriate Energy Amount for Exciting an Electron in an Atom

The excitation of an electron in an atom to a higher energy state requires a specific amount of energy. However, this concept is particularly difficult for students of this age to grasp. A common question often raised by students is why the electron cannot absorb any amount of energy, as would happen with a ball that is given energy to move. To further explain this concept, we used the narrative technique.

"The world's loneliest whale, known as the '52-Hz Whale,' is a mysterious sea creature that has garnered global interest. Its name comes from the unique frequency of its song, which is at 52 Hertz, much higher than the usual frequency that other whales can decode. This means that its song cannot be heard by other whales, making it extremely lonely. Therefore, there is a specific frequency at which the transmitter and receiver are tuned and communicate. This unusual characteristic was discovered in the 1980s by the US Navy, which was recording sounds in the ocean.

The story of this whale has touched many people, as the idea of a whale singing in the ocean without being able to communicate with its kind evokes feelings of sadness and sympathy. Scientists have tried to locate and study the whale, but so far, they have not been able to see or identify it. It is not clear whether the whale belongs to a known species or if it is a unique hybrid. Despite its isolation, the 52-Hz whale appears to be healthy and continues its journey through the oceans.

The '52-Hz Whale' has become a symbol of human loneliness and the need for communication. Books, songs, and documentaries have been written about its story, making it known worldwide. The whale's song continues to be heard by scientific monitoring stations, and the search for it remains active. Although we still do not have answers about its origin or future, the story of this whale reminds us of the importance of communication and connection, not only for humans but for all living creatures."

Just as a whale must emit a signal at a specific frequency to be detected by other whales, an electron must absorb the appropriate amount of energy in order to become excited.

A written examination followed, and the results obtained from the two groups were tested with an independent samples t-test using SPSS software to determine whether the mean scores differed statistically significantly at a 95% significance level. In each case, prior to the use of the t-test, the normality of the distributions was tested, and through the Kolmogorov – Smirnov test, it was determined that at a 95% significance level, they do not statistically significantly differ from a normal distribution. It should be noted that the narrative technique was applied to Group B. The average score of Group A was 17.2, while that of Group B was 18.4.

Table 17. Mean and Standard Deviation of Scores for the Two Groups

Group	N	Mean	Standard Deviation
A	10	17.2000	1.93218
B	10	18.4000	2.06559

Assuming the null hypothesis (H_0) that there is no significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.098 > a$. This means we accept the null hypothesis and conclude that the mean score of Group B is not statistically significantly higher than that of Group A at a 95% confidence level.

Table 18. t-test for Independent Samples

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
-1.342	18	0.098	0.196	-1.20000

The written examination was repeated—with different closed-type questions—on the same thematic after three months. The results were tested to see if the mean score differed statistically significantly both between the different groups and between the individuals who were members of the same group. The first test aimed to check the effectiveness of incorporating the specific historical narrative into the teaching unit, and the second to assess the possibility of extending the memorization of knowledge over a more extended period.

The average score of Group A was 16.0, while that of Group B was 17.6.

Table 19. Mean Scores of the Two Groups After Three Months

Group	N	Mean	Standard Deviation
A	10	16.0000	2.66667
B	10	17.6000	2.79682

Assuming the null hypothesis (H_0) that there is no statistically significant difference in the mean scores of the two distributions and the alternative hypothesis that there is, we obtained $p = 0.103 > a$. This means we accept the null hypothesis and conclude that the mean score of Group A does not differ statistically significantly from that of Group B at a 95% confidence level.

Table 20. t-test for Independent Samples After Three Months

t	df	Significance		Mean Difference
		One-Sided p	Two-Sided p	
-1.309	18	0.103	0.207	-1.60000

Additionally, we conducted a paired-samples t-test for each group separately at a 95% significance level to determine whether the mean score significantly decreased or not, to assess the improvement or otherwise of the long-term memorization of the taught material. For Group A, we obtained $p = 0.041 < a$, while for Group B, we calculated $p = 0.082 > a$.

Table 21. Paired-Samples t-test Separately for the Members of the Two Groups

	t	df	Significance	
			One-Sided p	Two-Sided p
Group A	1.964	9	0.041	0.081
Group B	1.500	9	0.082	0.168

This analysis indicates that for Group A, the mean performance score significantly decreased, whereas for Group B, there was no statistically significant decrease in the mean score. Therefore, the narrative technique did not lead to a further understanding of the topic but supported the students in better memorizing the taught material.

Conclusions

Four narrative techniques were alternately applied to groups of ten third-year Model Junior High School students, and the results showed that in three out of these four cases, there was a fuller understanding of the thematic concept, while in all cases, the techniques led to a longer retention period of the taught material. The narratives covered advanced Chemistry concepts, specifically:

- How a catalyst remains qualitatively and quantitatively unchanged while involved in a reaction.
- The role of surface area in reaction rate involving solids or pure liquids.
- The concept of energy degeneration.
- The appropriate amount of energy required to excite an electron in an atom.

This research provides a foundation for further exploration of narrative approaches and the application of existing ones to a broader audience of similar age or different age groups.

Regarding the limitations of the research, it would be useful to mention the small sample size and the lack of previous research on the narrative technique. Specifically, the sample of twenty participants is considered small for drawing generalized conclusions, given that this research technique in the selected thematic areas has not been studied in the past. To overcome these limitations, it is suggested to replicate the application of the same thematic areas in new samples and compare the results with those already recorded.

It could potentially spark significant research interest to design and implement narrative techniques at an interdisciplinary and cross-curricular level, or even to approach sections of the current school curriculum using this technique.

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Integrating Artificial Intelligence in Science Education: Benefits and Challenges

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Abstract

This paper investigates the use of artificial intelligence (AI) in science education, focusing on the revolutionary potential of AI as well as the problems that associated with its implementation. Through the provision of individualized instructional materials and adaptive learning pathways, artificial intelligence technologies offer a multitude of advantages. Implementing artificial intelligence in educational settings, on the other hand, is riddled with difficulties, such as financial limits, issues regarding data privacy, and the possibility of becoming overly dependent on technology. The unequal distribution of access to artificial intelligence tools can further worsen existing educational inequities, and it is imperative that ethical concerns around prejudice and privacy be addressed in order to safeguard the rights of students. In this study, the importance of a well-rounded strategy is emphasized. This approach should incorporate ethical standards, technology improvements, and fair access, and it should be supported by professional development opportunities for educators and collaboration among many stakeholders.

Keywords: Artificial Intelligence (AI), Science Education, Personalized Learning, Ethical Considerations, Educational Frameworks

Introduction

The introduction of artificial intelligence (AI) into the field of science education ushers in a revolutionary era that has the potential to dramatically enhance the quality of the educational experience experienced by students. Educational environments are being reshaped by technological breakthroughs, which means that instructors are confronted with innovative tools and complicated issues. Personalized learning experiences can be offered through the utilization of artificial intelligence, which enables students to interact with content that is tailored to their specific requirements, preferences, and speed. The capacity for dynamic adaptation helps to cultivate a more profound understanding as well as an even greater excitement for scientific investigation. On the other hand, such integration is not without its challenges; concerns over data privacy, the requirement for sufficient training for educators, and questions of equity in access to technology commonly come up in conversations regarding the role that artificial intelligence plays in academic institutions. For the purpose of realizing the full potential of artificial intelligence, it is essential to negotiate these issues with careful consideration, assuring the appropriate and ethical integration of AI in science education. Despite these obstacles, artificial intelligence holds a considerable promise for the field of scientific education; therefore, it is vital that these issues be overcome.By fostering collaboration between educators, technologists, and policymakers, institutions can create a framework that not only addresses these challenges but also enhances the learning experience for all students. This collaborative approach can lead to the development of innovative curricula that incorporate AI tools, allowing students to engage with complex scientific concepts in interactive and meaningful ways.By prioritizing inclusivity and accessibility, educators can ensure that all students benefit from these advancements, ultimately preparing them for a future where AI plays an integral role in scientific discovery and innovation.This proactive strategy will empower students to not only understand the principles of science but also to harness AI as a tool for exploration and problem-solving,

equipping them with essential skills for their future careers.Emphasizing hands-on projects and real-world applications will further deepen their understanding, fostering a generation of learners who are not only knowledgeable but also adaptable to the rapidly evolving technological landscape.

The incorporation of artificial intelligence (AI) into educational processes marks a revolutionary shift in pedagogical techniques, which profoundly alters the manner in which knowledge is transmitted and assimilated. Machine learning, natural language processing, and adaptive learning systems are some examples of the technologies that fall under the umbrella of artificial intelligence (AI), which is defined as the emulation of human intelligence processes by computer systems. Using artificial intelligence, traditional teaching methods in education are improved, and learning experiences are personalized to match the needs of pupils. According to the findings of recent research (A. Nykonenko, 2023), artificial intelligence has the potential to dramatically optimize pedagogical processes and meet the budgetary and time constraints that are inherent in conventional educational models. This potential is enormous. According to Martín-Núñez et al. (2020), this highlights the revolutionary potential of artificial intelligence (AI) in the field of science education. It also highlights the crucial role that educators play in embracing these breakthroughs, which empowers them to create the ever-changing educational landscape. As educators adapt to these technological advancements, they can foster a more engaging and effective learning environment that not only enhances student outcomes but also prepares learners for the demands of a rapidly evolving world (Sadiku et al., 2021). By integrating AI tools and resources into their teaching strategies, educators can tailor instruction to meet individual student needs, thereby promoting inclusivity and maximizing learning potential for all.This tailored approach not only supports diverse learning styles but also encourages critical thinking and problem-solving skills that are essential for success in the 21st century..

Recent advancements in the field of science education are indicative of an increasing emphasis on individualized learning, which is done with the intention of catering to the various requirements of pupils. Traditional teaching methods have been revolutionized as a result of the incorporation of novel technologies, which has equipped educators with the ability to effectively personalize learning experiences. The possibility for improved individual instruction has dramatically grown since the emergence of artificial intelligence (AI). AI tools are able to assess student performance data in order to provide individualized learning materials that support a deeper level of comprehension and engagement. According to Yılmaz (2024), numerous research have highlighted the benefits of artificial intelligence (AI) in the creation of adaptable learning environments that assist in accommodating different learning styles and paces, ultimately leading to enhanced educational outcomes. For the purpose of efficiently utilizing these technologies, there are still challenges to be faced, including financial limits, inadequate infrastructure, and inadequate teacher preparation. It is essential to address these obstacles in order to fully realize the transformative potential of artificial intelligence in the field of science education and to guarantee equal access for all students.

When it comes to improving educational outcomes, particularly in the field of science education, the incorporation of artificial intelligence (AI) into educational frameworks holds tremendous promise. The program provides students with individualized and adaptable learning experiences that may fit a variety of learning styles and paces. This ensures that students receive training that is adapted to their specific requirements. According to research conducted by Hoelscher et al. (2024), artificial intelligence has the potential to enhance the delivery of educational services, simplify administrative procedures, and enhance resource allocation. Furthermore, the perspectives of stakeholders are essential for the successful implementation of artificial intelligence within K-12 settings. Their ideas can drive the design of curriculum that emphasize critical thinking and problem-solving abilities that are relevant to scientific investigation. According to Sanusi et al. (2024), it is of the utmost importance to

address issues regarding data privacy and ethical use of artificial intelligence (AI), as these aspects have a substantial impact on the successful integration of technology in classrooms. It is possible for the education system to create a learning environment that is both engaging and efficient by combining the input of stakeholders with cutting-edge artificial intelligence techniques. This will ultimately result in enhanced educational outcomes in the field of science. This research makes use of a combination of literature reviews and case studies in order to investigate the incorporation of artificial intelligence (AI) in science education and to determine the advantages and disadvantages of doing so.

Benefits of Integrating AI in Science Education

The implementation of artificial intelligence (AI) in the field of scientific education has a number of revolutionary advantages that have the potential to improve teaching strategies and increased student engagement. (Sharifuddin & Hashim, 2024) Artificial intelligence technologies, such as chatbots and bespoke learning platforms, offer students the opportunity to access personalized learning experiences. These technologies enable students to advance at their own pace while simultaneously obtaining fast feedback on their inquiries. By catering to students' inherent motives and their demand for competence, this direct engagement helps students develop a better comprehension of complicated scientific concepts, which aligns with the principles of Self-Determination Theory (Alasgarova & Rzayev, 2024). A deeper understanding of these concepts is fostered by this immediate interaction. Educators are able to detect individual learning patterns and preferences, which further refines educational tactics, thanks to the capability of artificial intelligence systems to evaluate huge volumes of data. As a consequence of this, artificial intelligence helps to make studying more interesting and prepares students for a future in which technical competency is essential across all scientific fields (Boratkar & Sambhe, 2024). Therefore, the incorporation of artificial intelligence into science education marks a big step toward the creation of learning environments that are more effective and adaptable.

Through the promotion of individualized learning experiences that are suited to the requirements of students, the introduction of artificial intelligence has transformed educational approaches. These systems, which are driven by artificial intelligence, evaluate large amounts of data, which includes learning styles, performance metrics, and engagement levels. This gives them the ability to alter the material, pacing, and instructional approaches in accordance with the findings. Teachers are able to discover and fix knowledge gaps in real time because to the ability of artificial intelligence to deliver instant feedback. This helps to build an environment that is more adaptable to learning. For example, as noted in recent studies, the shift toward individualized learning models enables educators to address the compelling requirements of a varied range of learners while simultaneously increasing student engagement and motivation (Prajapati, 2024). In addition, the incorporation of non-formal learning activities might be a useful complement to these artificial intelligence tools. This can enhance the educational experience by bridging the gap between formal curriculum and real-world applications, as well as promoting scientific literacy among students (de Lima et al., 2023). Through the use of such an integrated approach, students are better able to comprehend scientific principles and are more prepared to face future challenges in a world that is always changing.

It is possible that the incorporation of artificial intelligence (AI) into science education will significantly boost the level of engagement and motivation among students. AI has the potential to convert traditional educational approaches into ones that are interactive and adaptive, effectively capturing the attention of students. This can be accomplished through the utilization of personalized learning experiences that are suited to individual needs. In the process of interacting with intelligent tutoring systems or gamified learning platforms that are powered by artificial intelligence, students actively participate in their own learning processes,

which ultimately results in a more profound comprehension of intricate scientific concepts. The implementation of AI has the potential to simplify administrative work, which will enable teachers to devote more of their attention to interacting with their students and giving them with constructive criticism. This paradigm change is in line with the growing desire for novel teaching approaches, which was highlighted in a study that addressed the perspectives of education stakeholders on the incorporation of artificial intelligence into curricula (Sanusi et al., 2024). This kind of involvement inspires students and provides them with the vital skills they need to be successful in a world that is becoming increasingly driven by technology.

Assessment and feedback systems have been revolutionized as a result of the incorporation of artificial intelligence (AI) into educational procedures, which has led to a more individualized learning experience. Educators are able to acquire insights into the performance of individual students through the utilization of analytics driven by artificial intelligence, which allows them to identify areas that require targeted intervention. For example, computers are able to perform real-time analysis of replies, which enables quick feedback that is specifically suited to each student's level of comprehension. This is especially important in topics such as science, where comprehensive grasp of concepts is essential (Prajapati, 2024). In order to ensure that students are consistently pushed while still receiving help, artificial intelligence can provide adaptive assessments that modify the level of difficulty dependent on a student's competence. Because of this change, students are provided with constructive feedback that is tailored to their own learning methods, which in turn stimulates engagement and fosters a sense of ownership over one's educational journey. To put this into perspective, practical assessment and feedback mechanisms eventually improve educational results and fairness in science education, and they are precisely aligned with the requirements of a student population that is comprised of a varied range of students.

Challenges of Integrating AI in Science Education

The incorporation of artificial intelligence into science education presents a substantial number of problems that teachers need to overcome in order to guarantee successful learning outcomes. There is a huge problem with the unequal distribution of access to technology, which results in an uneven playing field where pupils are concerned. People who have limited access to artificial intelligence tools may have difficulty keeping up with their peers, which can exacerbate existing educational disparities. When students rely on artificial intelligence for research and learning, they may prioritize the retrieval of knowledge quickly rather than engaging deeply with the subject matter. This can lead to a superficial understanding of the material. In addition, the incorporation of AI necessitates the development of new pedagogical techniques and skill sets by educators, which may not be practicable for all members of the teaching team (Kenchakkanavar, 2023). There is a pressing need for curriculum to continuously adapt as artificial intelligence technologies continue to improve. This is to ensure that both teachers and students are able to effectively exploit these advancements, rather than allowing them to become mere diversions (Martín-Núñez & Díaz-Lantada, 2020).

