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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 second issue of the International Journal of Educational Innovation (I.J.E.I.) of the Scientific Union for the Promotion of Educational Innovation (EEPEK), within 2022 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



## **Fighting fake news and propaganda through digital storytelling (Pixton) in Primary Education**

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### **Abstract**

In this study, primary school students worked on a project on fake news and propaganda. Through this intervention, students were exposed to many different European stories and myths, whose main core was the power and impact of lies. Young learners, reflected on the misleading power of fake news and created their own comics in order to inform the student community about ways to avoid becoming a victim of propaganda. The implementation of the project concerned the use of Pixton, as a vehicle to raise awareness about the dangers of propaganda and how can young children sharpen their critical thinking skills and avoid victimization. Learners throughout the project, developed and exercised 21st century skills and literacies. They were encouraged to think critically, interact effectively and act democratically.

**Keywords:** Pixton, ICT, fake news, learner generated comics

### **Introduction**

Literacy and the ability to recognize fake news from an early school age is the new skill, students are required to master, in order to protect themselves from the spread of false news and their possible victimization by control systems (<https://saferinternet4kids.gr/hot-topics-ef/digital-literacy/>, n.d.). The twenty-first century, finds English language teaching at a pivotal point in re-evaluating curricula and revising the teaching agenda. Language, text and communication norms are expanding rapidly to meet the needs and conditions created by new media and global networks. The language that defines the major part of this intercultural congestion of information networks is English, which is the dominant language of digital communication, unquestionably acquiring a dimension of cyber colonization. In our era, under the present circumstances, students should be encouraged to be involved in civil life by receiving the proper information, by expressing and communicating their experiences, beliefs and emotions about truth, lies and the mechanisms of misinformation. Over the last years, media education and digital literacy have become domains of major interest worldwide. Educational experts have stressed the need to enrich the school curricula by incorporating media education as a core subject in the educational setting. In our intervention, we informed students about all the hidden dangers of misinformation and we used digital storytelling as a dynamic classroom practice, “as a pedagogical tool that brings the creator/student and the reviewer together in a dialogue around nature based on representation, meaning and authority embedded in imagery and narrative” (Fletcher and Cambre 2009). Pixton, a popular online comic strip creator was imaginatively used by students and teachers, to promote student engagement and learning about the values of truth and democracy and to foster visual literacy (Utomo & Ahsanah, 2020). Students worked on a real-world, team-based problem, where they needed to develop skills of communication and cooperation in order to inform the educational community about the dangers hidden behind misinformation.

### **Exploring the Pixton application**

Pixton is a web tool that facilitates the creation of comics in a fast and simple way that can be easily saved and shared. It offers the possibility to use a wide range of scenarios, characters and objects. It provides a user-friendly interface and it is free for individual accounts. One important feature is that it allows users to add text and voice to characters. Users can easily

create their own comics and share them with the community. Pixton allows the editing of the shape and position of each comic panel. It is an innovative didactic tool that fosters creativity and participation in class. It is a student-centered tool that can also empower differentiated learning. It is accessible from computers, tablets and smartphones. There are three different categories of user accounts, Pixton for School, Pixton for Fun and Pixton for Business. Pixton for school, gives the opportunity to teachers to create classroom and individual accounts, in order to further involve students in the learning process.

### **Pixton and 21<sup>st</sup> century skills**

The development of 21<sup>st</sup> century skills can be supported by using technology in various subjects in the school context. Pixton, as a powerful storytelling tool, engages students in narrating stories of interest and bridges efficiently pedagogy and academic content. It can be aligned with curriculum standards and teach content knowledge and 21<sup>st</sup> century skills. Digital storytelling contributes to the development of digital, global, technological, visual and knowledge literacy (Çetin, 2021), critical thinking and problem-solving skills (McLellan, 2006). It enhances research and integration skills and helps students reach high metacognitive skills. Robin (2005) reports that digital storytelling offers many benefits for students. As Robin explains, digital storytelling permits students to learn to use the Internet to research rich, deep content while analyzing and synthesizing a wide range of content. Learners also develop communication skills by learning to ask questions, express opinions, construct narratives, and write for an audience (Meyers, 2014). They also improve their computer skills by using software that combines a variety of multimedia including: text, still images, audio, video, and Web publishing.

During the implementation of all stages of the project, students came closer to the formation of a multidimensional identity of a critical thinker and an active civilian. They adopted a more active role in embedding and reusing cognitive schemes and enriching their socio-cultural background.

### **Pixton and digital literacy: from consuming content to creating content**

Pedagogy and education have undergone significant changes during the last years since they were affected by the shift in entertainment and information channels. The educational community, globally showed interest on the need to prepare students for moving around the visual world and also the advantages of using images to teach and learn (Burwitz-Melzer, 2013).

The EFL classroom has successfully adopted the use of innovative technological tools, like Pixton, in order to engage students to learn how the medium works and how it constructs meaning. Students reach a high level of meta-cognitive maturity while using visual software like Pixton, collaboratively, because they have to overcome the interpretational openness of the multimodal text and compromise on one representation (Alter, 2018). Garrety and Schmidt (2008) claim that as “technologies have evolved, storytelling has changed and morphed with the times to include digital technologies, images and audio that enable a new generation to tell its story”

Educational experts (Anstey & Bull, 2004), have given a new meaning to the concept of text so as to include digitally based, multi-modal elements combined with traditional print-based texts. Pixton, by providing images, text and sound prepares students as navigators in research and discussions concerning hypertext and online resources (Schrader, 2008).

Learning in today's world means interacting from an early age with texts that entail multimodal elements like videos, music, graphic designs and hypertext. Paul Duncum (Duncum, 2004) states, “... there is no avoiding the multimodal nature of dominant and emerging cultural sites”. Students in Primary Education benefit significantly, while working with Pixton, since they adopt a more active role, that of a prosumer (Ivashkevich, 2015) and

not passively accepting the role of a consumer of digital products. It has been stated that young people often do not have enough “conceptual tools” to analyze and interpret existing media texts and their own mash-up creations (Jenkins, 2018); they also lack the artistic and technical skills to exercise their full power as prosumers. Pixton challenges young learners to move beyond media production as simply as a fun and engaging activity and exercise a critical prosumer agency (Buckingham, 2009).

### **Digital storytelling with comics**

Digital storytelling is defined as “all types of applications which use digital media either to support, to enable the creation or to generate stories” (Schafer, 2004). The interest that researchers show towards digital storytelling is motivated by the potential advantages brought by this medium. (Azman et al., 2015). Comic authoring tools, such as Pixton, trigger the learner’s interest since they are free to use and user friendly. A massive number of educators proposes the integration of visual representation tools, like the aforementioned- as part of a frequent classroom practice. Learner generated comics within the classroom practice, assign a “mirroring” of the prosumer’s ethic and they place a major value on “what people do rather than what they own”. Henry Jenkins (Jenkins, 2018), describes contemporary young people as digital prosumers who use new technologies to appropriate, resample, remix and rework existing artifacts, images and messages and hold high potential for productive citizenship and creative activism. In the case of this class project, students had to “read between the lines” of these fairy stories, reveal the deliberate lies hidden in these popular stories, overcome stereotypes and rework the dominant narrative. Writing the script for the comic, editing the sense, adding music and special effects and getting feedback about the final outcome based on peer feedback enhance student self-activity and place the student in a designer and creator role.

### **The profile of the participants**

The project was conducted in the fifth class of the 6<sup>th</sup> Primary School of Ilion, Athens. The number of students who participated in the project were 26; 15 boys and 11 girls. The major part of the student population was digitally competent, familiar with the use of a big variety of audiovisual software and the creation of multimodal texts. The students were accustomed to working in teams in a variety of many alternative approaches and the project was carried out with interest and enthusiasm, traits that helped young learners overcome any problems that may have appeared. The students worked in mixed ability groups, both as far as their English language level and the ICT skills are concerned. The project was employed both in class and at home, using a form of blended learning. The school was equipped with computers and the students had the opportunity to work in teams in the computer lab, using laptops. The duration of the project was approximately two months. The school subjects that were involved were: English, ICT, Art, Social and Political Education and Language.

### **Materials and Resources**

The materials that were used were: projector, computer and internet connection. Our resources were fairy stories, like “Puss in Boots”, “The Emperor’s New Clothes”, “Cinderella”, “The boy who cried wolf”.

### **Use of language**

The pedagogical intervention in all steps and phases was conducted in English. Students were given instructions in L2 and were encouraged to enhance their knowledge in English, to collaborate and communicate in a language that wasn’t their mother tongue, without feeling stressed or hesitant when making mistakes. Following the principles of Constructivism, mistakes were confronted as a useful means to realise students’ weaknesses and make the

necessary interventions in order to strengthen their language skills and boost their confidence in L2. The whole community of learners embraced the same methodology concerning mistakes: when the teacher or a member of a team pointed out that a student made a mistake, the teacher wrote discreetly the mistake on the board and all the students had to write it down in their portfolios. All corrected mistakes were written to the spaced repetition database and all the erroneous language misinterpretations were overwritten with the correct ones. This strategy paid off since learners eliminated linguistic mistakes and communication in English was unobstructed.