Concerns regarding data privacy and substantial ethical problems are becoming more prevalent as the use of artificial intelligence (AI) in science education continues to expand. These concerns need to be addressed. The usage of technologies that are driven by artificial intelligence raises worries about the huge volumes of student data that are collected. If this data are not handled appropriately, it could result in violations of students' privacy and the inappropriate use of sensitive information. When the potential biases that are inherent in AI systems are taken into consideration, ethical concerns inevitably arise. Should these prejudices not be adequately managed, they may unintentionally contribute to the perpetuation of current educational disparities. According to the research that has been conducted, artificial intelligence has the potential to improve educational efficiency and

enhance individualized learning experiences. However, in order to safeguard student rights and privacy, its implementation requires a thorough examination of ethical frameworks (Mallikarjuna, 2024). According to Eden et al. (2024), the aforementioned problems are further complicated by the fact that educational institutions are required to develop transparent policies and make certain that applications of artificial intelligence do not undermine the confidence and safety of students. In order to successfully include artificial intelligence into science education, it is necessary to have a well-rounded strategy that places a priority on ethical principles.

In light of the fact that more and more teachers are turning to artificial intelligence (AI) to improve science education, it is essential to take into consideration the consequences of accessibility and equity in its deployment. Artificial intelligence technologies offer the ability to personalize learning experiences, making it possible to provide students with training that is personalized to fit their unique requirements. The disparities in access to technology have the potential to worsen the educational disparities that already exist. As an illustration, students who come from underprivileged families could not have access to the resources they need to benefit from AI-driven technologies, which would further widen the success gap. It is imperative that these equity concerns be addressed in order to guarantee that the benefits of artificial intelligence are distributed evenly among all pupils, irrespective of their socioeconomic standing. According to the findings that emphasize fairness and inclusivity (Askarkyzy & Zhunusbekova, 2024), it is of the utmost importance to generate ethical rules about the utilization of data and the protection of personal information. According to Umar (2024), a method that is committed to having an equal integration of artificial intelligence in science education promotes learning and champions social justice in the academic world.

Change frequently elicits resistance from educational institutions and educators, especially as a result of concerns regarding the unknown ramifications of emerging technologies such as artificial intelligence (AI). Because artificial intelligence has the ability to replace traditional teaching positions, many educators are concerned that they may lose their autonomy and the essential human connection that is essential to pedagogy. Furthermore, they have a low level of digital literacy, which makes it difficult for them to make good use of AI tools (Prajapati, 2024). This concern is heightened by the circumstance. In addition, educational institutions confront difficulties in matching the incorporation of artificial intelligence with pre-existing curricula, which some teachers consider to be a severe disturbance to practice that has been established. There are a number of reasons why people are hesitant to adopt artificial intelligence (AI), including a reluctance to change traditional methodology, ethical concerns around data protection, and the possibility of biases inside AI systems. As a consequence of this, it is essential to cultivate a culture of adaptation within educational contexts in order to overcome this resistance and make the most of the benefits that artificial intelligence may bring to science education.

Case Studies and Examples of AI in Science Education

The transformative impact of artificial intelligence (AI) in science education is illustrated by a multitude of case examples, which enhance both the teaching and learning processes. There are studies that have been conducted on all stages of education, including preschool education (Samara & Kotsis, 2024; Samara & Kotsis, 2025) and primary education (Kotsis, 2024a; Kotsis, 2024b; Kotsis, 2024c; Kotsis & Tsiouri, 2024). An example of this would be adaptive learning platforms, which allow for personalized training that is suited to the specific requirements of each individual learner, hence promoting a more profound comprehension of difficult scientific concepts. As stated by Yılmaz (2024), the incorporation of artificial intelligence technology not only encourages a higher level of involvement but also offers insights that are informed by data, so enabling educators to efficiently alter their instructional tactics. The research highlights the utilization of artificial intelligence-driven virtual assistants

that provide real-time feedback and support, thereby providing a learning environment that is more interactive and responsive. However, despite these benefits, there are still problems that need to be addressed, such as the financial demands of implementation and the requirement that teachers receive training in order to be able to use these advanced tools (Franqueira et al., 2024). Addressing these challenges is essential for optimizing the role that artificial intelligence plays in science education, ensuring that it increases educational equity and accessibility, and ensuring that it personalizes learning.

Innovative techniques to incorporate artificial intelligence into elementary, middle, and high school education have demonstrated a great deal of success, highlighting the potential benefits for student engagement and learning results. The implementation of artificial intelligence curricula in schools frequently results in improved interaction and relevance in science lectures, which in turn creates a more engaging learning environment. According to research, educators are able to successfully incorporate artificial intelligence (AI) principles into computer science education if they receive the appropriate professional development for teachers. This is something that can be observed in Bavaria, Germany. Based on the findings of Jetzinger et al. (2024), this program provides educators with the opportunity to acquire the essential material and pedagogical knowledge to facilitate student comprehension of artificial intelligence technology. Students' problem-solving abilities and preparation for the workforce can be improved via exposure to cutting-edge technology, as demonstrated by initiatives that connect students with real-world uses of artificial intelligence (AI), such as partnerships with organizations such as the European Spallation Source (Darve et al., 2021). AI's transformational potential in improving science education from kindergarten through high school is demonstrated by these successful applications together.

Higher education is experiencing a rapid transformation in the landscape of science education, which is being driven by innovations that harness modern technology, particularly artificial intelligence (AI). According to Albelo and McIntire (2024), transformative technologies such as ChatGPT provide learners with tailored learning experiences that have the potential to improve student engagement and comprehension. These experiences also enable learners to more effectively assimilate huge volumes of data. While educators are beginning to grasp the dual potential of artificial intelligence to streamline course design and facilitate interactive learning environments, they must also continue to be vigilant about the ethical implications of these technical breakthroughs. According to Fuller and Barnes (2024), participants in a recent survey voiced their worries over an excessive reliance on artificial intelligence (AI) and the necessity of holistic skill development. This highlights the need for a balance between innovation and traditional academic rigor at the same time. Consequently, the incorporation of artificial intelligence (AI) into science programs has the potential to bring about enormous educational gains; however, allowing students to mindfully navigate the accompanying hurdles guarantees that they develop critical thinking abilities in addition to technological ability.

A complex interplay of benefits and obstacles is revealed by the worldwide landscape of artificial intelligence (AI) integration in education. This is due to the fact that different countries choose different approaches, which are greatly influenced by cultural and infrastructure issues. According to Lu et al. (2024), educators in higher education have recognized the potential of artificial intelligence-generated content to improve innovative teaching methods and ensure that students are engaged in the learning process. Educators, on the other hand, confront challenges when it comes to its actual application, which calls for a deep understanding of both educational practices and technology capabilities. On the other hand, the path that Latin America has taken in the realm of distance education demonstrates how the development of information and communication technology has influenced the incorporation of AI. According to the historical research, there has been a delay in the utilization of technology as a result of social inequities and availability problems. It also

underlines the great achievements that have been made by institutions like as Tecnologico de Monterrey and Universidade de São Paulo in Mexico and Brazil, who are pioneers in the incorporation of sophisticated educational technologies (Miralrio, 2024). Therefore, it is essential to encourage international collaboration and the exchange of best practices in order to overcome obstacles and make the most of the benefits that artificial intelligence may bring to science education.

Discussion

While the incorporation of artificial intelligence into science education gives a tremendous opportunity to improve the efficiency of learning, it also brings a number of critical obstacles that need to be addressed accordingly. Cedeño et al. (2024) have established that artificial intelligence has the potential to enhance student engagement and performance by facilitating tailored learning experiences and streamlining assessment procedures. This idea is supported by the literature that has been evaluated. On the other hand, it is impossible to ignore the ethical problems that surround the employment of artificial intelligence, such as concerns around privacy and equitable access to resources. According to Askarkyzy and Zhunusbekova (2024), the findings of empirical investigations underscore the importance of establishing rigorous ethical norms that guarantee that all students will benefit from breakthroughs in artificial intelligence without being subjected to discrimination or having their privacy violated. In the end, it is evident that artificial intelligence has the potential to change science education; but, in order to accomplish this, educators, politicians, and researchers need to work together and build frameworks that enable ethical deployment possible. It is only via such concerted efforts that we will be able to fully exploit the capabilities of artificial intelligence while also protecting the interests of all educational stakeholders.

The implementation of artificial intelligence in the field of science education has a number of significant benefits, notably in terms of boosting tailored learning experiences and increases in student engagement. It has been demonstrated through research that artificial intelligence systems have the capability to offer individualized instructional materials and adaptive learning pathways, hence considerably enhancing the outcomes of individual students (Yılmaz, 2024). (Albelo & McIntire, 2024) Artificial intelligence makes it easier for students to gain access to a wide variety of information and interactive learning opportunities, which can enhance their academic experiences. There are significant obstacles that educators need to overcome in order to take advantage of these benefits. Concerns about data privacy, financial limits, and the possibility of over-reliance on artificial intelligence technology are all important obstacles that stand in the way of successful deployment (Yılmaz, 2024). Furthermore, although artificial intelligence has the potential to improve the effectiveness of learning, there are concerns surrounding the possible reduction in the importance of direct educator engagement, as well as the ramifications this may have for critical thinking and tailored instruction (Albelo & McIntire, 2024). It is essential for educational institutions that want to increase the benefits of incorporating technology into their teaching methods to strike a balance between the revolutionary potential of artificial intelligence and the obstacles that it presents. This balance requires a thoughtful approach that prioritizes human interaction and mentorship while leveraging AI tools to enhance educational outcomes.Achieving this equilibrium not only fosters a more enriching learning environment but also ensures that students develop essential interpersonal skills and critical thinking abilities, which are vital in today's rapidly changing world.Incorporating technology in a mindful way can lead to innovative teaching practices that inspire creativity and engagement among students, ultimately preparing them for future challenges. By integrating technology thoughtfully, educators can create personalized learning experiences that cater to the diverse needs of their students, fostering a deeper understanding and retention of knowledge.

The development and integration of artificial intelligence (AI) technologies into educational settings are poised to undergo a profound upheaval in the landscape of science education. According to Mohammed Almansour et al. (2024), the proliferation of AI-powered technologies has the potential to enhance individualized learning experiences by adjusting to the specific requirements and preferences of each students. This is similar to the gains that have been observed in higher education. As a result of providing students with resources that are closely aligned with their interests and talents, such individualized approaches have the potential to improve students' engagement and comprehension. The adoption of these technologies by educators brings with it the challenge of addressing ethical concerns around bias and equity in the context of artificial intelligence applications. Previous research has demonstrated that a complete educational framework is required in order to guarantee that science education continues to be successful and inclusive while simultaneously encouraging ethical standards in the application of artificial intelligence (Mohammed Almansour et al., 2024). In the future, the successful incorporation of artificial intelligence (AI) into science education will be contingent on striking a balance between maximizing the benefits of technology and preserving a strong ethical foundation in order to adequately prepare students for a world that is constantly evolving. This balance will necessitate ongoing dialogue among educators, technologists, and policymakers to ensure that AI tools are designed and implemented in ways that promote fairness, transparency, and accountability within educational settings.Achieving this goal will require robust training programs for educators, fostering a deep understanding of AI's capabilities and limitations while equipping them with the skills to teach students about responsible use in their future careers.Such initiatives can empower educators to not only integrate technology effectively into their curricula but also to inspire critical thinking and ethical considerations in students as they navigate the complexities of an increasingly digital landscape. By prioritizing these educational strategies, institutions can cultivate a generation of learners who are not only proficient in technology but also aware of its societal implications, ultimately leading to more informed and responsible citizens.This holistic approach to education will ensure that students are not just passive consumers of technology, but active participants in shaping its future, fostering innovation and ethical standards in the digital age.

Conclusion

Although incorporating artificial intelligence (AI) into scientific education gives an unprecedented opportunity for transformation, it is imperative that educators and policymakers take the initiative to participate in this endeavor. Not only must educators embrace new technologies, but they must also become advocates for the responsible application of these technologies in order to fully harness the potential of artificial intelligence. In order to provide educators with the knowledge and abilities they need to successfully incorporate artificial intelligence tools into their lesson plans, professional development programs ought to be designed. It is strongly recommended that policymakers give funding precedence to research and pilot initiatives that investigate the applications of artificial intelligence in a variety of educational contexts. It is possible for us to create an inclusive framework that solves ethical concerns and assures equal access if we encourage collaboration between researchers, technologists, and educators. To what extent we are able to successfully traverse the intricacies of artificial intelligence in education will ultimately be determined by the coordinated efforts of various stakeholders. This will ultimately result in improved learning outcomes and a revitalization of scientific discovery for students all around the country. Investing in such initiatives not only fosters innovation but also equips educators with the necessary tools to enhance teaching methodologies and create personalized learning experiences tailored to individual student needs.By prioritizing these collaborative efforts, we can ensure that the integration of artificial intelligence in education is both equitable and

effective, paving the way for a future where every learner has the opportunity to thrive.This vision will require ongoing research, investment in technology infrastructure, and continuous training for educators to adapt to the evolving landscape of AI-driven educational tools.Such a comprehensive approach will ultimately empower students to develop critical thinking skills and creativity, preparing them for the challenges of a rapidly changing world.As we move forward, it is essential to foster partnerships between educational institutions, technology developers, and policy makers to create an ecosystem that supports innovation while addressing the diverse needs of learners.

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Practices in STEAM Education: Integrating Art and Robotics at Primary Education Skills Workshops with Thymio robot

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Abstract

Skills Workshops are considered compulsory in Greek schools, paving the way for the reconstruction and update of teaching practice. The STEAM (Science, Technology, Engineering, Arts, Mathematics) educational approach in the context of workshops can widen its application, bending or removing the boundaries between disciplines. However, the differentiating element of Art is often of secondary importance, compared to Educational Robotics and the other aspects of STEAM. This study proposes an educational program integrating the Thymio robot, specifically tailored for the Skills Workshops. It outlines the pedagogical framework (a well-defined pedagogical approach that focuses at the integration of art and robotics), the implementation strategies (practical steps for classroom activities), and the outcomes of pilot activities (description of pilot application and discussion of emerging results from teachers self-reflection form that serve as case studies), highlighting the potential for a more holistic educational experience that prepares students for the complexities of the modern world.

Keywords: STEAM, Art, Thymio, Skills Workshops

Introduction

The Skills Workshop Curricula that replace the Flexible Zone in Primary Education create the conditions for the design and implementation of innovative pedagogical approaches to transform teaching. The emergence of new desired skills in terms of both Education and the labor market, entails changes in the learning content and teaching methodology. A STEAM approach incorporating Art, aspires to exceed the main goal of STEM, the training of professional scientists, who solve issues of the technological world, while at the same time applying principles of exploratory learning, cooperative learning, and learning based on problem-solving (Mikropoulos, 2021).

Educational Robotics (ER) which was intertwined with STEM now finds a place in STEAM education, although it is often integrated into the new technologies curriculum. Associated with STEM, it contributed to introducing students to learning subjects related to computer science and programming, whereas with its integration into STEAM, it is combined with literature, history, music, art curricula (Karypi, 2018). Although the growing number of STEAM

education programs worldwide testifies to their appeal to the learners and educators involved, it goes hand in hand with the prominence of technology and robotics at the expense of art. The primary purpose of this study is to design a scenario, where the basic elements of a modern pedagogical model of the STEAM educational approach, will be creatively intertwined, with a focus on Art and Educational Robotics, within the framework of the Skills Workshops.

Skills Workshops

The implementation of Skills Workshops (SWs) in Primary and Secondary Education has been met by the educational community, with skepticism regarding the readiness or adequacy of teachers to teach, the minimal teaching time about the voluminous content of disciplines, the deficiency in the facilities of school units (Pradaki, 2022). Numerous obstacles were noted among them distance learning, the absence of direct contact with students, the closing of schools due to the pandemic, the insufficient infrastructure of schools and the acceptance of the action by a large part of the teachers (Christou, 2021). In addition, teachers participating in the educational act of SWs that was piloted in the school year 2020-2021 emphasized the difficulty of the pressing timetable for the implementation of the 4 incorporated cycles (Christou, 2021).

The SWs, however, are an innovative, dynamic, educational initiative that is substantial for the development of students' basic skills. The four target circles (1.21st century skills, 2.Life skills, 3.Technology, engineering, science skills, 4.Thinking skills) correspond to the targeted skills, which are sought to be strengthened throughout life, since these, promote the development of citizens who may adjust to changing workplaces but also to social life while at the same time contributing to the response to the complexity of the modern world (FEK 3567/Β΄/04-08-2021). The four cycles which form the core of the design of the workshops carried out in the school units, are interrelated with the four thematic units (1.Well-being, 2.Environmental awareness, 3.Social awareness and responsibility, 4.Creative-innovative thinking) which emerged from the Global Sustainable Development Indicators and the United Nations Sustainable Development Goals.