### **Aims of the project**

The aims of our project were:

- ✓ To raise awareness in students about information criteria for the trustworthiness of a source
- ✓ To enable young learners to recognize disinformation and the dissemination of fake news and gradually acquire a mature and responsible identity of a future citizen
- ✓ To familiarize students with the use of Pixton and enable learners to take a stand against misinformation through the use of comics
- ✓ To improve their digital dexterity with digital comic creation
- ✓ To develop their presentation skills in an alternative way, through comics

### **What are the students' opinions about Pixton? Methodology and implementation of the project**

Young students tend to be more curious and motivated to learn (Spencer & Walker, 2015). In all stages of the implementation of the project, the teacher adopted the Inquiry Based Model to promote learners' cognitive skills and knowledge. The 5E learning cycle has led students through five phases: engage, explore, explain, elaborate and evaluate. In all parts of the project, students were provided with a common base of hands-on activities. The use of the Inquiry Based Methodology assisted learners to apply a new understanding of concepts, share information and ideas and apply their newly acquired knowledge to other disciplines. Following the principles of IBL, learners rather than memorizing information from printed materials, they were encouraged to conduct research about media literacy and fake news, broaden their knowledge bank and develop their skills and mental frames. There was a strong sense of commitment from all members from the very beginning of the project till the very end, aiming at ameliorating ideas and knowledge. The Inquiry Based Learning, proved to be motivating and stimulating for pupils' construction of meaning, active engagement and cultivation of research skills. The IBL model, guides the teacher towards a student-centered approach and the teacher is expected to act not as a sole authority figure but as a mentor, offering support and motivation to students working on the project. Validity in the integration of ICT in an EFL class was given by tempting students to use different strategies, come in contact with different learning styles and orientate themselves towards a form of exploratory and autonomous learning in the field of Media Literacy, instead of simple memorization. The whole process entailed the following steps:

- Orientation: A coherent and engaging presentation of the identity and the key elements of digital literacy and fake news. Monitoring students' perceptions and pre-existent knowledge on the topic.
- Investigation: Students play the role of the researcher and collect information about a thematic area entitled Media Literacy and Fake News. Learners develop questions that they are eager to answer, like: "How can we raise awareness about avoiding extremism and propaganda from the media?", "How can we prevent ourselves from falling victims of fake news, bullying, hate speech, discrimination and indoctrination?" and also "What's the role of formal and non-formal education in raising public awareness about media literacy?"



- **Conclusion:** Learners conduct research on Media Literacy and present the results of the project. Dissemination of information and exchange of data between the members of all teams, helps the knowledge transfer and the emergence of new knowledge about the aforementioned issue.

- **Discussion:** At the final stage, learners assess the whole project with regard to the skills and knowledge gathered from this learning experience. The teacher invites the students to reflect on what worked about the process and what didn't.

The teacher played the role of a mediator and a guide rather than a sole authority figure. The teacher motivated and challenged the students to work on their Pixton projects by taking an active and participatory role in their own learning. The teacher had created a class in Pixton Edu and students created their own avatars, conducted research, interacted with each other and uploaded their projects within the Pixton class.



**Picture 1. Our Pixton Class**

### **Teaching sessions**

#### **First phase**

During the first phase of the project, (which lasted four teaching hours), students read books and watched videos of some very popular and well-known European fairy tales and stories, related to lies and propaganda ("Puss in Boots", "The Emperor's New Clothes", "Cinderella", "The boy who cried wolf"). They exchanged interesting viewpoints about how people interpret lying. Can people easily accept white lies? What really happened in the aforementioned stories? Is it politically correct to accept lies, simply because the end justifies the means? While being in class, children were asked to relate the fairy stories with today's reality and think how they could reconstruct the real meaning of these stories and present a new mini story in the form of a comic related to fake news and misinformation. Then they were invited to participate in a poll. The online poll used, was Mentimeter and the students answered the question "What skills do you activate while creating a digital comic?". The answers are presented in the following picture.

Go to [www.menti.com](http://www.menti.com) and use the code 8502 1992

## What skills do you activate, while creating a digital comic?

Mentimeter

imagination	writing skills	artistic skills
english language	participation	ICT skills
cooperation	empathy	communication skills

**Picture 2. Mentimeter**

Students were encouraged to think and work in teams about a story that they would like to present in the form of a comic. Teams continued collaboration asynchronously in the digital environment of eclass.

### Second phase

In the second phase, (which lasted three teaching hours), the teacher presented Pixton and explained how this visual representation software works. All the explanations and the instructions were given with the use of the native language. The strategy of using translanguaging as a tool, aiming to strengthen the communicative approach in the second language acquisition, is functional because both literacy and second language learning are promoted. After giving all the necessary guidance about the topic of fake news and misinformation, students were informed about the number of storyboards they had to present by the end of the project. The second phase took place in the computer lab and all the teams were of mixed ability. The teacher appreciated the easiness of Pixton and the fact that the students did not need extensive training to understand how to use the tool. After the first brief training, participants did not need any further guidance. Students were asked to work in teams, both in class and at home, in a blended form of learning, and present their comics concerning fake news and media literacy as a final product.



**Picture 3. Pixton comic**



Picture 4. Pixton comic

Third phase (45 minutes)

In the third and final phase, the participants were given a questionnaire, as an assessment tool, to monitor the students' viewpoints concerning the use of the aforementioned online tool. The questionnaires were analyzed on SPSS and the answers evidently show that a vast majority of students finds English language learning more interesting with the use of Pixton. Additionally, comic creation through the use of digital means seems to be easier for English language learners than the traditional, conventional form of comics and finally the majority of students found Pixton, a really easy tool for comic creation. Participant views and observations during the project evidently show that students use a large number of skills in the process of preparing scenarios and creating comics. Almost all participants talked about meaningful learning and deep exploration strategies. Participants also mentioned that in the process of writing their scenarios on the topic given, they investigated the topic in detail, learned in depth and for this reason their learning would be permanent. The answers of the questionnaire are presented in the tables that follow.

Table 1 . Questionnaire

Do you believe that Pixton makes English language learning more interesting?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	25	96.2	96.2	96.2
	No	1	3.8	3.8	100.0
Total		26	100.0	100.0	

Table 2 . Questionnaire

What kind of comic creation is easier for you? The digital ( like Pixton) or the conventional?					
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	The digital comic	24	92.3	92.3	92.3
	The conventional comic	2	7.7	7.7	100.0
Total		26	100.0	100.0	

**Table 3 . Questionnaire**

		Do you believe that Pixton is easy to use?			
		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	19	73.1	73.1	73.1
	No	7	26.9	26.9	100.0
	Total	26	100.0	100.0	

Furthermore, the learners provided their viewpoints on Pixton and the project in a discussion form in class.

Positive comments

✓ The comic software was a lot of fun and we really enjoyed the process.

✓ The teacher told us that Pixton was a form of alternative assessment but for us, it was a joyful activity in class with our friends.

✓ This “different” kind of activity, was an escape from the class routine.

✓ The topic of the project was taken from our everyday life and it was discussed in class during the lesson of Social and Political Life.

✓ Collaboration in teams made the Pixton project more interesting and engaging for us.

Negative comments

✓ Some students had to overcome a dominant feeling of technophobia and try to meet the demands of the project.

✓ Due to technical issues, sometimes it was hard for the teams to reach on time the final product in Pixton.

✓ Shy and introvert learners found some difficulties in collaborative work.

✓ Sharing one computer with other group members is sometimes inconvenient and creates tension among class members.

### Conclusion

In this study, the integration of comic strip creation software was positively welcomed by both teacher and students. The creation of digital comics had a positive impact in English language learning (Thacker, 2007) and enriched the methodological approach, changed the attitude towards standard assessment forms and increased motivation (Kilickaya & Krajka, 2021). Throughout the production of digital comics, students collaborated effectively and exercised their democratic skills. In the final stage, students mentioned that participating in this project was a great advantage for them, since through the use of Pixton, they developed their learning and innovation skills, information, media and technology skills. Concluding, students stated that they felt emotionally comfortable, happy, and experienced an educational process without stress and having fun. All of them expressed the hope to repeat this fruitful educational experience with Pixton in the future.

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## **Experiencing multilingualism in daily school life in Greece: Semi-structured interviews with adolescent bi/multilingual students**

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### **Abstract**

This paper explores bilingualism, multilingualism, and translanguaging as social practices in the Greek context. Historical and sociopolitical changes in recent years have caused transitions in the social context and the Greek schools as well. As a result, bi-/multilingualism is a wide usual practice in the public domain and family policy language, while it seems a contemporary pedagogical challenge. After a brief literature review of the theoretical concepts, the content of semi-structured interviews of three adolescent students with migrant backgrounds and bilingual families is presented and analyzed. The study aims to explore the use of translanguaging and bilingualism in the Greek context. The results relate to the examination of views at a micro-level of ideologies, concerning bilingualism and language maintenance or loss. In addition, it is obvious the recognition of the importance of bilingualism, but also the fear of using the language of the host society and the perception of the ease of using the English language.

**Keywords:** Bilingualism, multilingualism, translanguaging, code-switching, adolescents

### **Introduction**

*Bilingualism, multilingualism, plurilingualism, diglossia, code-switching, and translanguaging* are terms widely used in migration studies and language teaching/learning. However, as far as Greek society becomes more and more multicultural bi/multilingualism is converted into everyday practice for people with diverse backgrounds or multilingual families. In many domains of social life, the various circumstances demand the use of different languages or code-switching.

This behavior is observed both in the general population of young people in Greece, and people with a migrant background. On the one hand, the Modern Greek citizen should be trilingual, since the curriculum of the Greek compulsory education introduces English as a second language from primary school and a second foreign language of choice (usually French or German) in the last grades of primary school; and the same language-scheme is adopted in the curriculum of secondary education. At the same time, the dominance of the English language in technological development, music, cinema, lifestyle, etc., affects the language used daily by young people both worldwide and in Greece, which is the heritage language or the second language (Al-Zoubi, 2018).