As a parameter of the school's operation, SWs intervene in the organizational nature of education by upgrading its autonomy and redefining it from a "closed" to an "open" system. The modern program framework as formed by the application of SWs is structured with an open curriculum on a transdisciplinary and holistic basis (Asteri, 2021). In other words, every teacher who prepares the teaching plan, in order to teach SWs, organizes teaching actions considering the learning objectives but is not limited by disciplines. On the contrary, as SWs intersect the curriculum of other disciplines horizontally and vertically, they allow the merging of aimed knowledge by removing the boundaries between disciplines.

As the name "Skills Workshops" suggests, they are intended to be taught beyond traditional teaching methods of teacher-centered format. In the context of the Workshops, student-centered, group-centered and mixed teaching find fertile ground with the application of student collaboration practices, active learning, and peer teaching to approach not only life’s daily but also the school community’s problems. Indicative activities included construction, digital content projects, programming, and robotics.

Recent research data on their application confirm their positive contribution to the development of students' mental, social and digital skills. Pradaki (2022) investigating the opinions of 164 Primary Education teachers about the design, introduction, and implementation of the innovative action of SWs, through questionnaires, concludes that the learning outcomes of their students improved a little since the implementation of the program, while they benefited from it. Christou (2021) through 16 semi-structured interviews of Primary and Secondary teachers emphasizes the contribution of SWs in the acquisition of social, mental and digital skills of students, in the development of STEAM education and

educational robotics. Mammous et al. (2022) agree according to data collected by answers from 110 questionnaires, regarding the evaluation of the students' intended skills through the implementation of the activities of the thematic units, the educators gave a fairly high score to the learning skills acquired by the students.

Although SWs seem to improve student learning performance, research shows that this improvement might be small (Christou, 2021). Teachers express concerns about their readiness and competence to teach SWs effectively (Pradaki, 2022). In summary, SWs are a promising innovation in education, however, there are hurdles to overcome for their effective implementation.

STEAM

The STEAM educational approach, as an evolution of STEM, is increasingly expanding its application, thanks to institutions of either informal or formal education. Concerning formal education and specifically for Primary Education, the pilot introduction of SWs in the 2020-2021 school year and the universal application since then, provides the appropriate conditions for the expansion of the STE(A)M educational approach in every school unit.

The learning activities of the approach are designed to facilitate the construction, practice and expansion of knowledge as they are carried out. Indeed, it is applied in primary education, to familiarize students with the acquisition of knowledge, attitudes, and skills to solve real-world problems, and interpretation of natural phenomena, with the conclusions drawn based on the available data (Pasani, 2021). Also, students participate in assignments as citizens, constructing and reflecting on their knowledge while using ideas from science, engineering, technology, mathematics and arts. However, the STEAM approach is more than a methodological, instructional strategy. The integration of the basic principles of each field with art as interdisciplinary learning, in critical areas of mathematics, sciences, art through new technologies, constitutes a real innovation (Liao, 2019). Interdisciplinary knowledge and skills complement each other through collaborative practices, inquiry learning, active learning, working out projects with an emphasis on respect, social reciprocity, communication, promoting equality, i.e. with an emphasis on the social context of learning. Therefore, STEAM is a new vision to promote students' creativity, collaboration and collective existence through interdisciplinary awareness and consciousness (All Education Schools, 2019).

Several frameworks for teaching STEAM have been proposed internationally (Henriksen et al., 2019; Liao, 2016; Neofotistou & Paraskeva, 2017). For example, STEAM-integrated curriculum frameworks have been developed, such as the educational model which appears in the role of art but is aimed at gifted students (Lage-Gómez & Ros, 2021). Interdisciplinary and transdisciplinary approaches are also noted. For example, during experimentation with educational robotics activities for preschool students it was concluded, that educational robotics works effectively more as a means of exploring the possibilities of digital technologies in pedagogical learning environments rather than a lesson presented with instructions by teachers (Manera, 2019). The FASTER pedagogical framework consists of several key components to enhance STEAM education through educational robotics (Damaševičius et al., 2018). These components include project-based teaching, team-based learning, and educational robotics, learning scenarios, implementation and validation. Overall, the FASTER framework aims to create a synergistic relationship between different disciplines, enhancing student engagement and addressing the skills gap in STEM fields. Key aspects of the STEAM framework include interdisciplinary learning, creativity and innovation, hands-on learning, collaboration, focus on 21st century skills (Meletiou-Mavrotheris et al., 2022). Overall, the STEAM framework aims to create a more integrated and engaging educational experience that prepares students for a rapidly changing world.

Bertrand and Namukasa (2022) attempting to study which teaching stages of the STEAM approach promote a deeper understanding of Mathematics, ended up developing a new four-

stage STEAM pedagogical model. During the first stage, eliciting curiosity, which is a discovery and inquiry learning process, students are exposed to mathematical stories, photographs of real-life artifacts, drawings, and constructions of artifacts that may facilitate instructional connections. In the next stage, the design, collection and processing of data, information, elements takes place. Students deal with mathematical data, observe problems and situations, record processes, design to construct, make geometric measurements. In the third stage of construction, formation, completion, students use material from the previous stage to construct, create organize and synthesize information. During the fourth stage, diffusion and reflection on the final product, students have the opportunity to present a part of their work to an audience interested in mathematics.

Although Bertrand and Namukasa's pedagogical model contributes to the distinction of teaching stages, it is organized around Mathematics in STEAM (Bertrand & Namukasa, 2022). Thus one of the most critical elements in STEAM is the approach to Art and the rest of the STEM fields, cognitively and emotionally (Taylor, 2018). In this perspective the Arts provide the context where students enjoy experiences of success through their contribution to classroom work and receive positive reinforcement through their contribution to the learning of peers.

Arts and Educational Robotics

Incorrectly referring to the Arts only visual arts, painting, sculpture, and architecture are meant. Literature, poetry, theater, dance, music constitute art (Braund &Reiss, 2019).

The inclusion of arts, however, is not simply an addition to the list of STEM subjects. STEAM education incorporates art as both a teaching approach and inquiry-based learning. Henriksen ET al. (2016) offer examples where teachers use visual arts to demonstrate understanding of a scientific concept, music, or theater to explore a phenomenon. They also provide examples that demonstrate the deepening of understanding that can be achieved through multisensory learning, such as an experienced swimmer exploring the physics of waves, tides and currents, using prior experience, senses and additional knowledge to create new meaning (Quigley et al., 2020). It is a complex process of knowledge construction because students synthesize new knowledge through senses, experience, and new information. Arts thus lend themselves to the creative synthesis of knowledge, even though are often embodied only through the process of design, which is arguably an important component of visual art.

Several benefits of integrating the Arts into the STEM curriculum to create STEAM, have been highlighted as an outcome of research projects. Shukshina et al. (2021) suggest that the incorporation of creative elements into STEM education can increase student engagement and motivation, making learning more enjoyable and relevant. It also promotes a more holistic educational experience, encouraging students to apply theoretical knowledge in practical contexts and fostering a deeper understanding of scientific and artistic principles. Meletiou-Mavrotheris et al. (2022) support the enhanced creativity, the improved engagement, the holistic learning, critical thinking, collaboration skills, real-world connections and even diverse skill development. STEAM education nurtures a wider range of skills, including artistic, technical, and analytical abilities, preparing students for diverse career paths. Cultural awareness is remarked as the arts can introduce students to different cultures and perspectives, promoting empathy and social awareness. To sum up, integrating the Arts into STEM enriches the educational experience, preparing students to be well-rounded thinkers and innovators.

On the contrary, educational robotics as an innovation mean aims to prepare students for the future knowledge and society of information. Indeed, research attempts demonstrate learning benefits in terms of the development of social, cognitive and communication skills, although for Greece it is still at an initial, basic stage (Karypi, 2018). Robots are valuable educational tools, as they not only excite students but thanks to the multidisciplinary nature of robotic technology, they are related to fields of complex engineering, computer science,

and computer mathematics [24]. However, despite their potential, they are not widely used in schools due to cost and time. In particular, robots as modern, technological constructions have high purchase costs, which renders them inaccessible for schools that have limited budgets for educational equipment. Also, teaching reality with the integration of robots requires time for planning the activities, which are to be applied in the classroom and of course time, for teachers' training. Educating teachers on dual level, about functions and programming environment as well as the learning role robots possession beyond general-purpose tools. That is, as means that contribute to the development of creativity, cooperation and communication skills, cognitive skills, research skills (Karypi, 2018). Therefore, at a preliminary stage, it is considered necessary for the robot to be accessible, or in other words, that its basic operation does not require complex knowledge, so that it is accepted by the educational staff.

Thymio is a robot specially designed for children that include 6 ready pre-programmed robotic behaviors and ASEBA's accessible open-source programming environment. To detect obstacles in its front part there are five infrared sensors, in the back two, while to detect the black line on the ground, it has two other sensors at the bottom. It also possesses an infrared receiver for remote control, five touch buttons for its operation, speakers, a microphone, a three-axis accelerometer, a thermometer, 2 wheels with motors and 39 LEDs as color effects. Additionally, a hole between the wheels allows for a thin marker to be placed to draw while moving. At the same time the protrusions on its four upper corners are suitable for "building" with Lego-style bricks. It is an educational robot, considered suitable for elementary school students, since it gently introduces the visual programming language through exploration and experimentation (Shin et al., 2014). This robot, Thymio, offers a versatile design suitable for a wide range of age groups. In contrast, other robots like mBot are tailored for upper elementary students due to their focus on programming and coding, while BeeBot is designed for younger learners, lacking a programming interface and relying instead on directional buttons on its surface. Thus, Thymio stands out for its adaptability, incorporating both programming capabilities and arrow-based movement, making it suitable for integration into both upper and lower elementary classrooms.

In conclusion, despite the increase in STEAM education programs, art still plays a secondary role in advancing science technology. On the other hand, robotics technology is increasingly coming to the fore since it integrates scientific, technological and mathematical knowledge. However, a few scenarios are identified, where art is creatively combined with the use of robots and programming tools.

Methodology

Attempting to narrow the gap of the integration of STEAM and educational robotics in the unprecedented - for the Greek educational system - SWs, a pedagogical design was structured based on the model of Bertrand and Namukasa (2022). The choice of this model was not accidental. Firstly, it can be considered flexible in the sense that it allows its application to any age group regarding primary education. Secondly, it is not complex but realistic, i.e. based on it, there is the possibility of developing an educational program for every type of primary school. Third, it is identified as STEAM, so it is characterized by its interdisciplinary nature, even though it focuses on mathematical elements. Finally, it is up-to-date, as it was only shared in April 2022, so it is compiled with recent and older, scientific research data. Specifically, the model adopted the theoretical frameworks of Doppelts' creative design process (2004, 20099) and English, King, and Smeed's (2017) engineering design process as bases for analyzing the instructional models of four STEAM programs, resulting in the final model, as well four stages (Table 1).

Table 1. STEAM model of Bertrand and Namucasa

STEAM PEDAGOGICAL MODEL	
1st stage	Intrigue, generate curiosity
2st stage	Design and data collection
3st stage	Construction, creation and completion
4st stage	Reflection and diffusion

During implementation, the case study was preferred and qualitative and quantitative data were collected (Creswell & Plano Clark, 2018). The process was carried out in three phases. During the first phase, the educational material for the scenario (consisting of worksheets and the required materials), the teaching scenario evaluation form and teacher reflection form were compiled. In the next phase, the training scenario was implemented and the students' engagement was simultaneously recorded through collaborative learning activities and through the final work of art of students groups. A key indicator of students gained knowledge was the construction of the floating structure for the first grade groups and the achievement of designing geometric shapes as a result of coding Thymio for the fourth and fifth grade groups. The process was completed with the completion of the evaluation form of the educational material and reflection of the participating teachers. The present research was carried out after informing the schools headmaster about the goals, content, procedures of the educational scenario and its duration, while written consent was given. The teachers after being informed, expressed their desire to participate. A total of 51 students and 3 elementary school teachers took part.

To organize the activities of the STEAM scenario, the thematic units of the SWs and the curricula of mathematics, physics, arts and ICT were taken into account. The objectives of each discipline, inherent in STEAM, were analyzed to prepare the program according to the cognitive level and background of the students. The program was therefore included in the fourth thematic section “Creative-innovative thinking”, in the sub-theme “STEM-educational robotics” and addresses students of 1st, 4th, and 5th grade. Its implementation requires 11 and 9 teaching hours for the 1st grade and the 4th and 5th grades respectively.

The 1st grade students, motivated by their contact with suspended works of art, attempt to create their constructions, after being divided into working groups. For this purpose, they use building materials, Lego-style bricks, the Thymio robot, whose manipulation will cause real movement in the construction and any other material that the members of each group decide is needed based on the design they will carry out (Table 2).

Table 2. Educational Program 1st Grade

STEAM EDUCATIONAL PROGRAM 1ST GRADE CREATING A FLOATING STRUCTURE		
Stage	Workshop	Learning contents
1st stage Intrigue, generate curiosity (2 hours)	1st	Investigating the main features of Morgan, and Calder's floating artworks. Discussion of materials used in the creation of the works. Project to create a floating sculpture with Lego bricks and the robot Thymio as a driving force. The division into groups.
2st stage Design and data collection (4 hours)	2nd - 4th	Observation of suspended projects and planning on paper of each group's project. Getting to know the Thymio robot: Observing the external characteristics, and practicing with the pre-programmed behaviors.

		Emphasis on the behavior of the "obedient", the purple mode which allows it to move with a remote control or with the arrows on its top.
3st stage Construction, creation and completion (4 hours)	5th - 7th	Construction of a floating project with bricks, incorporating the robot into the construction. Control the movement of the artwork by running the robot and applying the purple mode. Improvement and completion of projects. Present the works to the whole class explaining how each group worked and indicating which artwork was a source of inspiration.
4st stage Reflection and diffusion (1 hour)	8th	Art exhibition. Reflection on the collaboration with the classmates but also the satisfaction with the final product.

4th and 5th grade students created their visual art pieces drawing inspiration from paintings by Kandinsky, Klee and Picasso. To achieve this they programed the Thymio robot to draw geometric shapes. Students worked in pairs for programming but had the option of expanding collaboration with other pairs to produce projects with a variety of geometric shapes. At the end, all students worked together and created a group art piece. The works of all classes were presented in an art exhibition at a special event and are posted on the school website (Table 3).

Table 3. Educational Program 4th and 5th Grade

STEAM EDUCATIONAL PROGRAM 4TH AND 5TH GRADE CREATING ABSTRACT, VISUAL WORKS USING THE THYMIO ROBOT		
Stage	Workshop	Learning contents
1st stage Intrigue, generate curiosity (2 hours)	1st	Investigation of structural elements in paintings by Kandinsky, Klee, and Picasso (Cubism). Discussion about the creators of the works and argument about the possibility of creating works of art using Technology and Robotics. The robot Thymio is a painter. Work in pairs of students.
2st stage Design and data collection (4 hours)	2nd - 4th	Connect the robot with a cable or USB stick to the computer and access the Thymio ASEBA visual programming environment. Program and design straight sections with a marker in the hole between the wheels, using the timer and motors. Determine the relationship between time and speed. Measure the length. Program and design angles using the timer and motors to find the best combination for 60, 90, and 120-degree angles. Measure angles with a protractor.

3st stage Construction, creation and completion (3 hours)	5th - 7th	Program and design triangles, squares, and polygons (each pair of students can draw one type of geometric shape, e.g. only squares). Create group projects and create a class project on meter paper. Coloring the shapes of each project using a variety of materials and means (brushes, sprays, markers...)
4st stage Reflection and diffusion (1 hour)	8th	Art exhibition. Reflection on the collaboration with the classmates but also the satisfaction with the final product.

The program was pilot implemented by three teachers and their classes consisted of 15 first graders, 22 fourth graders and 14 fifth graders from a rural area school in Kavala city in Greece. After its implementation it was evaluated by the 3 educators to gather feedback, through a teachers' evaluation and self-reflection paper form (Tables 4 & 5). The evaluation form consisted of 3 axes in terms of the theme of the scenario, the pedagogical approach and the educational material and was graded at three degrees, poor, satisfactory and very good.

The self-reflection form also consisted of three questions which were formulated as "I have followed the steps as suggested in the "Educational Activities" field|", "I asked for and had support in obstacles that I encountered that made my work difficult" and "Note down observations, suggestions for improvement, difficulties, thoughts that you think can contribute to improving the model" (Table 6). There was also a provision of free space for the brief formulation of the methods in the first two cases, and a 3-point scale was applied to determine the degree of the manifesting behavior (poor, satisfactory, and very good).

Table 4. Model evaluation in terms of its theme

The theme of the model	Poor (1)	Satisfactory (2)	Very good (3)
It is aligned with the syllabus			
It corresponds to the cognitive level of the students			
It corresponds to the proposed implementation time			
It is current, modern			
Comments			

Table 5. Model evaluation regarding the pedagogical approach of STEAM and group-centered teaching

The STEAM educational approach and team-centered teaching of the model	Poor (1)	Satisfactory (2)	Very good (3)
It is aligned with the syllabus			
It corresponds to the cognitive level of the students			
It corresponds to the proposed implementation time			
It is current, modern			
Comments			

Table 6. Teacher reflection

	Poor (1)	Satisfactory (2)	Very good (3)
I have followed the suggested steps. Briefly describe the method(s).			
I asked for and had support in obstacles that I encountered that made my work difficult. Briefly describe the method(s).			
Note down observations, suggestions for improvement, difficulties, thoughts that you think can contribute to improving the model.			

Step-by-step instructions for implementing Thymio robot activities in a classroom setting, particularly for the proposed STEAM program were provided. During the preparation step they gathered materials like Thymio robots, building supplies, and computers with Thymio programming software. After the class was set up, desks were arranged for collaboration, and a dedicated robot activity area was created.

The introduction to the Thymio robot step followed where students were introduced to the Thymio robot. Its features, applications in robotics and art, and programming capabilities were explained. A demonstration showcased turning on the robot, pre-programmed behaviors, and button experimentation. Next step was the activity planning, consisting of the group formation, the project brainstorming, and design discussion. Divided into small groups, students brainstormed project ideas like floating sculptures or geometric drawings. They sketched their visions and discussed material choices and robot integration. The adventure then shifted to programming. Students were motivated to connect the Thymio robots to computers and opened the ASEBA programming environment, in order to learn basic programming tasks like controlling movements and practiced following lines or avoiding obstacles. Finally, each group wrote a program for their project, enabling the Thymio robot to draw shapes or move as part of a sculpture. The building phase saw collaboration and creativity blossom as students constructed their projects using the chosen materials, seamlessly integrating the Thymio robot. Testing followed to ensure everything functioned as intended, with troubleshooting sessions ironing out any kinks.

Finally, it was presentation time! Each group proudly showcased their project, explaining the design process and the role of the Thymio. An art exhibition displayed their creations, inviting other classes and parents to witness their ingenuity. A reflection session solidified their learning, prompting discussions about robotics, art, collaboration, and how to improve for future endeavors. The project culminated in feedback collection. Students openly discussed their experience, while the teachers assessed projects based on creativity, functionality, teamwork, and presentation skills and noted their experience at the self-reflection form.

Results

This section details the findings of the study on designing a STEAM program for Skills Workshops (SWs) that emphasizes Art alongside Educational Robotics (ER).

The current implementation of SWs prioritizes technology and robotics, neglecting Art's role in STEAM education. This program addressed the gap by incorporating Art and ER

creatively within the STEAM framework of Bertrand and Namukasa (2022). The program catered to 1st, 4th, and 5th graders, aligning with the SWs' thematic units and curriculum objectives. It leveraged the four-stage STEAM model by Bertrand and Namukasa (intrigue design & data collection, construction & completion, reflection & diffusion). Students of 1st Grade created floating sculptures with Lego bricks and the Thymio robot, inspired by renowned artists like Alexander Calder. Students of 4th & 5th Grades drew inspiration from Kandinsky, Klee, and Picasso to create abstract art pieces. They programed the Thymio robot to draw geometric shapes and collaborate to produce a group artwork (Figure 1 & 2). The program culminated in an art exhibition showcasing student creations and was further disseminated on the school website.

Figure 1. Students' engagement snapshots

Data collected from evaluation and self-reflection form evaluation offered insight to the relevance of the models theme, the educational approach. Participating teachers admitted that the model outlined in the syllabus, ensuring focused and relevant learning experiences and that the activities catered to the appropriate students' cognitive level. Furthermore they underlined the fact that it was effectively implemented within the allocated timeframe, allowing for proper execution and student engagement. Teachers agreed that the model utilized up-to-date concepts, resources, and approaches, keeping students connected with contemporary practices and trends. In terms of the pedagogical approach of STEAM, it seamlessly integrated with the syllabus content, fostering interdisciplinary connections and collaborative learning. The model leveraged group work efficiently within the timeframe, promoting interaction and knowledge sharing. During their self-reflection the educators recorded they followed suggested steps, so that the implementation adhered to the recommended sequence of activities and instructional strategies, ensuring a well-structured learning experience. They sought support from researchers when encountering difficulties, crucial fact that demonstrated a commitment to overcoming challenges and improving the learning experience. Its significance cannot be overlooked as it demonstrated the successful integration of Art and ER within SWs, fostering a more balanced STEAM approach. It encouraged creativity, collaboration, and problem-solving skills in students throughout elementary grades during the engagement with the incorporating activities in order to complete the suggested task, the creation of art, as teachers observed at the self-reflection form.

Overall, this research highlighted the potential of STEAM education with a strong emphasis on Art and ER to enhance learning experiences and develop essential skills in primary school students.

Discussion

The findings from the implementation of the STEAM program integrating the Thymio robot reveal significant insights into the potential of this interdisciplinary approach in primary education. The positive reception from both students- as their broad-based participation and involvement in all program activities was perceived- and educators- as recorded at the evaluation and self-reflection form, highlights the effectiveness of combining art with

educational robotics, fostering a balanced STEAM curriculum that enhances creativity, collaboration, and critical thinking skills.

The pilot program demonstrated that students engaged deeply with both the artistic and technological aspects of their projects taking into account that the robotic art products were created. By creating artworks using the Thymio robot, students not only learned programming and robotics but also explored their creative capacities. This dual engagement aligns with current educational theories advocating for a holistic approach to learning, where cognitive and emotional development are intertwined (Manera, 2019; Damaševičius et al., 2018).

Plan teaching based on the STEAM educational approach is a new fact for Greek, public education, which is increasingly gaining ground and at the same time is facilitated thanks to the establishment of SWs. Of course, individual attempts to apply STEM, which are not widespread in schools, have been noted for a decade, but they are shown and encouraged, because they incorporate ER. Teachers need training on STEAM education frameworks and integrating Art and ER into their lessons. The provided program can be a starting point for educators to design similar activities for their classrooms. Thus, emphasis should be on using robots as tools for creative expression alongside technical skills development.

However, the vast majority of public schools do not have equipment for robotics activities. The instructional design, which is based on scientific evidence, is modern and adapted to the data of the Greek school classroom, is admittedly of decisive importance for public, formal education. The didactic proposal that was attempted is compatible with the above criteria, given that it includes affordable equipment. Even educational robotics equipment presents low procurement and maintenance costs, as well as unlimited possibilities of utilization by all age groups of primary education (Mondada et al., 2017; Shin et al., 2014). At the same time, the STEAM educational approach with the integration of art unites the disciplines in a wider field of application (Henriksen et al., 2016), attracting all students even those who may feel insecure about the sciences and mathematics. Schools must ensure access to necessary resources, including educational robots and art supplies. Budgetary considerations should reflect the importance of STEAM education, allowing for the procurement of diverse materials that support innovative projects. At the same time schools should prioritize the integration of arts within STEM curricula to create a more cohesive STEAM framework. This can involve developing interdisciplinary projects that allow students to explore concepts across multiple subjects.

Policymakers should consider supporting STEAM education initiatives and providing resources for teachers to implement them effectively. Funding for professional development programs on integrating Art and ER into SWs would be beneficial. In addition, accessibility of educational robots like Thymio needs to be addressed to ensure wider implementation. Further exploration of integrating other art forms like music, dance, and literature into STEAM programs with robotics would be valuable. By addressing the educational needs and providing necessary support, educators and policymakers can make STEAM education a reality in classrooms.

Patently practical challenges may arouse. Implementing a STEAM program that integrates the Thymio robot across various types of schools can present several technical and logistical challenges. Addressing these challenges is essential for ensuring the program's success and sustainability. Many schools, particularly those in underfunded areas, may lack the necessary technology infrastructure, including computers and educational robots. The establishment of partnerships with local businesses, universities, or non-profit organizations to secure donations or sponsorships for technology resources or the application for grants specifically aimed at enhancing STEM education may constitute viable solutions. Educators may not be familiar with programming or using robotics in the classroom, leading to hesitation in implementing the program. Training workshops focused on both the technical aspects of the Thymio robot and pedagogical strategies for integrating it into the curriculum or even

implementation of mentorship program where more experienced teachers can support their colleagues in using the technology effectively offer practical overcoming of the obstacle.

Logistical challenges may concern time constraints, as teachers often face tight schedules, making it difficult to allocate sufficient time for STEAM projects that require in-depth exploration and classroom space limitations because not all classrooms are equipped to handle group activities involving robotics, particularly if space is limited. Flexible scheduling within the school day to allow for extended project time like block scheduling or dedicated STEAM days might be interesting ideas. About space limitations, outdoor learning, when appropriate, for certain activities, especially those involving movement and exploration and utilization of common areas such as libraries or computer labs for STEAM activities, could allow for more room to collaborate and create.

By proactively addressing these technical and logistical challenges, schools can create a more effective and sustainable STEAM program that integrates the Thymio robot. With the right resources, training, and support, educators can overcome barriers and provide students with enriching learning experiences that prepare them for the future.

In conclusion, it is generally accepted that teaching practice is not carried out smoothly. However, ER combined with STEAM facilitates the modernization of teaching and learning while aligning with global technological progress and school reality (Karypi, 2018). Art, whose birth coincides with human existence, contributes to the authentic and attractive teaching of Sciences (Braund & Reiss, 2019). The fusion of these elements may provide instructional designs that are flexible, adaptable, contemporary, applicable and effective. The integration of art and ER through the Thymio robot not only enriches the learning experience but also prepares students for the complexities of the modern world. By addressing the outlined implications for practice, policy, and research, educators can foster a more inclusive and effective STEAM educational environment.

Limitations

This pilot study presents several limitations that should be taken into account. Firstly, the generalizability of findings is restricted due to the small pool of participants. Secondly, the scope of implementation was focused on data emerging from the teachers' point of view rather than the students. Student engagement was evaluated primarily based on the final outcomes of each group's project, specifically whether they successfully constructed their floating sculpture or designed a geometric shape with the robot. For future iterations, it is advisable to incorporate a comprehensive evaluation tool for the educational materials that is directed towards the students, rather than solely focusing on the teachers as was the case in the current application. Additionally, this evaluation should assess the students' acquired knowledge to further reinforce the findings. Each of these limitations suggests areas for further research.

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Outcome-based assessment vocational education: Conceptual model and an application example

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Abstract

This paper presented a comprehensive and adaptive outcome-based assessment model for vocational education, addressing the need for industry-aligned, flexible, and integrative assessment practices. The model's components ensure a holistic approach to evaluating both technical and soft skills in technical vocational education and training programs. It is outlined in detail the conceptual author's model with its five interconnected elements as well as the whole implementation process. Follows the discussion of the challenges in implementing the model, its strength and implications for vacational education practices. The model is shown in an exemplary application in student profile "computer science and technology" demonstrating the potential for enhancing the relevance and effectiveness of vocational education. It offers a framework for aligning educational outcomes with industry needs, potentially improving graduate employability and workforce readiness.

Keywords: outcome-based assessment, VET, employability, industry need.

Introduction

Outcome-based assessment has become a critical methodology in the evaluation of education, moving the focus from inputs to outputs in learning. This model, with origins in Spady's (1994) work, stresses the necessity of establishing clear, observable, and quantifiable learning outcomes. In recent times, outcome-based assessment has gained momentum across educational areas as institutions and policy creators acknowledge its capacity to connect educational aims with societal and industrial requirements (Biggs & Tang, 2011). This approach denotes a considerable shift from conventional assessment techniques, prioritizing the demonstration of abilities and competencies over pure knowledge gain.

The value of outcome-based assessment in vocational learning cannot be praised unconditionally. As highlighted by Winther and Klotz (2013), vocational education and training (VET) frameworks globally are progressing toward this method to enhance student preparedness for the needs of the contemporary job market. Outcome-focused assessment in vocational schooling ensures learners cultivate practical, industry-applicable competencies directly relevant to their selected domains. Additionally, it enables a more transparent and accountable educational procedure, granting stakeholders like employers and policy creators the capacity to plainly comprehend and appraise graduates' capabilities (Mulder, 2017). This synchronizing of learning outcomes and industry demands is integral in tackling the skills deficit frequently seen in rapidly developing technical arenas.

This paper puts forth a conceptual framework for executing outcome-based evaluation in vocational learning, with particular attention to technical and vocational education and training (TVET). Further, it offers a practical example in computer science and technology, exhibiting the model's applicability in a modern vocational setting. The structure of this paper incorporates an exhaustive literature review, succeeded by a thorough delineation of the suggested conceptual model, encompassing a visual depiction. Next, an implementation instance in TVET computer science and technology is presented, followed by a discourse on the model's advantages, plausible limitations, and inferences for vocational education practice. Finally, the paper summarizes critical results and recommendations for future research pathways.

Literature Review

Outcome-Based Education: Definition and Principles

Outcome-based education (OBE) is an instructional methodology centered on clearly delineated, quantifiable learning objectives. Spady (1994), a pioneer in this domain, characterized OBE as an integrated approach to structuring and managing an educational framework aimed at the effective realization of end goals by all learners at the conclusion of their academic journey. Salient attributes of OBE encompass precisely expressed learning outcomes, an adaptable curriculum, and continuous assessment and feedback. Historically, OBE is rooted in the 1950s with the advent of pedagogical goals, but truly assumed form in the 1980s and 1990s. Its advancement was driven by the need for enhanced accountability in schooling and superior synchronization between academia and job market requirements. Killen (2000) underlines that OBE is evolving from an emphasis on instructional content to what students can practically apply with their knowledge and abilities post-graduation. Recent scientific articles proposing various models for OBE are: for higher education (Nguyen et al, 2020; Xu, 2020); model with the integration of artificial intelligence for application in higher education (Prihantoro, 2023); model for English teaching classes (Rahayu et al, 2021); model of development of a OBL-assessment application for vocational high school (Universitas et al, 2023); curriculum formation and evaluation in OBE (Japee & Oza, 2021);

Assessment in Vocational Education

Traditional evaluation techniques in vocational schooling are often based on gauging theoretical understanding through written examinations and standardized testing. However, these methods were limited in appraising practical abilities and competencies integral to vocational settings (Mulder et al., 2007). Assessment in OBE must be in confruence with competency-based approaches as frequently used to evaluate learning outcomes in technical and vocational education (Yusop et al, 2022). Lavanya et al. (2020) proposed model for assessment tool to measure student skill, and knowledge in OBL. The shift toward competency-based assessment denotes a major transformation in vocational education. As elucidated by Wesselink et al. (2010), this approach focuses on analyzing students' capacity to integrate knowledge, skills, and mindsets in the execution of professional tasks. Competency-based assessment incorporates methods such as practice simulations, portfolios, and workplace evaluations. These techniques enable assessors to obtain a more comprehensive perspective of a learner's competence in realistic occupational situations. Moreover, this approach facilitates enhanced cohesion between education, assessment, and labor market demands, culminating in better-equipped graduates (Biemans et al., 2009). Finally, the shift to competency-based assessment in vocational education allows for more holistic and authentic evaluation of students' occupational abilities, better alignment with workplace demands, and increased accountability in preparing *work-ready* graduates.

Current Practices in TVET

Global tendencies in TVET exhibit an expanding emphasis on outcome-oriented approaches. UNESCO-UNEVOC (2014) documents a developing consensus on the significance of harmonizing TVET curricula with industry requirements and cultivating transferrable abilities. There is also a drift toward more flexible learning avenues and acknowledgment of previously attained competencies. Concrete instances from various nations highlight these inclinations. In Germany, the dual framework, combining classroom education with on-the-job training, has integrated outcome-focused principles to reinforce industry pertinence (Deissinger, 2015). Australia has actualized a comprehensive competency-based training (CBT) model in its TVET domain, linking industry benchmarks to learning objectives and assessment criteria (Wheelahan, 2016). In Singapore, the SkillsFuture effort has stressed lifelong learning and evolution of future-proof capabilities, with a robust emphasis on quantifiable outcomes and industry relevance (Tan, 2017). Overall, TVET systems worldwide are increasingly

adopting outcome-based approaches to strengthen industry alignment, develop transferable skills, allow for flexible pathways, and ensure programs are equipping students with the relevant competencies demanded by the modern workplace.