On the other hand, bilingual families seem to be a special case, since they follow a specific language policy for the everyday conversations at home, between parents and children. Despite this, attendance at the Greek school, which offers monoglossic education for basic literacies, demands the learning and speaking of the Greek language only (except for the foreign language courses). It is, therefore, of particular interest to explore the experiences of adolescents with migrant backgrounds or with parents of non-Greek origin regarding their bilingualism and linguistic differentiation. Their attitudes and views towards bilingualism can be examined with language ideologies and emphasize the use of language in specific communicative practices and social contexts. Furthermore, the feelings of adolescents about the use of their first and second language provide stimuli for reflection on language policy-making, but also for teachers and language teaching in the school context.

## **Theoretical background**

### *Bi/Multilingualism*

Starting with the key terms, *bilingualism* refers to the ability to use two different languages equally well; to this extent, *multilingualism* is the use of more than one language fluently (Baetens Beardsmore, 1982). Both terms are used for individual speakers or groups of speakers. In contrast, these two notions should be not confused with *diglossia*, which defines the use of two distinct varieties (one regarded as high, the other as low) of the same language for divergent functions (Ferguson, 1959, 1996; Holmes, 2008) or *polyglossia*, a more sophisticated concept, which defines the distribution of more than two different varieties in a community (Holmes, 2008).

### *Translanguaging*

*Translanguaging*, as an extension of the term *language* and borrowed from Cen Williams terminology (Baker, 2001, Tsokalidou, 2017), is a dynamic process of student/teacher engagement of bilingual “multiple and discursive practices” due to conceptualizing “their bilingual worlds” (García, 2009: 45, 78). The notion of *translanguaging* is included in the broader and former “code-switching”, a linguistic term used in academic discourse for decades, related to the linguistic repertoire and the language choice of variety or code in correspondence with certain social factors (interlocutors, context, topic, domain, addressees, setting of speaking, social distance, status, formality, the function of interaction) (Ferguson, 2003; Holmes, 2008). Nevertheless, *translanguaging* steadily gains popularity, thanks to the ideological development of bi/multilingualism in the academic, educational, political discourse, and in everyday communication (from the school environment to street communication) in today’s globalized world (Lewis et al, 2012).

### *Plurilingualism*

The term *plurilingualism* was suggested by the Council of Europe, as a warmly welcomed individual element of European citizens to learn and use additional languages to L1 (to satisfy needs of mobility and integration), besides the societal phenomenon of multilingualism in the framework of the transnational European Union (García & Otheguy, 2019).

### *Commonalities and differences*

The common ground on which concepts of bi-/multilingualism and translanguaging can be explored is the current socio-cultural conditions and the ability of speakers to use two or more languages simultaneously. On the other side, the difference lies in the fact that *multilingualism* (as a wide global phenomenon, with holistic content) and more concretely *bilingualism* (in personalized terms) are recognized as assets when populations with a dominant language learn foreign languages to increase their qualifications and become more competitive in the labor market (Cenoz, 2013; Cenoz & Gorter, 2015). At the same time, students with an immigrant background or with parents of different nationalities, living in a relatively monolingual society, face difficulties to use translanguaging at school, and therefore in the learning process, in the public domain, and in social life.

### *Bi/multilingualism in everyday life and Intercultural Communication*

Although multilingualism is not a recent phenomenon, it has recently gained particular interest from scholars, due to the strong need for intercultural communication (Cenoz, 2013). Deepening the issue of intercultural communication in the modern world, starting with the major historical and sociopolitical events of the second half of the 20<sup>th</sup> century (Second World War, revitalization movement in the 1960-the 1970s, collapse of the Soviet Union) (Judt, 2006) to nowadays’ effects of globalization and recent geopolitical conflicts and relocations, the western world is characterized by considerable ethnic, cultural, religious, racial, and linguistic diversity. Thanks to boosted migration and mobility flow people are challenged to embrace diversity and communicate changing codes and languages (Hua, 2014). So, in a multilingual

environment, bi-/multilingualism in everyday life is connected with appropriate language choices preferred in various domains (home/family, church/religion, work/employment, and school/education), taking into account the sociocultural surroundings per occasion. Moreover, in comparison with manifestations of multilingualism in the past, there is no longer a geographical restriction, it is not linked with specific social strata, professions, or religions, and thanks to the Internet development, multilingual communication is characterized by multimodality and instantaneity (Cenoz, 2013).

In addition, as the family is the primary agent of socialization, the field of family language policy has been explored to explain how the implicit beliefs and norms for language acquisition influence children's language socialization through family interactions (Kheirkhah, 2016; Ochs, 1996; Shohamy, 2006; Tannenbaum, 2012). This justifies the adoption of concrete and different linguistic attitudes compared to the background experiences and the language maintenance or loss in the migration setting (Fishman, 1970; Li Wei, 2012). Important research surveys reflect on the social impact on families' choices concerning the minority language, majority language or both languages use for everyday communication (Schwartz, 2010), the intended goals (Spolsky, 2012), or language management, ideologies, and practices (Kheirkhah, 2016). Of course, parents' experiences of multilingual practices are inescapable in raising children (Curdts-Christiansen & Wang, 2018).

Furthermore, bilingualism is addressed positively in everyday interactions, as several studies advocate in favor of bilinguals' cognitive advantages across their lifetime compared with monolinguals (Bialystok & Craik, 2010; Bright & Filippi, 2019). Also, bilingualism is important in the context of trade and technological and electronic environments, migration, minorities, in traditionally bilingual countries, and translation. To this extent, European Union has established *plurilingualism* to encourage the linguistic skills of European citizens (Abdullahi, 2017; Cenoz, 2013).

On the opposite, contradiction is often expressed, especially for "linguistic hegemony" (Hatzisavvidis, 1999). Concretely, English is viewed as an agent for linguistic imperialism, a vehicle for social and economic mobility (Brutt-Griffler, 2005), a solution proposed for escaping from poverty (Bruthiaux, 2002; Pennycook, 2004), or as a global lingua franca, to achieve global justice and prosperity (Cenoz, 2019; Picento, 2015). In the Greek context, speaking English is associated with language learning, but is also a basic communication requirement for learners with immigrant backgrounds (Skourtou, 2011). Of course, the preferences of language learning (LL) in Greece are widely known: European languages primarily: English, French, and German in the official public school system, and Spanish/Italian, and non-European ones such as Turkish, Chinese, Russian, or Arabic in secondary level and through private educational institutions.

#### *Language ideologies*

As Gkaintartzi and Tsokalidou (2011) mention, the term "language ideology" has been discussed by researchers from various perspectives. In short, it is associated with a discussion about the formation and development of beliefs and attitudes toward language learning, but also the use of a particular language (Fairclough, 1989; Gkaintartzi & Tsokalidou, 2011; Martínez-Roldán & Malavé, 2004). Language ideologies arise as social constructions (Cenoz, 2013; Gkaintartzi & Tsokalidou, 2011; Schieffelin et al., 1998). Considering this, we could understand adolescents' views and beliefs about native and second language use by focusing on the agents of socialization that promote such ideological reflections on the power of language knowledge, heritage language, and English as a "language ticket" in intercultural communication in the globalized world (Blommaert, 2010; Cenoz, 2019).

## **Methodology**

### *The study*

The current study presents semi-structured interviews conducted with three bilingual/multilingual adolescents, enrolled in Senior High School in Patras and Thermo Etoloakarnanias. The primary goal of the research is to examine the practices of multilingualism and translanguaging (using both native language and second language) in everyday life in the concrete Greek provinces and cities, as far as our society becomes more and more multilingual. The study focuses on attitudes towards the different languages spoken, experiences, and views about multicultural communication in modern reality by 17-year-old persons with a multicultural background.

### *The sample and the interviewees' profile*

Sampling was based on the available subjects. Also, the age group was taken into account, so that the respondents have common experiences, despite their diverse backgrounds. The profile of the interviewees concerns adolescent students of the first two grades of Senior High School. The research sample consists of two adolescents with migrant backgrounds and one adolescent of semi-Greek origin. Specifically, interviews were conducted with:

- a 17-year-old boy from Romania who has been in Greece for the last two years. He lives in Patras and is studying in the First grade of Vocational High School (EPAL). His level in Greek is estimated between B1-B2. [Hereinafter referred to as R]
- a 17-year-old girl from Albania who has been in Greece for about a year and a half and is studying in the second year of Senior High School in Thermo, Etoloakarnania. Her level in Greek is estimated between B1-B2. [Hereinafter referred to as A]
- a 16,5-year-old girl with a Greek father (with studies abroad) and a mother of Iranian origin, and with relatives in England. This girl has stayed in England for a long time and most of the time in Greece. She attends the Second year of Senior High School in Thermo, Etoloakarnania, as well. [Hereinafter referred to as G]

### *The research tool*

The research tool is a semi-structured interview, based on ethnomethodological research and the selection of a qualitative interpretive approach (Babbie, 2017; Creswell & Poth, 2018; Long, et al., 2012). With these tools, it is taken into account that human experience is fluid and arises as a "social construction" and thus is transferred. Furthermore, the spontaneous answers of the respondents are analyzed concerning the scientific literature in the examined field. The semi-structured interviews were conducted individually and by telephone (to facilitate the conversation and to avoid interruptions on Internet access). They followed after a personal communication between the researcher and the parents, who were asked for their consent for the child's participation in the research through a consent form/sheet. The interview included demographic data (origin and native language (L1), age, time/years of living in Greece for the adolescent and his/her parents, and the following 4 questions:

Q1: Which language do you use in your daily life (home, school, with friends, with other people)? When? Please give us an example!