Challenges in Implementing Outcome-Based Assessment

The implementation of outcome-based assessment in TVET has multiple challenges. Institutional barriers often include rigid organizational structures and resistance to change, which limits the flexibility needed for effective outcome-based practices (Klein & Wikan, 2019). Teacher preparation poses another challenge, as many may not be adequately trained in outcome-based assessment methods or have difficulty with the paradigm shift (Barman & Konwar, 2011). Moreover, implementing outcome-based assessment often requires significant resources for curriculum development, teacher training and the creation of authentic assessment environments. Limited financial resources and infrastructure can hinder full implementation, especially in developing countries or underfunded institutions (Cheng, 2015). While outcome-based assessment can improve the relevance and quality of TVET, systemic barriers related to inflexible institutions, teacher readiness, and resource constraints are the limitations of the effective implementation and sustainability of this approach.

Conceptual Model for Outcome-Based Assessment in Vocational Education

Description of the Model Components

The suggested conceptual framework for outcome-based assessment in vocational education encompasses **five interconnected elements**:

1. Definition of Learning Outcomes: This element entails precisely articulating the knowledge, abilities, and competencies students need to exhibit upon finishing a program or course. As stated by Biggs and Tang (2011), these outcomes should be specific, quantifiable, achievable, applicable, and time constrained.
2. Assessment Design: This element focuses on constructing evaluation approaches directly aligned with the defined learning objectives. It involves selecting suitable assessment tools such as practical projects, simulations, and workplace-based tests (Gulikers et al., 2004).
3. Performance Criteria: These are precise, observable benchmarks that delineate levels of achievement per learning outcome. Performance criteria enable objective grading and consistency in evaluation (Sadler, 2005).
4. Feedback Systems: This element includes developing mechanisms to provide students with prompt, contextualized, and constructive feedback. Effective feedback is imperative for student learning and progress (Hattie and Timperley, 2007).
5. Continuous Improvement: This element ascertains the framework stays adaptive. It requires routinely garnering and examining assessment data to enhance curriculum, pedagogy, and evaluation approaches (Education Development Center, 2019).

Visual Representation (Diagram/Drawing)

The diagram shows a circular cycle connecting the five components: Learning outcome definition, Assessment design, Performance criteria, Feedback mechanisms, and Continuous improvement loop. Arrows indicate the flow and interconnection between components.

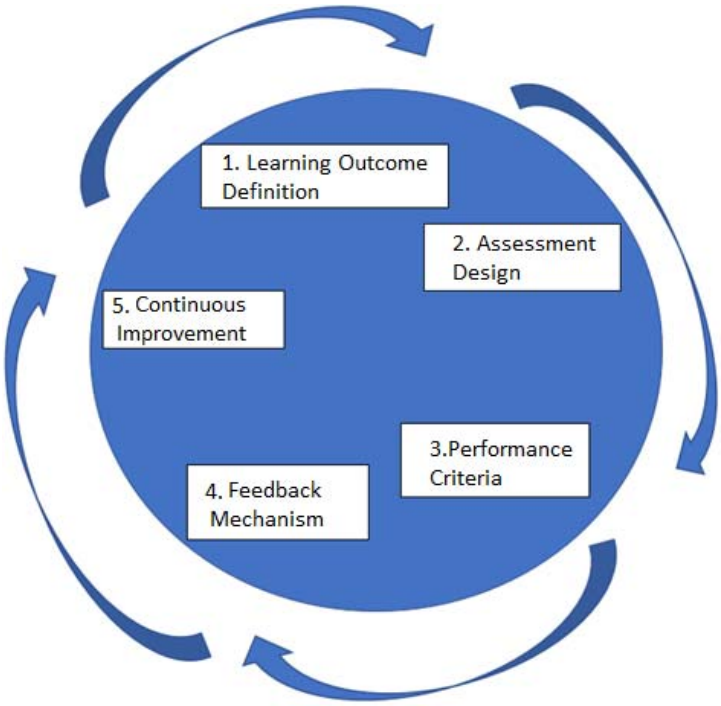

Figure 1: Conceptual Model for Outcome-Based Assessment in Vocational Education
Author' s source

Explanation of How the Model Addresses Vocational Education Needs

Alignment With Industry Requirements

The suggested model directly confronts the imperative necessity of harmonizing vocational education with industry requirements. By first clearly delineating learning outcomes, the framework guarantees these are directly associated with professional competencies. As Wesselink et al. (2010) highlight, this synchronization is integral to bridging the divide between academia and actual practice. Additionally, the assessment design element enables creating authentic evaluative activities emulating real-life situations, while performance benchmarks can be cultivated in partnership with industry specialists to ensure applicability and currency.

Flexibility for Different Vocational Fields

The model's versatility makes it pertinent across an extensive scope of vocational areas. All constituents can be re-organized to the distinct requirements of various industry sectors and occupations. For example, learning goals and performance benchmarks can be modified to represent the specialized competencies needed in diverse realms like engineering, healthcare, or culinary arts. Such adaptability is vital in the continuously changing vocational education landscape, as stressed by Mulder (2017) in his analysis of competence-based vocational preparation. The framework allows for calibration to prepare students for evolving skill demands within their respective fields.

Integration of Practical and Theoretical Assessment

The model facilitates a balanced integration of practical and theoretical assessment, a crucial aspect of vocational education. The assessment design component allows for the incorporation of methods that evaluate both theoretical knowledge and practical skills. This could include written exams to assess conceptual understanding, alongside practical projects, or work-based assessments to measure skill application. As Baartman et al. (2006) argue, this integrated approach is essential for developing competent professionals who can apply theoretical knowledge in practical contexts. Moreover, the model's feedback mechanisms

allow students to receive guidance on both aspects of their learning, fostering a comprehensive development of their vocational competencies.

Application Example: Outcome-Based Assessment in TVET Computer Science and Technology

Context: Specific TVET Program or Course

This example applies the model to a two-year technical and vocational education program in Computer Science and Technology. The program is intended to equip learners for entry-level software development and IT support roles. It integrates theoretical classroom teaching with practical lab work and industry internships. The target cohort comprises high school graduates between 18-25 years old, possessing fundamental computer skills and aspiring towards a career in the IT sector. The curriculum is designed to accommodate academically oriented and practical, skills-focused students. Overall, the program aims to fulfill the rising need for qualified IT experts across various industries like finance, healthcare, and e-commerce.

Learning Outcomes for the Selected Program/Course

Technical skills outcomes: Upon completion of the program, students will be able to:

1. Design and develop software applications using current programming languages (e.g., Java, Python, C++).
2. Implement and manage database systems using SQL and NoSQL technologies.
3. Configure and maintain computer networks and security systems.
4. Develop responsive web applications using HTML5, CSS3, and JavaScript frameworks.
5. Apply version control and collaborative development practices using tools like Git.

Soft skills outcomes: Graduates of the program will demonstrate the ability to:

1. Communicate technical concepts effectively to both technical and non-technical audiences.
2. Work collaboratively in diverse teams to complete complex projects.
3. Apply critical thinking and problem-solving skills to troubleshoot software and hardware issues.
4. Manage time and resources efficiently to meet project deadlines.
5. Adapt to innovative technologies and methodologies through self-directed learning.
6. Adhere to ethical standards and professional practices in the IT industry.

Assessment Methods Aligned with Outcomes

Practical Projects: Students will complete a series of hands-on projects that mirror real-world scenarios. These include:

1. Developing a full-stack web application for a simulated client.
2. Creating a mobile app with cross-platform functionality.
3. Implementing a secure network infrastructure for a small business.

Projects would be assessed using rubrics that evaluate both technical proficiency and project management skills. Peer reviews will be integrated to enhance collaborative learning.

Theoretical examinations: Written and online exams will assess students' understanding of core concepts and theories. These will include:

1. Multiple-choice questions to evaluate breadth of knowledge.
2. Short-answer questions to evaluate depth of understanding.
3. Case studies to assess analytical and problem-solving skills.

Exams will be designed to test not only recall but also application of knowledge to realistic scenarios.

Industry-based assessments: To ensure alignment with industry standards, the program will incorporate:

1. Internship evaluations by industry supervisors.
2. Industry certification exams (e.g., CompTIA, Cisco, Microsoft).
3. Capstone projects evaluated by a panel of industry experts.

These assessments will provide external validation of students' skills and enhance their employability.

Implementation Process

Curriculum Mapping

Implementation starts with thorough curriculum mapping, aligning learning outcomes to specific courses and assessments. This approach guarantees all outcomes are appropriately embedded and evaluated within the program. Mapping involves cooperation between faculty, industry advisors, and curriculum experts to ensure harmony with both academic principles and workplace needs.

Assessor Training

Faculty and industry partners partaking in evaluation undergo rigorous training. This approach encompasses workshops on outcome-based assessment concepts, rubric building, and constructive feedback. Regular calibration meetings held to ensure reliable grading between assessors.

Student Orientation

At program onset, students become familiar with the outcome-based methodology. They receive comprehensive details on learning objectives, assessment formats, and expectations. Regular feedback sessions are organized to help students track their progress in achieving the defined outcomes.

Evaluation of the Application

Success indicators (of career readiness):

1. High percentage of students achieving targeted outcomes.
2. Positive feedback from industry partners on graduate competencies.
3. Increased employability rates of graduates.
4. Entrepreneurship rates measure (the number of graduates who start their own businesses); needs a system for after-graduation student's career track.
5. Progression Rates: The percentage of students who advance to university needs a system for after-graduation student's career track.
6. Level of mastery of *Technical Skills* (assessment of students' proficiency in specific technical skills required for their field); of *Soft Skills* (evaluation of students' communication, problem-solving, teamwork); of *Transferable Skills* (assessment of students' ability to apply learned skills to new situations and contexts).

Areas for improvement:

1. Continuous updating of outcomes to match rapidly evolving industry needs
2. Enhanced integration of soft skills assessment across all courses

Discussion

Strengths of the Proposed Model

The suggested outcome-oriented assessment framework shows considerable strength in meeting the intricate requirements of vocational education programs. Its extensive scope guarantees that all facets of vocational learning, from hard skills to soft competencies, are appropriately covered and gauged. The model provides a comprehensive approach to nurturing and evaluating abilities via its structure of well-defined learning goals, aligned

evaluations, and continuous betterment mechanisms. Additionally, its adaptability across technical areas is an invaluable asset, enabling customization for diverse vocational sectors. Such versatility ensures the model remains applicable and potent across various industries, from conventional trades to emerging technological realms (Billett, 2011; Wesselink et al., 2017). The framework is organized to address the multifaceted and evolving needs of the 21st century employment landscape.

Potential Challenges in Implementation

Despite its merits, applying this model may encounter notable obstacles. Resource needs are a major issue, as creating authentic, industry-aligned evaluations and preparing assessors can require substantial investments. Many institutions may find difficulty meeting the financial and time commitments for comprehensive implementation (Cheng, 2015). Furthermore, obtaining stakeholder support poses another roadblock. Opposition to change from educators habituated to conventional assessments, alongside skepticism from industry partners unaccustomed to outcome-centric approaches, may hinder adoption. Surmounting these challenges necessitates clearly conveying the model's advantages and a graduated implementation plan to regulate resource distribution and manage stakeholder outlooks (Mulder, 2017). A thoughtful management strategy can help address reservations and highlight the framework's far-reaching benefits.

Implications for Vocational Education Practice

Implementing this model bears broad ramifications for vocational education practices. It compels a fundamental shift towards learner-centric, competency-driven teaching and evaluation. Such realignment can strengthen the concordance between academic preparations and industry requirements, potentially elevating graduate employability and overall technical education efficacy (Billet, 2011). The framework prompts a re-envisioning of conventional TVET approaches to address the contemporary abilities sought by employers. Its widespread adoption promises to bolster both individual and systemic career readiness in an evolving economy. Innovations in the field of education have been born out of the development of modern society and the technological revolution. Revolution 4.0 has brought more products and services based on robotics, artificial intelligence, the Internet of Things (IoT) and big databases into everyday life. It is assumed broadly that today's students will work in occupations that do not yet exist. Future professions require new knowledge and competences, which should be provided to learners through an innovative approach in education, to promote the acquisition of different competences and creative thinking. In recent years, educational institutions have gradually begun to implement various activities to respond to these changes. For example, new pedagogical models are introduced (in the form of an individual approach to learning, flexibility of learning content, online and blended learning, use of information and communication technologies in the learning process, project-based learning, i.e. learning by doing, formative assessment and etc.), change in the educational environment (use of different spaces of the building as an environment for conducting an educational process), active involvement of parents in the educational process; leadership of the director, aimed at the development of the educational institution and pedagogical specialists; introduction of the teacher as a mentor in the learning process, etc. It is necessary to continue the activities to achieve intelligent education, in view of the interests of modern students and technological progress. Intelligent learning environments could provide just-in-time learning that is based on the broad capabilities and levels of adaptation and greater specification of student learning conditions (Tham&Verhulsdonck, 2023). In a narrower sense, smart learning can be comprehended as the personalization of learning, not only anytime, but everywhere, by applying the tools of artificial intelligence and considering the individual learning style of students. The role of smart education nowadays is to support learners in the 21st century to meet and successfully cope with the challenges of a digitalized

society, including developing the ability to solve problems. The innovation of the modern education system is also related to the processes of globalization, which have an impact on the need to acquire a set of competencies for quick adaptation to the labor market, in which creative and flexible thinking is a prerequisite for successful implementation. *The main goal* of modern education is to prepare specialists who are competent in various fields and can skillfully use different professional tools and constructively interact with each other. Using innovation, modern schools can promote not only student satisfaction with the learning process, but also support their social and mental development.

Therefore, the search for suitable adaptive and innovative means (models, systems) of assessing learning outcomes should also be prioritized. Especially regarding vocational training and education and the assessment of competences and skills practical manual creativity creative attitudes. This perspective is encouraging and desirable the development and improvement of methodologies for truthful assessment of the above mentioned.

This paper presented a comprehensive outcome-based assessment model for vocational education, addressing the need for industry-aligned, flexible, and integrative assessment practices. The model's components ensure an integrated approach to evaluating both technical and soft skills in TVET programs. The proposed model and its application in computer science and technology demonstrate the potential for enhancing the relevance and effectiveness of vocational education. It offers a framework for aligning educational outcomes with industry needs, potentially improving graduate employability and workforce readiness. Further research should focus on longitudinal studies of model implementation, cross-sector adaptability, and the impact on long-term career outcomes for graduates.

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Educational excursions at home and abroad. Opinions of teachers of secondary schools of Eastern Attica

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Abstract

Educational excursions are part of experiential learning and act as an aid to the educational process. Their presence offers multi-level benefits to the educational community. This paper, based on the reference to learning and the benefits of experiential learning, aims at an ad hoc investigation of the advantages of educational excursions, both at home and abroad. The positive results of the excursions are recorded and their added value to the educational community (teachers and students) is presented. At the same time, difficulties and problems in their implementation are identified and, in conclusion, proposals are made for more successful and safer educational excursions. The paper presents the results of the research in relation to benefits-difficulties-suggestions, which was conducted in the school year 2023-2024 in a sample of 95 secondary school teachers (high school) of schools in Eastern Attica.

Key words: learning, experiential learning, extracurricular learning, domestic and international field trip

Introduction

The process of learning is personal and individual in character and involves processes that take place in the life of the individual, both at the biological and the spiritual level (Bigge, 1990). As a human intellectual process, it is an outcome of many evolutionary stages, which are a long-standing field of study of different sciences. Scientists have formulated evolutionarily numerous theories regarding the stages/levels and ways/begins of learning (Flouris, 2005). Recent studies have contributed to the value of collaborative and experiential learning in the educational process and the connection of new knowledge with previous experiences (Foskett & Lumby, 2003).

Experiential learning refers to the learning that results from experience and from the links between school life and students' social life and social reality (Kamarinou, 1998). The value of experiential learning was first perceived by Dewey (Dewey, 1938), who articulated the view that all genuine forms of education are born out of experience. Furthermore, Piaget also pointed out the process of interaction between the person and the environment. The modern school as it is called to transform traditional learning practices and open to society aspires to adopt educational institutions and activities that foster collaborative and experiential teaching process (Al Kadri et al, 2019).

The presence of field trips acts in the upper context and is interconnected with experiential learning, which takes place in and out of the school environment (Waite, 2011). Moreover, educational field trips, both domestic and international, are part of outdoor learning, contain numerous benefits and aim to learn through experience. For all these reasons, their planning and implementation requires methodicalness and overall coordination (Kafetzis, 2010).

The purpose of this research is to examine the contribution of educational excursions, both domestic and international, to the educational reality, to record the views of secondary school teachers regarding their benefits in the overall learning process and to identify difficulties and points towards their more successful and safer realization.

Theoretical framework

omestic & international study tour

In the present study, the typology of domestic and international educational excursions is the object of study. In table 1 a thorough classification of lyceum excursions is presented.

The category of domestic educational excursions includes either day trips or multi-day trips. Daily or multi-day domestic activities include school walks, educational/teaching visits, excursions, educational trips of pupils, trips in the context of sports activities, participation in conferences/conferences, as well as in the Greek Parliament. Multi-day actions of up to seven (7) days include trips which include a stay of more than one day and which are carried out by pupils in the last year of the last grade of General High Schools (G.L.L.). The participation of 70% of the number of students in the class is a prerequisite for a multi-day trip.

The category of multi-day educational trips abroad includes many categories of trips, which take place in the context of European and international activities. These include educational exchanges following transnational cooperation agreements/ memoranda of understanding, twinning, educational programmes of the General Secretariat for Religious Affairs, European activities/programmes carried out under the Erasmus European programme, programmes of international organisations, participation in international meetings, conferences, workshops, competitions, student science olympiads and other international events, invitations to schools, awards with a trip abroad following participation in competitions and other international events.

Table.1 Lyceum Excursion Classification

Class	Type of Tours	Duration	Usual Destinations	Location
A' Lyceum	One-day or two-day educational excursions, visits to museums, environmental centres, historical sites. In addition, school walks, educational trips for pupils, trips in the context of sports activities, participation in] workshops/conferences, as well as in the Greek Parliament.	Up to 2 days	Museums (e.g. Archaeological Museum of Athens), Delphi, Epidaurus, Centre for Environmental Education in Cleitoria.	Domestic excursions
B' Lyceum	Multi-day excursions (3-4 days), with an emphasis on history, culture and environmental education.	3-4 days	Historical cities (e.g. Thessaloniki, Ioannina), mountainous areas (e.g. Karpenisi, Trikala, Corinthia).	Excursions domestic & international
C' Lyceum	Multi-day excursions which take place in the framework of European and international actions (educational exchanges following transnational agreements/cooperation memoranda, twinning, educational programmes, European activities/programmes carried	5-7 days	Major cities in Greece (e.g. Athens, Patras, Rethymno) or abroad (e.g. Rome, Paris, Vienna, Barcelona).	Excursions domestic & international

	out in the framework of the Erasmus European programme, programmes of international organisations, participation in international meetings, conferences, workshops, competitions, student science olympiads, etc. and other international events, invitations to schools, awards with a trip abroad after participation in a competition procedure approved by the Ministry of Education and Culture, pilot projects of international school networks approved or coordinated by the Ministry of Education and Culture, visits to research centres, educational institutions, universities, cultural centres, visits to European institutions/international organisations after a relevant invitation and acceptance of any request from the international organization for participation in International School Sports Activities and Games).		

Institutional framework in Greek education

The educational excursions are included in the Government Gazette 456 T.B/13.02.2020 (New Ministerial Decision on Excursions 20883-GD4) entitled: Excursions-Educational visits and travels of students of public and private secondary schools within and outside the country. All categories of visits are included in the Official Journal, article by article. At the same time, the same GSC sets out in detail the conditions for travel, the detailed organisation/processing and the approval procedure, depending on the type of travel, either by the teachers' association of the school unit or by the respective Secondary Education Directorate.

Organisation/targeting

The implementation of field trips requires both direct and indirect links to the curriculum (Bartkus, 2012). Their realization takes place after a specific planning, which includes delimited stages: First: integration into the current institutional framework and their target-oriented organisation based on a horizontal, annual educational planning. Second: implementation in stages on the basis of the current framework, with preparation of study material prior to the visit and on-site evaluation. Ad hoc use of the data for exploitation and highlighting their specific characteristics as ancillary educational elements. Thirdly: a general accountancy dimension by examining their immediate benefits and capturing their long-term added value (Fykaris, 2004).

In addition, the creation of successful conditions for their successful and safe conduct plays a catalytic role in their implementation. Meeting the conditions of safety is a prerequisite which is achieved at several stages of implementation: the choice of suitable means of transport, the choice of a destination which is in line with the needs and requirements of the educational unit to which it is directed, the adaptation of the programme to the circumstances and the consideration of the specific characteristics of the pupils. In general, safety is seen as a primary element and guarantee of both immediate success and future repetition (Kibble, 2013).

The importance of educational excursions-Review of existing literature

Value added/Benefits

In the aforementioned Government Gazette 456 T.B/13.02.2020 (New Ministerial Decision on Excursions 20883-GD4), it is noted in the preface that educational excursions are a necessary complement to the education of students, as through their implementation they provide the opportunity to learn about the achievements of man in the long-term course of civilization and to cultivate their sociality. In addition, it is noted that for this purpose, areas of particular educational value (cultural, archaeological, historical, ecological) are selected, while it is considered necessary to provide pupils with prior information and information about the place they are going to visit, in order to ensure the use of previous knowledge and the acquisition of the richest possible experiences.

In this study, the benefits of educational excursions are categorized in two ways: a. the benefits at the individual student level and b. the benefits to the school community.

In relation to the first benefit, during field trips, many benefits are recorded for students: observation is activated, communication and interaction is fostered, positive attitudes towards science and critical thinking through the search for information and harvesting of new experiences and self-activity are cultivated (Broh, 2002). New learning is developed through curiosity, discovery, cooperative team teaching and learning interaction, elements that more successfully consolidate new knowledge (Seow & Pan, 2014). Particularly for secondary education (high schools), their implementation is an ideal opportunity to relieve the already burdened teaching schedule.

All the aforementioned benefits students multiply and contribute catalytically to strengthening their academic performance and preventing undesirable behaviours (Feldman & Matjasko, 2005).

In relation to the second benefit, through the educational excursions, the opening to the local and wider economic and cultural society is made tangible. Through the interconnection with society, their acquaintance with people who are active in it and the resulting experience, pupils become aware that they are part of a wider and universal community, which multiplies the pedagogical and teaching benefits. By activating these processes they are more successfully guided into new learning, develop empathy and gain useful social skills that follow them into later adult life (Lunenburg, 2010).

Implementation problems

The realisation of educational excursions involves at the same time difficulties of implementation, both before and during their realisation. The present study will illustrate the difficulties in connection with their realization in secondary education. The following are identified as negative elements before their implementation: Insufficient planning, lack of organization and unsuccessful preparation are elements that dynamite the implementation. This result is led to by teachers who, due to lack of time because of the workload (especially in high schools), unsuccessful connection with the target setting and study of the curriculum, proceed to poor assessment and inadequate planning (Koulouri-Adtonopoulou & Kassaris, 1988). The catalytic elements of failure during realization also include the lack of investigation

of educational needs in relation to the requirements of the school unit's student population. Finally, the negative elements include the lack of security, which can dynamize the outcome and become a fully destabilizing element.

In addition, the literature identifies the short duration of excursions as a serious disadvantage. This disadvantage results in a continuity gap and fragmentation in learning (DeWitt & Storksdieck, 2008).

Suggestions for improvement

At the opposite end of the implementation problems are the suggestions for successful field trips. These include adequate preparation and organisation, investigation of the specific educational needs and requirements of the student population, as well as the creation of safety conditions that guarantee successful realisation. Especially for high schools, early planning at the beginning of the school year, implementation of multi-day (five-day) events in the middle of the school year can guarantee a successful outcome.

Finally, the disadvantage of their short duration and fragmentation of their performance can be prevented by two approaches: according to the first approach, each educational excursion can be organized with a target, which falls organically into the curriculum and at the end there should be utilization and extension of the experiences (Meadows, 2019). According to the second approach, educational excursions can be integrated into a single, horizontal educational programme, which is implemented in phases, includes several visits and is embedded in a corollary. In this case are necessary preparation throughout the year, good planning and broader coordination of the many faculty members involved (Coulangeon, 2018).

Methodology

The quantitative method was chosen for this small-scale survey, as it allows the researcher to collect quantitative data from a large sample of respondents at the same time, while providing the possibility of presenting the results in a grouped way, highlighting trends. A questionnaire was provided for investigation. The survey was conducted during the period 01.11.2023-31.05.2024 on a sample of 95 secondary school teachers (3 high schools-3 high schools) in Eastern Attica, who have organized and participated in more than two educational excursions per year.

The questionnaire used for the present study was tested for reliability and validity after conducting a pilot study on a limited numerical sample. The questions included in it were:

1.Gender

Man
Woman

2. Years of experience in secondary education

0-5
6-10
11-15
16 +
More

3. Education level

High School
Lyceum

4. Please indicate your level of disagreement/agreement with the following statements concerning the benefits of field trips in the learning process, based on the following scale: 1 = Strongly disagree, 2 = Strongly disagree, 3 = Neither disagree nor agree, 4 = Agree, 5 = Strongly agree

	1	2	3	4	5
Educational trips develop students' empathy and social skills.					
During the educational trips, communication and interaction between students is encouraged.					
The field trips foster a positive attitude towards science and critical thinking.					
Educational trips allow students to be self-directed and gain new experiences.					
The educational excursions achieve the opening to the local and wider economic and cultural society.					
Educational excursions are an ideal opportunity to relieve the teaching schedule of high schools.					
Educational excursions are a catalyst for the improvement of academic student performance.					
The implementation of educational trips helps to prevent undesirable behaviour in the student community.					

5. Please indicate your level of disagreement/agreement with the following statements concerning the difficulties of implementing educational excursions on the following scale: 1=Completely disagree, 2=Disagree, 3=Neither disagree nor agree, 4=Agree, 5=Completely agree.

	1	2	3	4	5
Unsuccessful connection with the objectives and purpose of the curriculum leads to the failure of field trips					
Poor preparation and lack of organisation undermine the performance of educational excursions					
The lack of investigation of the educational needs and requirements of the student population leads to the failure of the educational trips.					
The workload in the high schools contributes to the difficulty of implementing educational excursions.					
Inadequate security can undermine the realisation of educational excursions.					

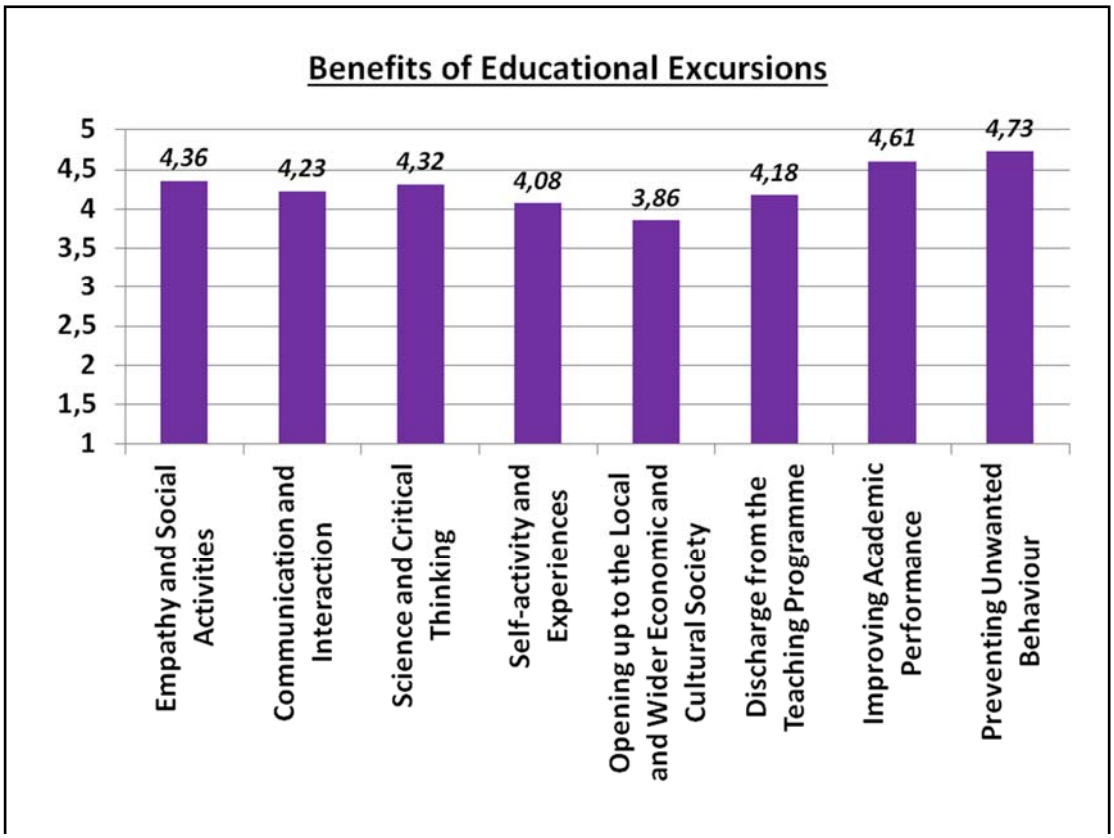
6. Please indicate your level of disagreement/agreement with the following statements concerning the points for a more successful and safer realisation of educational excursions, on the following scale: 1 = Not at all, 2 = A little, 3 = Quite a lot, 4 = A lot, 5 = Very much.

	1	2	3	4	5
The link to the specific target and the overall purpose of the curriculum leads to the success of the field trips.					
Adequate preparation and organisation contribute to the successful execution of the educational excursions					
Exploring the educational needs and requirements of the student population leads to successful field trips.					
Saving time in the high schools contributes to the successful implementation of educational trips.					
Ensuring safety conditions guarantees the success of the educational excursions.					

Most teachers were female (68.9%), with 11-15 years of experience (55.9%) teaching in high school (70.5%).

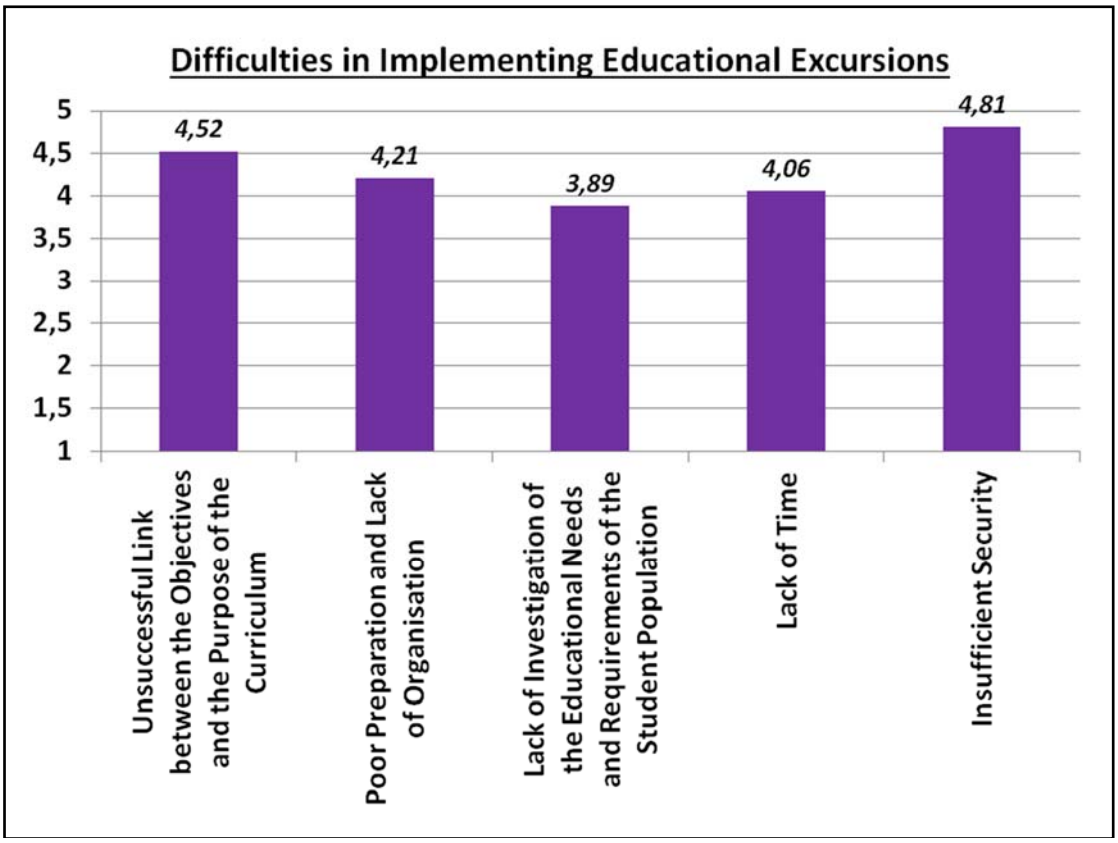
Results

Most participants agreed that there were identified benefits of field trips in the learning process, particularly in terms of developing empathy, cultivating students' social skills, improving academic performance and preventing undesirable behaviours in the learning community. No difference in the views of respondents was found based on their demographics.