Q2: Do you consider bilingualism as an asset or a problem and why?

Q3: How do you feel when using L1?

Q4: How do you feel when using L2?

The spontaneous responses were transcribed and analyzed through content analysis methodology (Bazeley, 2013), making correlations with already studied data in the scientific bibliography.

## **Results**

Starting from the study of the answers to each research question we can critically discuss the following issues.

Q1. Which language do you use in your daily life (home, school, with friends, with other people)? When? Please give me an example!

The interviewees used different languages depending on the social environment and context in which they were each time. In the family environment, they spoke mainly the heritage language (Romanian, Albanian, or Greek-English). Meanwhile, as far as the dominant language in the school curriculum was Greek, and the participants used only this language with teachers. However, with their Greek-speaking friends or classmates, the adolescents often used translanguaging and switched codes for communication. At the same time, the students with a migrant background positively recognized and welcomed the English language speaking of their classmates, and the help they received from them since the English language seems to bridge the communication gap of linguistic diversity. Translanguaging and the use of bilingualism as a daily practice, however, also existed in-home communication according to the respondents.

- R claimed: "But I think I should start talking more Greek, but with my family, I usually talk Romanian, my native language"
- A mentioned that communication was complicated, even with her parents, given that: *"I push them up and mix them up all the time. Like, when I'm at home, I usually speak Albanian with a little bit of Greek. Like, like, I never finish a sentence in one language... I always switch in the middle of the sentence. And, yeah, because both of my parents and my siblings know both Albanian and Greek. So, we just like... it's really complicated talking... We don't talk in just one language"*.
- A similar answer was received by the third respondent (G): *"When you come to us you can hear many languages. So, we have English, Greek, Iranian and Romanian. Yeah, with my brother I speak mainly in English and Greek, with my mother I'm gonna talk either in person in Greek or English and with my father mainly in Greek. Also, my parents when they... Also, about the Romanian, my parents do want us to learn about something else [she meant the language] and they talk in Romanian"*.

Translanguaging seemed to be an inevitable process to achieve effective communication, for finding the appropriate vocabulary in each language use. It should also be noted that G felt the need to switch her language during the interview (English to Greek) as well, for words related to the skills of using academic vocabulary (G: *So, there was a problem there because I and my brother had like κάποιες ελλείψεις στη γλώσσα στα ελληνικά [some lacks in the language in Greek] in comparison with other children*)).

Q2: Do you consider bilingualism an asset or a problem and why?

All three multilingual respondents answered that bilingualism has advantages and disadvantages. With examples from their experience, participants justified their point of view.

R	<ul style="list-style-type: none"> <li>• "you get a better job"</li> <li>• "you have a better vocabulary"</li> </ul>	<ul style="list-style-type: none"> <li>• "you can lose vocabulary"</li> <li>• "most of the time I forget words"</li> <li>• "You lose vocabulary very fast".</li> </ul>
A	<ul style="list-style-type: none"> <li>• "you know a lot about other cultures"</li> <li>• "It can actually help you, like, get a proper job"</li> <li>• "You can communicate with"</li> </ul>	<ul style="list-style-type: none"> <li>• "you start forgetting (...) the other languages, your native language for example."</li> <li>• "Sometimes I cannot find the word (...) you start forgetting a lot of things"</li> <li>• "Your memory (...)"</li> </ul>



	people from different countries"	weakens."
<b>G</b>	<ul style="list-style-type: none"> <li>• "like English (...) is international (...) you can talk everywhere on the planet in English..."</li> <li>• "can communicate with people from other countries"</li> <li>• "There is no barrier in that with languages"</li> </ul>	<ul style="list-style-type: none"> <li>• "A problem is..."</li> <li>• Like my mother... she is Persian. And (...) when we (the children) were younger (...) until seven years old (...) my mother talked to us in English. So, (...) me and my brother had like κάποιες ελλείψεις στη γλώσσα στα ελληνικά [some lacks in the language in Greek] in comparison with other children, which have both parents speaking in Greek".</li> </ul>

On the one hand, the advantages included the ability to speak many foreign languages and their impact on professional life and personal progress, such as eloquence and rich vocabulary. Equally important was the view about in-depth knowledge of other cultures (A). So, an intercultural perspective of cultures was shaped. A special point was the use of English as an international language that breaks down the barriers between people. On the other hand, the disadvantages included loss of vocabulary skills, because of memory weakness (as A claimed) or confusion. Also, when the children were very young and the language of the dominant/host society was not used at home, they faced language deficits when they started school. Thus, expression in specific contexts was prevented from being completed in a single language.

*Q3: How do you feel when using L1?*

Regarding their feelings about using the native language (L1), the respondents answered the following:

<b>R</b>	<ul style="list-style-type: none"> <li>• "I feel like I can express myself better... I know everything that I'm going to say and I say it, I can express things better"</li> <li>• "I feel more comfortable"</li> <li>• "my native language... that's how I learned it, I grew up learning that language"</li> </ul>
<b>A</b>	<ul style="list-style-type: none"> <li>• "usually more easygoing"</li> <li>• "more carefree"</li> <li>• "more rebellious and more..."</li> <li>• "I just get really nostalgic when I'm speaking in my native language because it brings back all the memories like when I lived back in Albania. And this kind of... not sad... but I left Albania..."</li> </ul>
<b>G</b>	<ul style="list-style-type: none"> <li>• "So, Greek is my initial language I would say because it has a very rich vocabulary"</li> <li>• "And yes, it's my native, you know, I use it. Like when I'm going to talk about something formal, I use my native language, because I grew up with it. And I feel like (...) Like nice..."</li> </ul>

- “When I go to (...) England (...) and we meet with other people and say I am Greek, they get like excited, because they said ‘Oh, ancient Greek, Homer, and Acropolis’..., so that's cool. When you hear other people saying your language is cool, you feel cool too. And you speak that language...”

Generally, when L1 was spoken, positive emotions came up, related to the best expression, carefreeness, security, safety, clearness, convenience, and confidence, as far as there was a sense of spontaneity and effective communication. The argument in most cases was expressed with the word “just” since L1 is the heritage language and had been acquired from birth. From the G’s answers, pride for the heritage language was highlighted as well, given that the Greek language was her native language and had cultural symbolism of supremacy due to ancient Greece’s glamor abroad.

*Q4: How do you feel when using L2?*

The use of the second language caused mixed emotions in the interviewed adolescents of the present research. Fragments of their given answers are:

<b>R</b>	<ul style="list-style-type: none"> <li>• “I <b>need</b> to speak Greek outside because I live in Greece”</li> <li>• “a bit uncomfortable, like, it's like I’m speaking a code, I don’t know how to say. Like I speak what I've learned”</li> <li>• “This is bad sometimes because I'm scared at school to use it”</li> <li>• “I feel scared sometimes”</li> <li>• “Stress as well”</li> </ul>
<b>A</b>	<ul style="list-style-type: none"> <li>• “[Speaking for Greek] hard issue, like a big obstacle for me in my life”.</li> <li>• “When I use English, like, I just became more kind of like <b>professional</b>. I don't know why... I just have this kind of vibe”</li> <li>• “Also using English it's easier for me (...) easier than Albanian (...) English is easier. And it's just, I just really like English. Like as I said... English just makes things easier”</li> </ul>
<b>G</b>	<ul style="list-style-type: none"> <li>• “So, although, I am in Greece, I live in Greece, I was born in Greece...Like for me, English was always important to me, because, like all my family from my mother's side is in England”.</li> <li>• “So, in England, we have a lot of cousins there. And, yeah, I always like English because I could talk to them, and my friends there”</li> <li>• “So, I feel very like relaxed when I speak in English. It is easy too. And I like the accent too.”</li> <li>• “Yeah, I would say I prefer English a little bit better because it has (...) a special part in my heart”</li> </ul>

Taking all the above into consideration, it is observed that in the case of the first adolescent with a migrant background and a relatively short stay in Greece, the use of the language of the host society frightened the speaker. Stress and fear came up. Also, the expression of the necessity to speak Greek was characteristic. Alongside, he claimed that he had experienced uncomfortable situations. Probably, the fear was caused by the possibility of making expressive

mistakes in front of the native speakers of a language, since the learning of Greek had not occurred naturally, but through the educational process.

However, regarding the use of English, according to A and G, English seemed to be easier than native languages (Albanian and Greek). The girl from Albania claimed that she felt “more professional” speaking English, while the semi-Greek girl connected the use of L2 with enhancing the family bonds and communication with other relatives; that's why she felt “more relaxed”.

From these contexts, stimuli of reflection arise on the ideologies and prejudices that people have about the ease of some languages, e.g., due to grammar. Perceptions and feelings follow family, emotional bonds between members of (linguistic) communities, and get symbolic dimensions of language (Cummins, 2000, 2001) and the power of language (Fairclough, 1989).

### **Discussion**

Through the analysis of all three interviewees' discourse, multilingualism and translanguaging are positively appreciated by multilingual adolescents today. However, the adolescents live in a general monolingual environment; and in the Greek educational system practices like translanguaging are not applied formally to support the non-Greek speakers' linguistic inclusion. Nevertheless, the English language, since it dominates in the adolescents' answers, plays a crucial role as a linguistic channel for communication, when it comes to second language learners with poor vocabulary skills (Cenoz, 2019). This illustrates that bi-/multilingualism is either completely rejected in Greece or is limited to the superficial use of English as a mediate language (cases of translations and scaffolding) (Skourtou, 2011). At the same time, it is important to establish the existence of individual multilingualism, regardless of speech adequacy or proficiency skills (Cenoz, 2013).