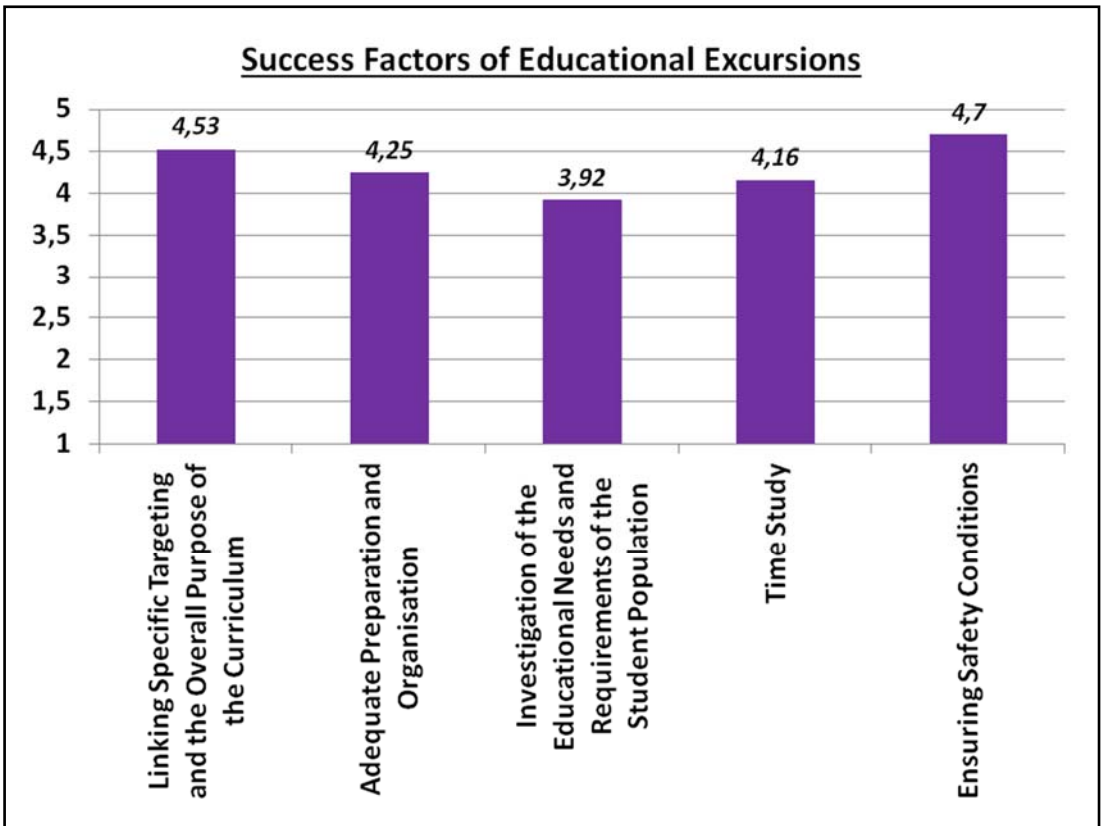
Graph 1. Illustration of the average benefits of field trips on the learning process.

With reference to the difficulties in implementing educational excursions both before and during their realisation, participants agree that poor preparation and lack of organisation, unsuccessful connection with the objectives and purpose of the curriculum and, above all, poor security can be destabilising elements in the implementation of educational excursions. No difference was found in the respondents' opinions based on their demographics.



Graph 2. Illustration of the average of the difficulties in implementing educational excursions.

Finally, in the process of finding points for a more successful and safer realization of the educational excursions by the teachers, it was found, in contrast to the above-mentioned, that adequate preparation and organization, the investigation of the specific educational needs and the requirements of the student population, the connection of the specific objectives with the general philosophy of the curriculum and the guarantee of safety conditions guarantee the success of the educational excursions. No difference was found in the opinions of the respondents on the basis of their demographic data.



Graph 3. Illustration of the average of the points towards a more successful and safer realization of the educational excursions.

Discussion

The present small-scale survey found that teachers recognize the benefits of field trips in the learning process, a finding that is consistent with the suggestions of other scholars, both in terms of benefits at the individual level and in the school community in general (Broh, 2002; Seow & Pan, 2014; Feldman & Matjasko, 2005; Lunenburg, 2010). Specifically for benefits at the individual level, teachers contribute to the finding for activating observation, fostering communication and interaction, developing positive attitudes towards science, increasing critical thinking through seeking information and harvesting new experiences, and self-activity, points that are consistent with the findings of previous empirical studies. Also, teachers' responses conclude that by going on field trips, new learning develops through curiosity, discovery, cooperative team teaching and learning interaction, elements that more successfully consolidate new knowledge. The above conclusions are consistent with the suggestions of other scholars regarding the enhancement of students' academic achievement and the prevention of undesirable behaviours. (Broh, 2002; Seow & Pan, 2014; Feldman & Matjasko, 2005; Lunenburg, 2010). At the same time, they find that, especially for secondary education (Lyceums), their implementation activates and positively motivates students. Finally, it was found that through the educational excursions, the opening to the local and wider economic and cultural society takes place in practice, students perceive that they are part of a wider and universal event, which multiplies the pedagogical and didactic benefits and the activation of useful social skills, an element that is also found in the literature (Lunenburg, 2010).

Conclusions

This paper has attempted to highlight the benefits of educational visits to the school community, to identify the elements that make their implementation dysfunctional and to detect ways of conducting them effectively. It was perceived that teachers agree on their benefits to the learning process, as they find that they activate students in multiple ways. However, their realisation may not have a successful outcome if basic prerequisites and conditions for their implementation are not met. At this point, the intervention of teachers is crucial, as they are called upon to prevent potential failures through appropriate planning and organisation. It is estimated that the contribution of this study in the field of education lies in the fact that it utilizes the literature references in their ad hoc implementation, their performance in secondary education, traces the data of the Greek reality and attempts to find solutions to possible adversities. The present study can be applied in the educational process and can be utilized especially in the field of suggestions for improvement, as the teachers' responses revealed fruitful ideas for future adoption and usable concerns.

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Transformative Action Research for Purposes of Academic and Scientific Socialization in Greek Tertiary Geotechnical Education

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Abstract

This paper presents a qualitative action research study, designed to explore the transformative impact of critical thinking on undergraduate Geotechnical Education students in Greece. The methodology was an intervention, consisting of thirteen workshops, premised on aesthetic experience and research action. A pre-intervention discussion identified limited academic and scientific socialization and, therefore, demonstrated the need to address this challenge. A focus group discussion was conducted halfway through the research to evaluate the development of the research process. A written interview, upon completion of the intervention, shed light on the impact of the experience on the students. This action research draws on constructivist learning theory, presupposing reflection, action and collective work. Although the data analysis process is currently in progress, initial findings establish broadening of assumptions about the role and mission of a geotechnical scientist, empowerment of soft skills, as well as student agentive potential.

Keywords: qualitative, action research, intervention, aesthetic experience, research practice

Introduction

This paper presents a qualitative action research study for purposes of academic and scientific socialization, aiming to explore the transformative impact of critical thinking (Mezirow, 2009; Kokkos, 2010) on undergraduate students of the Natural Sciences. In the context of the research, academic and scientific socialization refer to broadening of student assumptions, empowerment of competences, and development of student agency (OECD, 2019). Academic socialization is addressed through aesthetic experience while scientific socialization is approached via research practice, always aiming at the holistic development of the future scientist (Christodoulou, 2009).

The research methodology is an intervention scheme premised on study groups. The intervention is based on the application of critical thinking in the context of a combination of aesthetic experience and research practice. Gougoulakis (2024) argues that critical reflection and dialogue constitute key elements in transformative learning processes.

Initially, the present study aims to explore the students' current assumptions of their role as future scientists, and related facets thereof, challenge them, and, potentially, cause a transformation of these assumptions. Secondly, it seeks to investigate potential transformative impact on the metacognitive and social skills of the students, as well as on the importance attributed to them by the students themselves, prior to, and following participation in the action research. And, last but not least, it seeks to approach student agency issues in order to identify potential implications for the Curriculum of the Geotechnical Sciences, and for related educational policies.

Most research in higher education focuses on the development of methodological strategies and techniques aimed at enhancing students' knowledge and skills. However, times are changing, and the world needs people who are not only open-minded enough to embrace new ideas, but, even more importantly, people who are able to create new thinking. The Organization for Economic Co-operation and Development 2030 Compass (OECD, 2019)

proposes empowering and supporting students in order to promote well-being and contribute to the sustainability of society. As Cranton and King (2003) argue, educators, and learners alike, must participate equally in transformative learning, bringing with them their beliefs, and values, not intending to impose them, but aiming to test them, reflect on them, and arise wiser than before.

Research context

The goal of higher education is to create autonomous thinkers (Mezirow, 1997). Cranton (2006a; 2006b) argues that teachers must be supportive of learners' efforts to achieve autonomy. Transformative learning is an effective framework within which learners can develop a clear picture of their abilities and better understand their way of thinking, in order to adapt and function effectively in a constantly changing, international professional reality. As Kegan (1982) argues, human development is all about the individual's strife to emerge transformed and independent after a period of integration and consultancy.

Higher education is considered a suitable field for the implementation of transformative actions. In the context of higher education, the adult individual should be given the opportunity to consciously benefit from academic and scientific activity, whether as a student, or as a teacher. Conventional teaching models, which require copying, and rote learning are becoming increasingly outdated, without any provision for communication, collaboration, initiative or autonomous thinking. On the contrary, there is an urgent need to provide opportunities for the application of creative and critical thinking in order to strengthen academic and research skills in the field of Higher Education, in a more coordinated manner, basically within Curricula, so as to address all students (cf. The mission of Greek Higher Education, Law 4957/2022/Article 3/Par. 3).

Action research is a methodological approach "that has the potential to explore transformative learning in educational settings" (Gravett, 2004). Action research has only recently begun to emerge as an effective method of transformation (Taylor, 2000).

Taylor explicitly supports the use of action research in the context of transformative learning (ibid.). More specifically, she encourages teachers to improve their teaching through action research, "ensuring that critical reflection, trust and authentic relationships are at the core of their study". Taylor (1998) argues that the guiding principles for action research are fully aligned with the strategies proposed for transformative learning, with collaborative inquiry and critical reflection being the two most fundamental pillars.

Gravett (2004) confirms that any intervention, which is implemented in a transformative context, through an action research design, is sufficient evidence of upgraded teaching and improved teaching and learning techniques.

Additionally, Illeris (2016) argues that, in an educational process, aiming at a holistic approach to learning, each process must be carefully designed. Nonetheless, it is equally important, and essential, that teachers do not hesitate to implement innovative ideas.
McNiff and Whitehead (2010) describe action research as a conscious process, through which the researcher can discover new methods to improve his teaching, which means that he conducts action research aiming to create new knowledge.

In this sense, action research is seen here as both a tool for improving teaching practice, but, more importantly, in the context of the present study, expanded frames of reference (Mezirow, 2009) are sought through experience, dialogue, reflection and collaboration for the personal and social development of all parties involved. These four elements, namely, experience, dialogue, reflection and collaboration, which essentially constitute the four pillars of the present research, lie at the center of the theory of constructivism, as originally formulated by Piaget (1964) and, subsequently, further developed by Vygotsky (1978), who spoke of "new knowledge as an outcome of social interaction".

According to the rationale developed above, this action research program was designed for, and implemented in, the field of Higher Geotechnical Education, with the aim of exploring the potential of critical thinking to cause transformation, through immersion in creative thinking and research practice.

Significance of the study

Relevant literature shows that research in transformative learning (Mezirow, 1991; 2009) in Adult Education is gradually gaining ground. The present study is developed within an action research framework based on the theory of transformative learning. More specifically, it seeks to explore the transformative potential of critical thinking through the processes of academic and scientific socialization of undergraduate Geotechnical Education students in Greece.

Initially, while research based on transformative learning theory in the Humanities seems to be increasingly pursued, on the contrary, in the field of Higher Geotechnical Education it is rather limited, even less so in the context of action research. Therefore, there are questions warranting answers regarding transformative teaching and learning in Higher Geotechnical Education.

Furthermore, there is currently no single, autonomous, critical thinking-based thematic unit, drawing on a combination of aesthetic experience and research practice, in the context of Tertiary Geotechnical Education. Therefore, the present study seeks to detect possible implications of an interdisciplinary rationale for the specific context of Higher Geotechnical Education, in which the research is conducted. These implications will potentially inform the Natural Sciences Curricula as well as the field of University Pedagogy (Gougoulakis & Oikonomou, 2014), in terms of the role of the teacher, the development possibilities of students, and the educational policies of Geotechnical Departments.

Last but not least, in the present action inquiry study, transformation is sought in an English-speaking environment, thus attributing an international dimension to both the research itself and, more importantly, offering participants the opportunity to experience this dimension. Interaction, both during the workshops, and during the data collection process, was conducted in English on the grounds that opportunities to use and reuse the foreign language promote comprehension and production of foreign speech. As the process develops, knowledge of the foreign language is facilitated and strengthened (Pica, 1994; Swain, 1985; 1995). Gass (1997) claims that interaction in the foreign language is a valuable tool for second language acquisition. In line with the relevant literature, the present study provided participants with an engaging context and gave them ample opportunity for critical reflection, interaction, dialogue and collaboration in an English speaking context.

In summary, the present study lays claim to originality on the basis of using transformative learning theory in an action research project, implementing the transformative action research project in the field of Geotechnical studies, and using English as a Foreign Language throughout the research procedure, both as a self-development, and, also, as a data collection tool.

Methodology

Most studies conducted within the framework of transformative learning theory are qualitative. The present study was based on an intervention, consisting of thirteen sessions, spanning over one academic year.

The sampling method was purposive, meeting specific criteria, such as early adulthood (18-25 years of age), student representation across all semesters of study, willingness to participate in a collaborative research scheme based on aesthetic experience and research practice, and, at a minimum, an intermediate level of English. An invitation to be informed about the research was extended to all students of the Geotechnical School from the entire spectrum of semesters. Twenty-five students responded positively. Following an analysis of

the structure, content, research process and the obligations that participation in this research would entail, twelve students expressed interest to sign up. As this sample was representative of the entire spectrum of semesters, with moderate knowledge of English, and an expressed willingness to participate in a collaborative research team, four study groups were created. The participants were assigned a mutually acceptable code to ensure the element of confidentiality.

Considering that no independent course in the Geotechnical Sciences Curriculum includes academic and scientific socialization processes, utilizing critical thinking based on aesthetic and research experience, participants faced relative difficulty in fully realizing the requirements of the activities each time, and in identifying appropriate material, defining objectives, preparing for each session, and, were, also, confronted with challenge conducting the entire process in English as a Foreign Language. Therefore, a reasonable amount of time had to be allocated between sessions for the intake and consolidation of a large volume of new data and information.

For reasons of validity and reliability, a combination of data collection tools was used in this research study. The data collection tools used were a pre-intervention interview, a focus group discussion conducted mid-interventionally, self-awareness sheets, group work evaluation forms, a post-intervention discussion, the researcher's notes kept in a diary, and the session creative and critical thinking activity sheets.

The research tools

According to Kvale (1996, p. 104), the interview technique is used in cases where the research focuses on investigating the personal assumptions of the participants while, further, Robson (2007) argues that the “semi-structured” interview in qualitative research is the most appropriate way of collecting data in cases where the research is long-term, and the aim is to identify whether these assumptions have been modified. The introductory semi-structured interview consisted of predetermined discussion topics, prepared by the researcher, which provided security in terms of determining the cognitive background, experiences, needs and desires of the students, thus aiming to explore, and establish necessity of implementation. The interviews were conducted individually in oral form, in English, and were audio-recorded with the students’ written consent for reliability reasons. As previously mentioned, not only the workshops, but, also, the entire data collection process was conducted in English. Students were encouraged to interact in English, as relevant research suggests that consistent use of the foreign language, in “language-related episodes”, and participation in “collaborative dialogues”, can lead to linguistic, cognitive and behavioral empowerment (Swain & Lapkin, 1998). Negotiating meanings and communicating ideas was of primary importance. In difficult cases, however, students were encouraged to describe more extensively, or explain, using simple language rather than resorting directly to the mother tongue. It is reasonable that the students’ attitude toward emerging language challenges varied from time to time. However, the choice of each student was always respected.

Zuber-Skerritt (1992a; 1992b) supports action research in the context of Higher Education. She proposes the “CRASP” Model as a definition of action research: “C” stands for critical collaborative research (Critical), “R” for research conducted by people who reflect (Reflective), “A” for accountability in terms of publishing the results (Accountabilty), “S” for self-assessment practices (Self-assessment), and “P” for the participatory element in problem solving (Participatory). Having said all this, it is clear that, in the context of the present action research, the students were required to work in groups, reflect upon their choices regarding strategies, and content, receive feedback on their work, and evaluate their own performance while, at the same time, be active both in the preparation, but, also, in the presentation stages. Based on these processes, adjustments and changes were made that would further inform the research with the emerging needs, level of satisfaction, questions and expectations

of the students. Therefore, obtaining new data in the form of feedback from the group members was most crucial. All of the above were achieved through an enlightening discussion in the context of a focus group interview. Consequently, it becomes clear that the CRASP Model provided a most appropriate framework for the present action research on account of the fact that its core elements have their roots in constructivist learning theory, and transformative learning, and, thus, served the present action research rationale effectively.

The post-intervention interview was semi-structured, and aimed to shed light on the "how's" and "why's" of any changes in the students' assumptions, skills, and dispositions observed after the implementation of the intervention. According to the relevant literature, the semi-structured interview allows the researcher to delve into issues that could not have been predetermined (Iosifidis, 2003, pp. 40-41). In addition, participants were asked to contribute their own thoughts on a research process they created and experienced, to justify their opinions, evaluate the process, make new suggestions for adjustments and, finally, express themselves in the form of free comment. The post-intervention interview was conducted in written form to ensure rich contribution of data from the participants (Handy & Ross, 2005). For any further explanation or clarification, the students responsibly declared that they would be at the researcher's disposal. This interview took place in English, in the same way as with all data collection procedures.

The main idea behind the intervention proposed here is that of critical reflection. Various types of diary notes encourage reflection, acting formatively on the learner, when kept during an activity. Cranton (2016) speaks of "diary activities" that can promote critical reflection. In the context of these activities, the learner divides a sheet of paper into two sections, calling one of them "Feelings" and the other one "Thoughts". Learners are asked to record their thoughts and feelings about specific variables related to the lesson each time. According to Cranton, after the learners have written down their thoughts and feelings, the educator studies the notes, adds further comments, and, thus, establishes constructive dialogue in the group. In the context of this research, we adapted the activity by analyzing it into a series of specific cognitive and behavioral prompts, which required completion by the students. For example, the prompts "I think that…", "I feel that…", "I learned that/to…", "I asked…", "I need to rethink…" appear on the self-awareness sheet, and invite the student to think about the content, and process of each workshop. In this case, through critical reflection, the students came into contact with the idea of self-discovery. A "Free Comment" section encouraged participants to express themselves more openly, regarding self-awareness issues. Here, we utilized Cranton's (2016) idea as a form of activity that fosters transformation through dialogue, which was the original intent, and, also, as a tool for collecting and analyzing data at the same time. The "Group work Evaluation Form" used in this study was inspired by the "Take a Stand" activity of the "Perspective-taking" thinking technique of Project Zero by Harvard University, which was also used in the research.

The Group work Evaluation Form is a tool for cultivating critical thinking. Students were asked to reflect as a group in order to delve deeper into the way their group worked, and to make assessments. The form required responses regarding the steps taken by the group members to reach the goal set each time, the challenges they faced on the way to achieving that goal, how they addressed those challenges, what needs to be reviewed, while, in addition, they were asked to offer any ideas or suggestions related to working in study groups. The rationale behind this type of activity is to motivate learners to apply reflective skills, work collaboratively, explore the perspectives of their partners, envision new perspectives, and revise their work strategies. Therefore, it is safe to argue that such an activity carries with it a transformative potential, beyond its usefulness as a data collection and analysis tool.

The intervention

The research design was composed of a thirteen-workshop intervention, simulating the structure of a conventional university course. It was designed in such a way that half of the sessions were based on the application of critical thinking drawing from aesthetic experience (Koutsoukos & Fragoulis, 2017), while the rest offered participants the opportunity to utilize their critical thinking drawing from research.

The material compiled for the aesthetic experience sessions was derived from literature, and the arts, thus addressing issues of academic empowerment. The material was common among the four groups, and to utilize critical thinking, the Perkins' (1994) method of observation and analysis of works of art, the Project Zero palette of thinking techniques by Harvard University, and the Learning by Design methodological approach (Kalantzis & Cope, 2005) were drawn on. The research papers, used in the respective sessions, were selected by the groups, who worked on them in order to critically evaluate them and, in this way, practice their research skills. Each group sought, and selected for critical analysis and presentation, research papers that were relevant to the particular scientific, and research interests of its members. To approach these tasks, the instructions given in the framework of the Doctoral Program of the Educational and Social Sciences of Frederick University of Cyprus were used, after special adaptation to suit the level and needs of the undergraduate students. Each research-based workshop included a short tutorial, conducted by the researcher, aiming to address gaps in the students' knowledge of research, as these were identified in each preceding research workshop.

The aesthetic experience and research workshops were held alternately (Figure 1). The idea was for the students to gain an insight into theoretical issues of academic identity, such as qualities and skills that characterize a scientist, while providing them with the opportunity to apply these very same qualities, principles, and skills in the next research session. The sessions were designed to be held with an interim of at least fifteen days in between, thus, giving the four groups time to explore literary and audio-visual material, as well as trace research papers, but, also, compile queries, and concerns, which, they believed, required an answer in the next session.

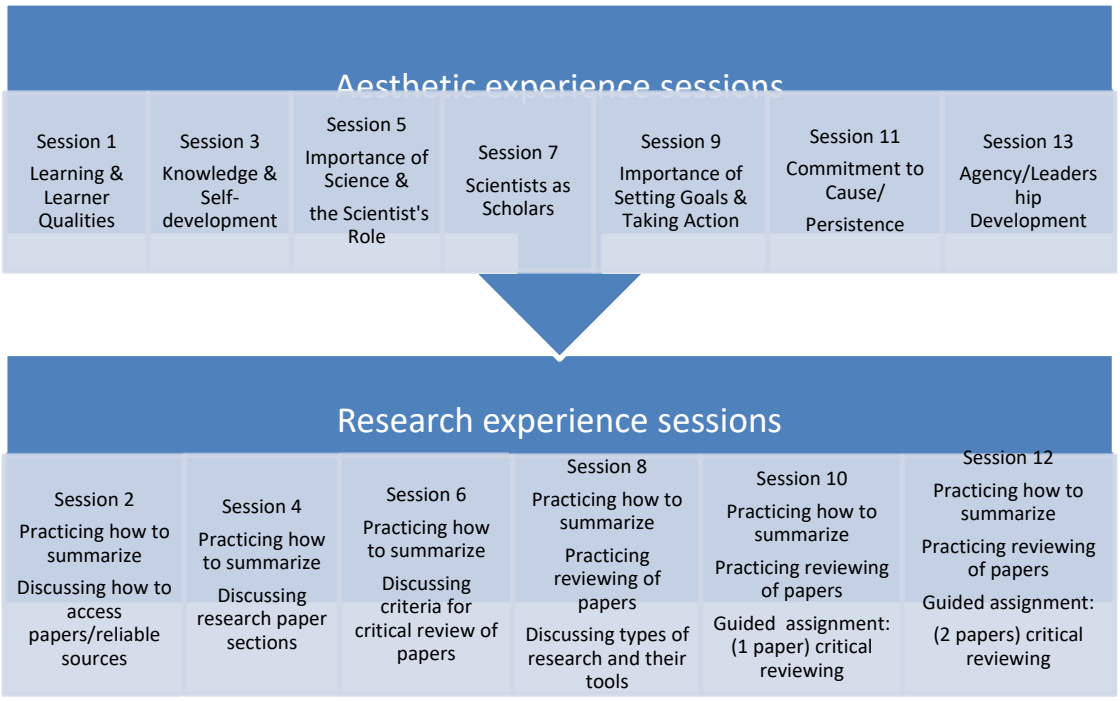

Figure 1. Alternating aesthetic and research experience workshops

The debate about validity and reliability in quantitative and qualitative research is ongoing. We must always consider the research goal, and how well it will be served by a specific type of research and its methodology. The criteria for validity and reliability between the two types of research differ. Quantitative research is based on numbers, and seeks a high rate of generalization, while qualitative research is based on people's stories, and seeks meanings in order to interpret them in relation to the goal the research has set.

Guba and Lincoln (1989, op. cit. in Cohen et al., 2018, p. 247) suggest that "the term validity be replaced by the term authenticity". Accordingly, Maxwell (1992) posits that the term "understanding" be used as it is more appropriate than the term "validity" for qualitative studies. Examining, and cross-referencing our perceptions and opinions, about a topic with those of other people can ensure validity. Furthermore, Lincoln and Guba (1985, op. cit. in Cohen et al., 2018, p. 270) choose the term "dependability" in contrast to "reliability", as the goal of qualitative research is not to replicate the results in other cases or generalize the findings to the wider population, but to describe the nature of the research process. In order to overcome the problems of "authenticity", the research presented here used clearly formulated questions, understandable to the respondents. In addition, the data collected are analyzed and interpreted extensively, as the data analysis phase is underway, while findings from the twelve participants were cross-referenced to the findings from three students of the Geotechnical Sciences, who had not participated in the action research project. On the other hand, in terms of addressing "dependability" challenges, the present research uses the strategies of triangulation, extensive field knowledge, and participant validation of data.

Discussion

Although the intervention and data collection phases have been completed, the content analysis and data interpretation phases are currently in progress. However, initial findings eloquently reveal illuminating information in relation to the three questions posed in our research.

Initially, the students' perception of their scientific role, pre-interventionally confined to that of a specialist consultant in the workplace, seems to have expanded, an element that reveals a more reflective attitude toward previously held assumptions about this role (Table 1). Analysis of the data collected, following the students' participation in the intervention, places in the picture additional roles for the geotechnical scientist, such as that of researcher, reviewer, observer, feedback provider and that of a reflective scientist. Regarding critical qualities involved in the work of a scientist, post-interventionally, the participants highlight elements such as curiosity, open-mindedness, inquisitiveness, self-awareness, commitment, critical thinking, goal setting, and embracing different perspectives. The students' perspective demonstrates an expanded frame of reference, which now encompasses the concept of social contribution and work for the benefit of humanity. In the new frame of reference, this perspective has clearly undergone a significant qualitative shift from a focus on the individual to empathy toward fellow human beings.

Table 1. Transformed frame of reference for the role of a geotechnical scientist

When asked how they perceive their role as geotechnical scientists, and the perspectives involved in it, the students answered…
Student 2 *"As far as I know, a geotechnical scientist works in [field of work] and advises people on how to make good quality [product name]"* (pre-interventionally) *"A geotechnical scientist has many missions … works in [field of work], … promotes the [product], chooses the best variety, … But beyond the practical things, … he must develop in various fields, … express his point of view, … acquire knowledge, … explore new methods, …*

evaluate the feedback he receives, be open to new things, … pass on his knowledge to the younger ones, … inspire, … recognize his strengths and weaknesses" (post-interventionally) *"For me personally, the whole process of research has helped me improve … to understand myself better … I learned to listen … to consider the opinions of others … to collaborate … to provide information that may affect the lives of others for the better…"* (transformed frame of reference)
Student 10 *"The job of a geotechnical scientist is to be part of the process [of producing the material]. He has the ability to make [material name] into a great [product name]… is responsible for the construction… and monitoring of the … process"* (pre-interventionally) *"A geotechnical scientist is a professional… monitors the process… decides the right time to… supervises production… takes care of hygiene… watches industrial indicators… … scientists are not only that but also research, think, explore… do research work… present their work publicly … work collaboratively … provide feedback … encourage employees … seek partnerships …"* (post-interventionally) *"… a deeper look at the elements of a true leader … understand the supreme importance of patience … perseverance … willingness to go the extra mile … to improve personally and professionally … to work for the benefit of the people…"* (transformed frame of reference)

Secondly, cross-referencing of the data confirms that specific social and metacognitive skills and competences of the students have been empowered (Table 2). The students share that, after participating in the present action research, they feel less hesitant to participate in new research projects, be confronted with challenge, adjust, monitor their emotions, and reactions, and obtain a clearer picture of themselves, of their strengths and weaknesses. The students' personal perspective of the skills, and competences of a scientist appears to have expanded, showing signs of transformation. It becomes evident that the students now highlight resilience and self-awareness as two of the competences a scientist must possess, and try to develop.

Table 2. Transformed Frame of Reference for Confronting Challenge

When asked about confronting the study group challenge, the students answered…
Student 8 "*I would not feel very comfortable because I have never done it before …", I would need practice … probably working with more people so I can exercise my communication skills … practice, doing the same thing…*", "I like working individually… I am anxious in groups… I think I will be judged …" (pre-interventionally) "*I have learnt to be patient and work in teams … that co-operation is important in a group … learnt the importance of perseverance and of setting goals … how to be self-aware and how to express my opinions and ideas*" (post-interventionally) "*another point is patience … learning can be difficult that's why you should never give up and always believe in yourself*", "… developing collaboration skills through group work would be very important for future scientists …" (transformed frame of reference)
Student 5 *"… first of all, I have never been a member of a study group before … I just tends to do it on my own … I prefer working individually … would think of quitting from this project*", *I don't like disagreements … not used to study groups … working individually … so that I can focus better …*" (pre-interventionally) *"at first, I wanted to leave the group … but as time passed, I was able to express myself easier or accept other's opinions and advice … but the persistence this research taught me lead me to make it through the end of the sessions … working with a group has affected me*

in a positive way. It taught me to be patient and listen carefully to my colleagues …" (post-interventionally) "*I'm going to search for another research project or group workshops to participate in … looking forward to the next challenges and how I am going to be able to face them …*", "*dilemmas can always occur in every stage of our scientific career*", "*the point is to find ways to overcome problems*", "*not being manipulated by successes or failures but we should have self-control*" (transformed frame of reference)

Finally, when invited to envision their future, in the introductory discussion, prior to the research, the students describe their professional career in strictly technical terms, considering themselves mostly as 'performers', or 'employees' rather than 'agents' or 'game changers'. Nonetheless, nearing the end of the academic year, after completion of the research process, a different picture emerges from the data (Table 3). When the students are confronted with the same question, they provide a discernibly different perspective of themselves. They place particular emphasis on issues such as determination, and initiative. Furthermore, they seem to go a step further by interpreting these emerging assumptions as critical for the scientist, thus validating their transformed view of the role, and mission of a geotechnical scientist, as discussed above.

They internalize and appropriate the concepts of pioneering, autonomous thinking and action, and successfully addressing challenges, and incorporate them into their new understandings of the scientist's mission. According to Housen (2002), content transfer, that is, critical thinking that is transferred from one situation to another is a clear indication of transformation.

Table 3. Transformed Frame of Reference for Agency

Invited to envision themselves, and their professional future, ten years from now, the students responded…
Student 3 "*with a stable job, in a [job position], advising people … being in a lab …*" (pre-interventionally) "*could possibly picture myself teaching … being a member of a research team … more comfortable with sharing my ideas …"* (post-interventionally) *"now picture myself in many situationships and work invironments*" (transformed frame of reference)
Student 7 "*I don't know for sure, maybe, I will work in a [place of work], maybe I will work in a lab …. I don't know for sure*" (pre-interventionally) "*I am indecisive … I am thinking about it", "I could think of myself as a scientist, and researcher … as I have learnt to work in a research group … teaching in a school or university, especially for me teaching is a possible career, something close to this*" (post-interventionally) *"I can have many different identities at the same time (scientist, researcher, leader, teacher etc) which will make it easier for me to choose my career field in the future this way*" (transformed frame of reference)

Drawing on the students' narratives, osmosis of the Natural Sciences with the Humanities in the action research framework described here appears to have a positive impact on the Geotechnical Education students. The students' perspectives, reflecting broadened academic thinking and research familiarization, constitute an interdisciplinary challenge for both fields.

Conclusion

The action research study presented here aimed to explore the potential of critical thinking to induce transformation of assumptions, skills and dispositions in undergraduate Geotechnical Education. The methodology adopted in the context the present research was that of the intervention. In this context, thirteen English Language workshops were conducted in the course of one academic year. Data analysis was conducted using the qualitative approach. A pre-intervention interview, a focus group discussion, a post-intervention interview, the researcher's diary, and the creative and critical thinking activities of the workshops provided the tools for data collection. From the initial analysis of the data collected, findings emerge, which clearly document that the sum of learning activities implemented in the context of the critical thinking based intervention has the potential to transform students' assumptions, competences, and dispositions, and contributes positively to their academic-research socialization in the field of the Natural Sciences.

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