It is also confirmed that multilingualism is a holistic phenomenon, while bilingualism has an individualistic character upon speakers. Also, there are cognitive outcomes, as multilingual speakers realize the use of their language, conceptualize it and talk about it in meta-linguistic discussions (Cenoz, 2013).

Regarding the minority language, the interviewees testify that they use it intensively when communicating with other members of the minority and people with shared cultural identities (parents, siblings, relatives, and friends from their homeland). The heritage language is recognized and estimated with high cultural value, and there seems to be a fear of losing it (Gounari, 2014). In fact, at the level of Family Language Policy, the effort to maintain the native language is visible as desired and performed. Likewise, despite code-switching's frequency, the dilemma of maintenance or loss of the native language in favor of the full use of the host country's language is replied to with the practical adoption of the heritage language inside the home and with relatives. Also, in all the adolescents' words, possessive pronouns were used (*my language, my country, etc.*), making obvious their positive emotions about the undoubtedly useful, efficacious, and confident feelings for their heritage language, in perfect agreement. It is therefore obvious the nostalgia and the love for their homeland and memories. Even for the use of Greek as a native language arise emotional and symbolic dimensions of language and superiority (Cummins, 2001; Holmes, 2008).

Furthermore, it seems that there is no social pressure to follow an assimilative behavior in the language, adopting only the Greek, for the generation of 17-years-olds in the Greek social context. On the contrary, this generation can express its self and ethnic identity, through the linguistic communicative tool, adopting even translanguaging in the public societal domain (in informal interpersonal relationships). Along with this, intercultural communication is enhanced thanks to cross-linguistic and cross-cultural interaction of code-switching and negotiating of identities (with English gaining a particular position compared to other second languages (Cenoz, 2013, 2019).

Last but not least, the views on the use of a language reflect the perceptions that others have about our language; and they are social constructs (Cenoz, 2013). Taking into account the terms of sociology and psychology, the use of a specific language encourages some emotions related

to self-esteem and self-image. For example, the second interviewee (A) referred to changes in “personality” and attitude [So, basically, when *I talk in each language, I have like my voice changes. So, when, and even my attitude changed, like, even my personality, for some reason, I don't know how it happened. I think it's something like psychological or something I don't know...*]. Additionally, the third interviewee (G) claimed that her feeling about speaking her native language stems from how others feel about using that language (*When you hear other people saying your language is cool, you feel cool too*). Here the social effect is illustrated.

### Conclusion

Given the small sample studied we cannot generalize the results of this study. However, the present research is a clear indication of what occurs in the current social context of the becoming a more and more multicultural society in Greece, in two provincial regions. In the future, by extending the research field from the present essay, further investigation could be conducted for multi/bilingualism and translanguaging in the public domain, of the (non) use of minority language in the school context, the workplaces, or recreation areas in the Greek environment.

To sum up, in multilingual societies, bilingualism is widely used. Despite the more controlled official situations, especially in school, where multimodal and multilingual aspects are associated with dominant practices (Garcia & Othegu, 2019), translanguaging is a never-ending continuum in multilingual speakers and language learners’ discourse for the conceptualization of language and meaning-making (Wright et al., 2017). Translanguaging interconnects learners’ identity and cognitive complexities and permits their active participation in language utterances socially and educationally determined. In other words, it permits the integration of new language features into a given linguistic repertoire, already known to the speaker (Wright et al., 2017) and benefits social inclusion (Hughes et al., 2006; Kokkini, 2019; Lightbrown & Spada, 2011) and the individual’s socioemotional development (Kokkini, 2019: 40-42; Tsokalidou, 2018). Finally, translanguaging is and should be considered a principal element for pedagogical practices in bilingual classrooms, as far as multiple advantages are enumerated (Baker, 2001, 2011; Cenoz & Corter, 2015) for assisting the learning and teaching process (García, 2009; Tsokalidou, 2017). In the end, this powerful linguistic mechanism bridges the two sides between the social spoken language and the home-native language (Cummins & Early, 2011).

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## **Gender differences in Attitudes and Behaviors associated with Electromagnetic Radiation of Mobile Phones and Wireless Networks**

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### **Abstract**

The issue of gender differentiation has preoccupied researchers and led them to conduct studies covering many areas of interest. However, research on electromagnetic radiation from devices such as mobile phones and wireless networks is relatively limited. The purpose of the research was to investigate the attitudes and behaviors of young people regarding the electromagnetic radiation emitted by mobile phones and wireless networks, and whether they are related to their gender. The participants were 198 men and 421 women. The data was collected using a close ended questionnaire. The general conclusion of the research was that young people have a negative attitude towards the electromagnetic radiation emitted by mobile phones and wireless networks without any correlation with their gender. However, correlation was found with certain behaviors they follow to protect their health from it, especially when specialized knowledge was required.

**Key words:** attitudes, behaviors, electromagnetic radiation, students, gender, mobile phones, wireless networks

### **Introduction**

#### **Mobile phones and Gender differences in contemporary life**

Mobile phones combined with the increase in the use of wireless technologies are the most important developments in Information and Communication Technologies (ICT). Smartphone technology and their constant connection to the internet have led to a huge increase in the number of users of all age groups (Piper et al., 2019). Young children use mobile phones mainly for entertainment and education. Teenagers and young adults also use them as a means of communicating with their peers. Finally, older people use them in e-commerce, e-government and for their information (Andone et al., 2016). It is obvious that all the new features offered by mobile phones and wireless technologies can influence people's attitudes and behavior as well as their usage patterns (Park et al., 2021).

Gender differences have always been an important factor whenever any pattern of behavior is studied in the social sciences. This provides very critical demographic information and ultimately helps researchers, educators and policy makers understand the issue in greater depth. An important part of the research focuses on the differences between genders in the field of Sciences (Barrow-Green et al., 2018; Chiu et al., 2018). The researchers argue that the different attitudes and perceptions of genders towards Sciences are directly related to the different experiences during school ages, as well as the different way in which they perceive the science of Physics. Like any other habit, there are significant gender differences in mobile

phone habits. There is considerable evidence that men and women have different patterns of Internet activities and preferences for mobile phone use (Taywade & Khubalkar, 2019).

#### **Electromagnetic radiation and health**

The extensive use of new technologies, especially mobile phones, has raised the awareness of researchers because problems have been identified in the physical, mental and social health of users (Shoukat, 2019). Users of new technologies are becoming interested in issues related to electromagnetic radiation, because devices such as mobile phones, laptops and wireless networks, emit electromagnetic waves in the radio frequency range (Mailankot et al., 2009). Human exposure to electromagnetic radiation has increased rapidly in recent years. The reasons are the development and use of wireless technology and the change in humans' social behavior (World Energy Council, 2016).

The World Health Organization (WHO) defines Health as the state of complete physical, mental and social well-being, characterizing it as a fundamental human right (WHO, 1946). The International Agency for Research on Cancer (2011) has classified electromagnetic radiation in the radio frequency range as possibly carcinogenic to humans (group 2B). Because it usually takes more than twenty years for a cancer to develop, the currently negative research findings do not clearly indicate the absence of risk (Magiera & Solecka, 2020). The absorption of energy from radiation can cause the molecules of the human body to vibrate, which leads to tissue heating. This absorption is determined by the Specific Absorption Rate (SAR). It is calculated as the energy absorbed by a certain mass of tissue, within a certain period of time and is measured in units of power per mass (W/kg) (International Commission on Non-Ionizing Radiation Protection, 2009). United States and European Union have set safety limits for the energy absorbed by the body from exposure to a cell phone (Varshney et al., 2018). Many researchers express strong concerns about the effects of long-term exposure to electromagnetic radiation from mobile phones on living organisms (Hu et al., 2021; Kesari et al., 2018; Magiera & Solecka, 2020; Sharma et al., 2020).

In addition, research has shown that electromagnetic radiation can also affect human cognitive functions (Brzozek, 2018). Other research focuses on the addictive side of specific technologies, which are particularly harmful to the mental health of users (Ayadi et al., 2021). We conclude that the extensive use of mobile phones can have a serious impact on people's physical, cognitive and social health.

#### **Education in developing critical thinking for health decisions**

The development of critical thinking contributes to the creation of active people and is one of the main goals of education, beyond the acquisition of knowledge (Albanese & Paturas, 2018). Students should be able to think critically and use their knowledge to make appropriate decisions about their personal health and safety. Adolescent risky behaviors are linked to their perceptions of risk and may remain in the form of habits throughout their lives (Martha & Griffet, 2007). Studies on teenagers' risk perceptions of mobile phones are very rare. However, some studies have shown that there are significant differences in relation to the individual's age, gender, and educational background (Kang & Jung, 2014).

Therefore, it is important to design effective teaching approaches aimed at acquiring scientific knowledge and developing critical thinking about electromagnetic radiation emitted by devices that people use every day. For their design, it is necessary to investigate the attitudes and behaviors of mobile and wireless users, because as previously mentioned the number of relevant studies is limited.

#### **Research questions**

The research questions of this study can be summarized as follows:

- a) What is the attitude of respondents towards electromagnetic radiation in the radio frequency spectrum emitted by mobile phones and wireless networks in terms of its effects?

b) What are the respondents' behavior and practices regarding protection from the emitted electromagnetic radiation of these devices?

c) Is there any correlation between attitudes and behaviors of respondents, according their gender?

### Methodology

A total of 198 (32%) men and 421 (68%) women participated to the study. The collection of quantitative data was carried out using a close ended questionnaire. The questionnaire and the data of this research are part of a larger research on electromagnetic radiation and pollution. Due to the size of the questionnaire, the limited time to complete it and the particular characteristics of the sample, after experts consensus, questions with binary answers (yes - no) were chosen, although Likert-type questionnaires are mainly used in research when examining attitudes (Joshi et al., 2015).

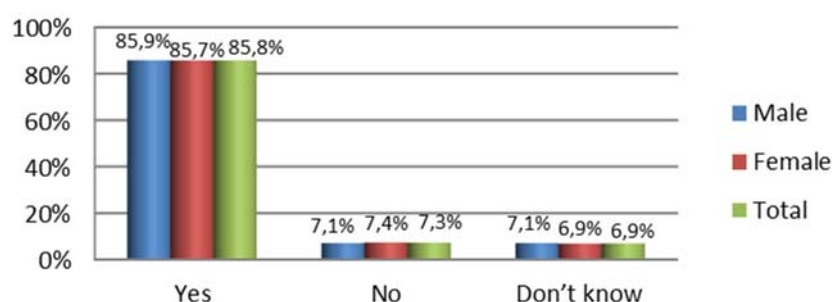
The validation and feasibility of the questionnaire was carried out in the pilot research. Three experts confirm the face validity and content validity of the research tool. The Kuder-Richardson Formula 20 (KR-20) coefficient was chosen to determine the internal consistency because our data was binary variables. The value of the KR-20 coefficient in this research was .722 and considered as acceptable (Foster, 2021; Glen, 2016).

The statistical processing and analysis of the data was based on the statistical program SPSS (Statistical Package for Social Sciences) version 21. Descriptive statistics were used and the appropriate tables and diagrams were created for the visual representation of the results with Microsoft Excel 2007. To inquiry the correlation of the answers with the variable "Gender" of the respondents, the statistical criterion  $\chi^2$  test (Pearson chi-square) was used with a significance level  $\alpha=.05$  (Shih & Fay, 2017).

### Results of Analysis

#### Attitudes questions

According to participants' responses to 1<sup>st</sup> question, "Do you think that the use of mobile phones causes biological effects in humans?" there wasn't any significant difference between answers of men and women (Figure 1).



**Figure 1: Participants' answers to 1<sup>st</sup> question: "Do you think that the use of mobile phones causes biological effects on humans?"**

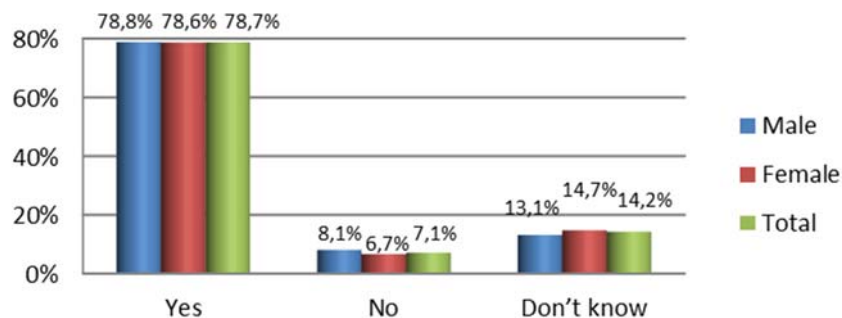
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 1<sup>st</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(2, N=619)=.023, p=.989>.05$  (Table1).

**Table 1. Chi-Square Test of Independence between 1<sup>st</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,023 <sup>a</sup>	2	,989
Likelihood Ratio	,023	2	,989
Linear-by-Linear Association	,021	1	,884
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.

In 2<sup>nd</sup> question, "Do you think cell phone towers have biological effect on animals?" again there wasn't any significant difference between answers of men and women. Both believe that there is a risk in a high percentage (Figure 2).



**Figure 2: Participants' answers to 2<sup>nd</sup> question "Do you think cell phone towers have biological effect on animals?"**

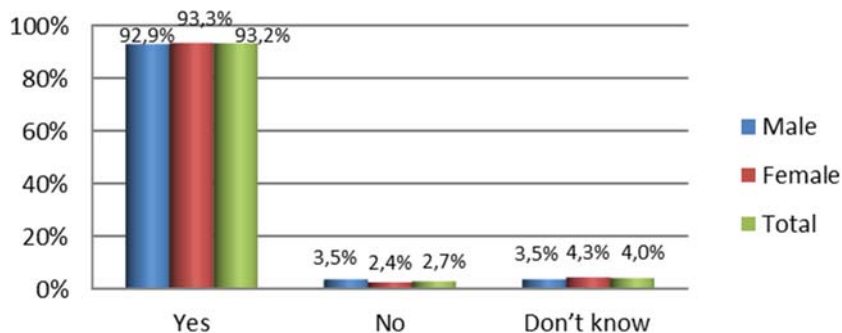
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 2<sup>nd</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(2, N=619)=.629, p=.730>.05$  (Table 2).

**Table 2. Chi-Square Test of Independence between 2<sup>nd</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,629 <sup>a</sup>	2	,730
Likelihood Ratio	,624	2	,732
Linear-by-Linear Association	,591	1	,442
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.

In 3<sup>rd</sup> question, "Do you think that electromagnetic radiation can cause health problems in humans?" both men and women answered positively, with almost same percentages (Figure 3).



**Figure 3: Participants' answers to 3<sup>rd</sup> question: "Do you think that electromagnetic radiation can cause health problems in humans?"**

A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 3<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(2, N=619)=.845, p=.655>.05$  (Table 3).

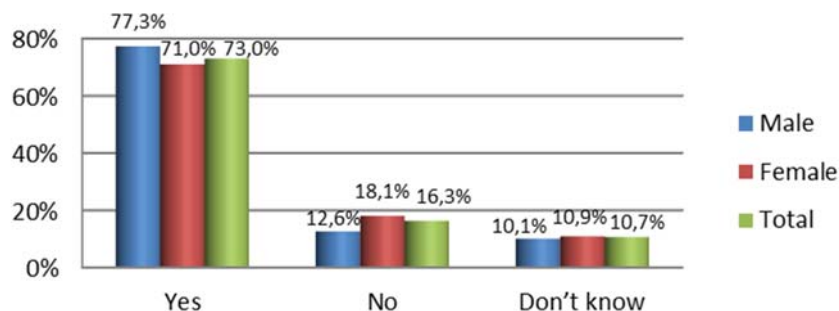
**Table 3. Chi-Square Test of Independence between 3<sup>rd</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,845 <sup>a</sup>	2	,655
Likelihood Ratio	,822	2	,663
Linear-by-Linear Association	,717	1	,397
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.



In 4<sup>th</sup> question, "Do you think that electromagnetic radiation is more dangerous for young children than adults?" 77,3% of men answered positively. Women answered positively in this question with a lower percentage (Figure 4).



**Figure 4: Participants' answers to 4<sup>th</sup> question: "Do you think electromagnetic radiation is more dangerous for young children than adults?"**

A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 4<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(2, N=619)=3.237, p=.198>.05$  (Table 4).

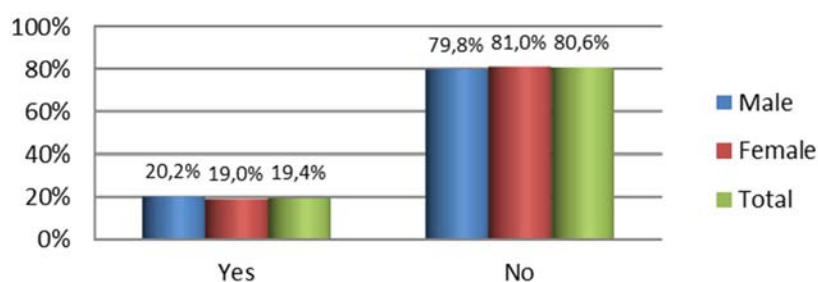
**Table 4. Chi-Square Test of Independence between 4<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	3,237 <sup>a</sup>	2	,198
Likelihood Ratio	3,345	2	,188
Linear-by-Linear Association	1,067	1	,302
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.

#### Behaviors questions

In 5<sup>th</sup> question, "Would you install a mobile phone antenna on the roof of your house?" only 19.4% of respondents gave a positive answer. Both men and women answered in the negative, with almost same percentages (Figure 5).



**Figure 5: Participants' answers to 5<sup>th</sup> question "Would you install a mobile phone antenna on the roof of your home?"**

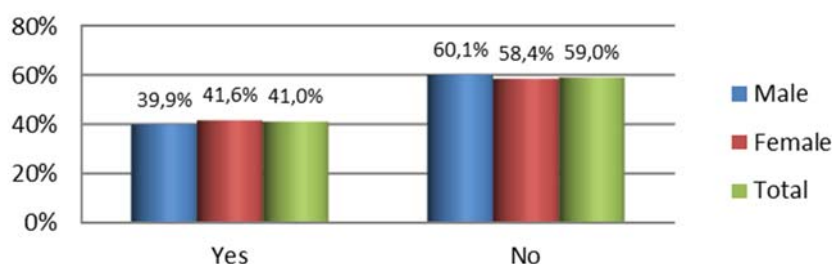
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 5<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=.124, p=.725>.05$  (Table 5).

**Table 5. Chi-Square Test of Independence between 5<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,124 <sup>a</sup>	1	,725
Continuity Correction <sup>b</sup>	,059	1	,808
Likelihood Ratio	,123	1	,725
Linear-by-Linear Association	,124	1	,725
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 6<sup>th</sup> question, "Would you prefer, within the boundaries of your area, to not have mobile phone antenna towers?" both men and women with almost same percentages of around 60% answered in this question in the negative (Figure 6).



**Figure 6: Participants' answers to 6<sup>th</sup> question "Would you prefer, within the boundaries of your area, to not have mobile phone antenna towers?"**

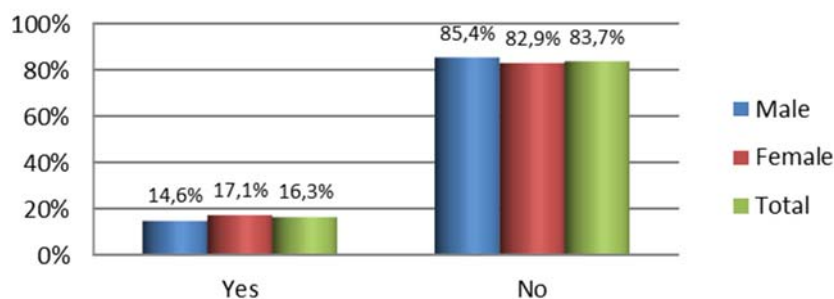
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 6<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=.155, p=.694>.05$  (Table 6).

**Table 6. Chi-Square Test of Independence between 6<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,155 <sup>a</sup>	1	,694
Continuity Correction <sup>b</sup>	,094	1	,760
Likelihood Ratio	,155	1	,694
Linear-by-Linear Association	,155	1	,694
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 7<sup>th</sup> question, "Would you rather not have wireless networks in university classrooms?" only 16.3% of respondents answered positively. Both men and women had almost same percentages of responses (Figure 7).



**Figure 7: Participants' answers to 7<sup>th</sup> question "Would you rather not have wireless networks within the university (classrooms, laboratories)?"**

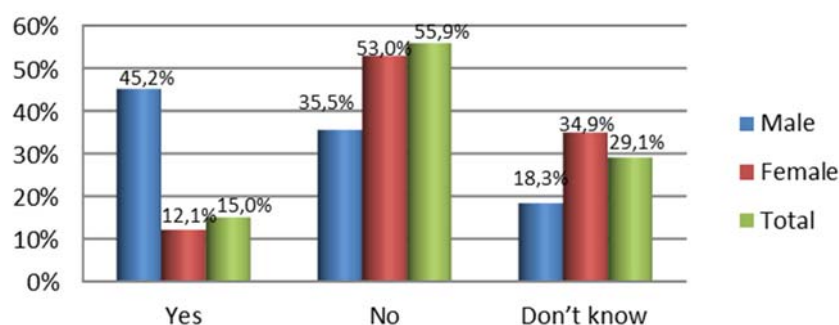
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 7<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=.595, p=.441>.05$  (Table 7).

**Table 7. Chi-Square Test of Independence between 7<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,595 <sup>a</sup>	1	,441
Continuity Correction <sup>b</sup>	,428	1	,513
Likelihood Ratio	,604	1	,437
Linear-by-Linear Association	,594	1	,441
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 8th question, "Is the rate of SAR of a mobile phone the main criterion for you when buying it?" a large difference was found in the answers of the respondents. The percentage of men's positive responses was 45.2%, while that of women was only 12.1% (Figure 8).



**Figure 8: Participants' answers to 8<sup>th</sup> question "Is the rate of SAR of a mobile phone the main criterion for you when buying it?"**

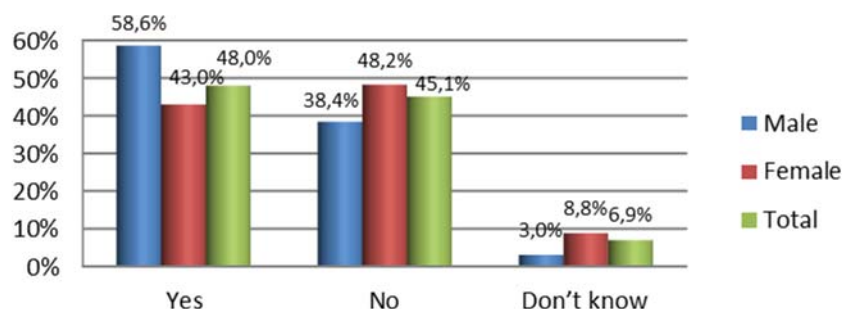
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 8<sup>th</sup> question and the gender of the participants. There was a significant relationship between the variables,  $\chi^2(2, N=619)=24.862, p=.000<.05$  (Table 8).

**Table 8. Chi-Square Test of Independence between 8<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	24,862 <sup>a</sup>	2	,000
Likelihood Ratio	26,043	2	,000
Linear-by-Linear Association	12,979	1	,000
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.

In 9<sup>th</sup> question, "Do you prefer to use wired network to connect your computer to the Internet at home?" a large difference was found again in the answers of the respondents. The percentage of men's positive responses was 58.6%, while that of women was 43% (Figure 9).



**Figure 9: Participants' answers to 9<sup>th</sup> question "Do you prefer to use wired network to connect your computer to the Internet at home?"**

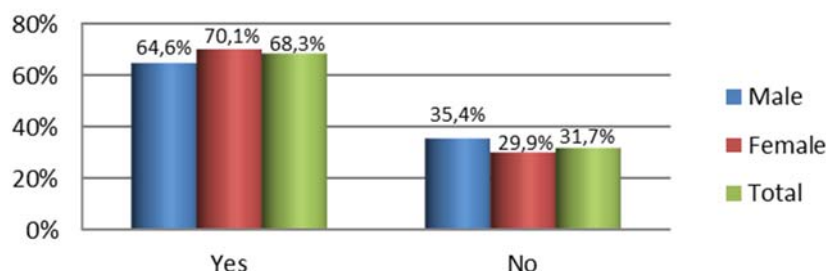
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 9<sup>th</sup> question and the gender of the participants. There was a significant relationship between the variables,  $\chi^2(2, N=619)=16.142, p=.000<.05$  (Table 9).

**Table 9. Chi-Square Test of Independence between 9<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	16,142 <sup>a</sup>	2	,000
Likelihood Ratio	17,018	2	,000
Linear-by-Linear Association	,596	1	,440
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5.

In 10<sup>th</sup> question, "Do you prefer to use wired headphones or speakerphone mode while talking on your mobile phone?" women scored the highest percentage of positive responses with 70.1%. The percentage of men who answered positively was a little lower with 64.6% (Figure 10).



**Figure 10: Participants' answers to 10<sup>th</sup> question "Do you prefer to use wired headphones or speakerphone mode while talking on your mobile phone?"**

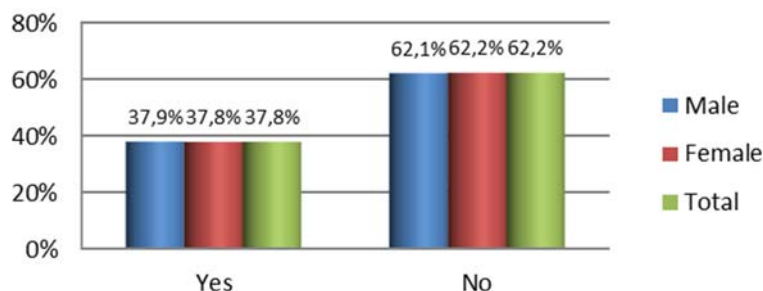
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 10<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=1.832, p=.176>.05$  (Table 10).

**Table 10. Chi-Square Test of Independence between 10<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,832 <sup>a</sup>	1	,176
Continuity Correction <sup>b</sup>	1,589	1	,207
Likelihood Ratio	1,814	1	,178
Linear-by-Linear Association	1,829	1	,176
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 11<sup>th</sup> question "Do you prefer to talk on corded telephones instead of cordless?" both men and women scored almost the same percentages in their answers (Figure 11).



**Figure 11: Participants' answers to 11<sup>th</sup> question "Do you prefer to talk on corded telephones instead of cordless?"**

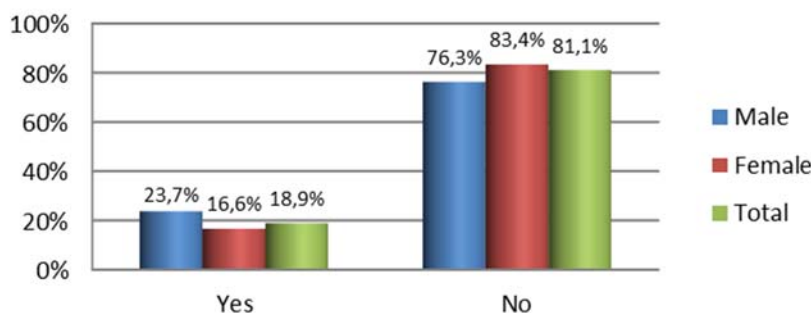
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 11<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=.001, p=.979>.05$  (Table 11).

**Table 11. Chi-Square Test of Independence between 11<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,001 <sup>a</sup>	1	,979
Continuity Correction <sup>b</sup>	,000	1	1,000
Likelihood Ratio	,001	1	,979
Linear-by-Linear Association	,001	1	,979
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 12<sup>th</sup> question "When you don't use your home's WiFi network, do you turn off your router?" women scored the highest percentage of negative responses with 83.4% (Figure 12).



**Figure 12: Participants' answers to 12<sup>th</sup> question "When you don't use your home's Wi-Fi network, do you turn off your router?"**

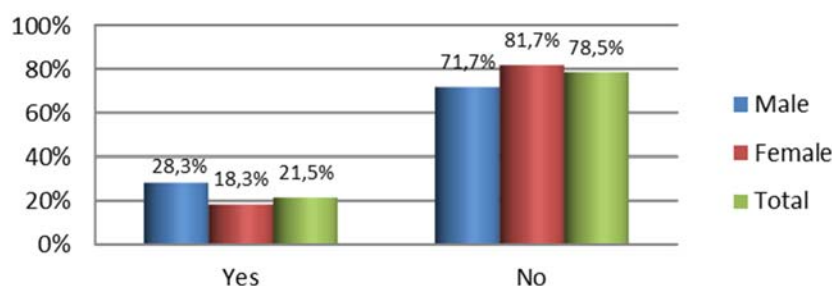
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 12<sup>th</sup> question and the gender of the participants. There was a significant relationship between the variables,  $\chi^2(1, N=619)=4.441$ ,  $p=.035<.05$  (Table 12).

**Table 12. Chi-Square Test of Independence between 12<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	4,441 <sup>a</sup>	1	,035
Continuity Correction <sup>b</sup>	3,990	1	,046
Likelihood Ratio	4,314	1	,038
Linear-by-Linear Association	4,434	1	,035
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 13<sup>th</sup> question "When you sleep do you turn off or set your mobile phone in 'flight mode'?" women scored the highest percentage of negative responses with 81.7% (Figure 13).



**Figure 13: Participants' answers to 13<sup>th</sup> question "When you sleep do you turn off or set your mobile phone in 'flight mode'?"**

A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 13<sup>th</sup> question and the gender of the participants. There was a significant relationship between the variables,  $\chi^2(1, N=619)=7.972$ ,  $p=.005<.05$  (Table 13).

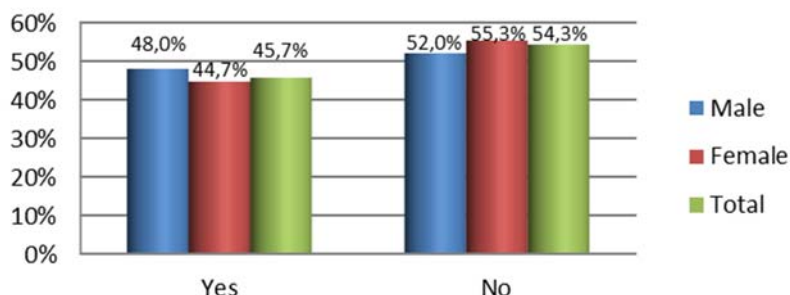
**Table 13. Chi-Square Test of Independence between 13<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	7,972 <sup>a</sup>	1	,005
Continuity Correction <sup>b</sup>	7,390	1	,007
Likelihood Ratio	7,718	1	,005
Linear-by-Linear Association	7,959	1	,005
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table



In 14<sup>th</sup> question, "When you don't use your mobile phone, do you place it at a distance more than one meter from your body?" women scored the highest percentage of negative responses with 55.3% (Figure 14).



**Figure 14: Participants' answers to 14<sup>th</sup> question "When you don't use your mobile phone, do you place it at a distance more than one meter from your body?"**

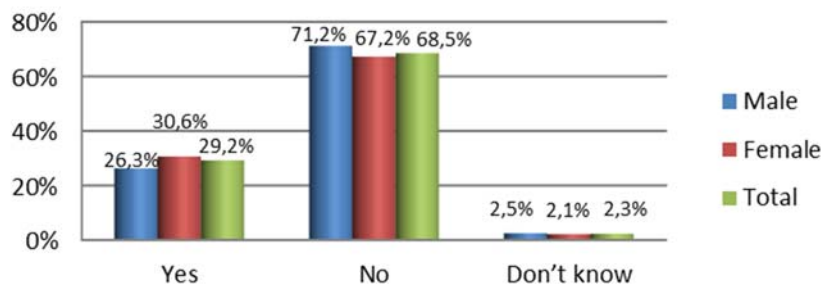
A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 14<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(1, N=619)=.600, p=.439>.05$  (Table 14).

**Table 14. Chi-Square Test of Independence between 14<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	,600 <sup>a</sup>	1	,439
Continuity Correction <sup>b</sup>	,473	1	,492
Likelihood Ratio	,599	1	,439
Linear-by-Linear Association	,599	1	,439
N of Valid Cases	619		

a. 0 cells (0,0%) have expected count less than 5. b. Computed only for a 2x2 table

In 15<sup>th</sup> question, "When you don't need internet, do you disconnect your Laptop or Tablet from WiFi?" men scored the highest percentage of negative responses with 71.2% (Figure 15).



**Figure 15: Participants' answers to 15<sup>th</sup> question "When you don't need internet, do you disconnect your Laptop or Tablet from WiFi?"**

A Chi-Square Test of Independence was performed to assess the relationship between the answers of the 15<sup>th</sup> question and the gender of the participants. There wasn't a significant relationship between the variables,  $\chi^2(2, N=619)=1.286, p=.526>.05$  (Table 15).

**Table 15. Chi-Square Test of Independence between 15<sup>th</sup> question and participants' gender**

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	1,286 <sup>a</sup>	2	,526
Likelihood Ratio	1,299	2	,522
Linear-by-Linear Association	,649	1	,420
N of Valid Cases	619		

a. 1 cells (16,7%) have expected count less than 5.

### **Discussion - Conclusions**

Starting the discussion by answering the research questions of the present study, it was found that the young people's attitude towards the electromagnetic radiation emitted by mobile phones is negative, and they consider it dangerous for living organisms. Other researchers have reached similar results (Muhayawi et al., 2012; Nasser et al., 2018). The percentages noted by the respondents are identical, regardless of gender, so no correlation of the attitudes with the gender of the respondents was found. Many times the content of science courses does not meet the interests of girls, which has the consequence of differentiating the knowledge of genders in the matter of science and technology (Barrow-Green et al., 2018; Chiu et al., 2018). However, the different knowledge and different interests between the genders do not seem to affect their attitude towards electromagnetic radiation. According to research, when the word radiation is used, readers automatically consider it as harmful regardless of its origin (Morales Lopez & Tuzon Marco, 2022). In addition, the internet, which is one of the main means of information for young people, has been found to use the term radiation incorrectly (Sesen & Ince, 2010).

Continuing with the next research question, found that the majority of the respondents don't follow behaviors of protection from the emitted electromagnetic radiation, despite the negative attitude they have towards it. The discrepancy between attitudes and behaviors has also been observed by other researchers (Bhattacharjee & Sanford, 2006; Lee et al., 2017). Correlations between behaviors and gender were mainly found in behaviors that required some specialized knowledge, such as wireless networks and SAR. It seems that the answers were influenced by the knowledge that the participants have acquired during their lives, which are differentiated by the interests of genders. In contrast, no correlations were found in questions that referred to simple behaviors such as corded phone use.

It is very difficult to identify the cause of the inconsistency between attitudes and behaviors. However, we can mention some factors. We start from the youth's need for constant communication, and the anxiety of loneliness (Khademian et al., 2020). In addition, there are many studies that report the phenomenon of young people's addiction to internet and mobile phones (Caponnetto et al., 2021; Kim et al., 2021). If we take these factors into account, we may understand the behaviors of young people, and why they are unable, for example, to turn off their mobile phone or wireless network, thus interrupting their continuous communication. Finally, we should mention that the possible serious effects of electromagnetic radiation are not immediate, since the development of a cancer takes several years. This affects attitude strength, and as a consequence the behaviors of young people. Something similar has been found with smoking attitudes and behaviors. While the health effects are known, they are not enough to stop it, since addiction, and the harmful effects after years, affect the attitude strength (Lee et al., 2017).

In conclusion, it is important to approach the issue of electromagnetic radiation from mobile phones and wireless networks with a preventive policy, because scientists haven't reached definitive conclusions regarding the health effects on living organisms. Further investigation is needed to search for the causes that lead young people to specific behaviors. The purpose of modern education is to empower students with the knowledge and train them for life, regardless of their gender, providing equal learning opportunities.

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## **Introducing impulse to 6th-grade students kinesthetically: The impact on their reasoning**

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### **Abstract**

Pioneers of educational theory have called for a greater emphasis on kinesthetic learning, a claim also supported by interdisciplinary embodied cognition research. This article focuses on the effectiveness of a body-based intervention designed to familiarize participants with the physics concept of impulse. We investigated whether the use of one's own body as an element of activity can help 6th graders successfully adopt adequate reasoning when answering relevant questions. The assessment procedure took the form of an interview and our conclusions demonstrated that students adopt a multimodal framework (speech, gestures, body movement) to solve problems designed to include human-centered experiences, the haptic manipulation of objects, and everyday illustrated situations. The performance of a respectable number of students shifted from a lack of insight into a scientifically accepted conceptualization. Introducing purposeful planned movement when teaching physics concepts in the early years is a valuable tool for any educator wishing to add value to his students' learning.

**Keywords:** kinesthetic learning, embodied cognition, multimodality, impulse

### **Introduction**

The embodied cognition paradigm has challenged the perception that knowledge is disembodied and abstract mental representations. It argues that "cognitive processes arise from...continuous kinesthetic interactions between the brain, the body and the environment" (Thompson, 2007, p. 10) manifesting that the cognitive system is organized to support the targeted action in the environment (Robbins & Aydede, 2008). Barsalou (1999) theorized that knowledge is based on perceptual symbol systems, i.e. symbols consisting of structural elements of neural activity that arise from sensory perception. In a learning setting, this thread of research reveals that humans reuse brain structures once activated during a previous action, highlighting the presence of simulations in cognitive function (see Anderson, 2010; Decety & Grèzes, 2006). The embodied cognition paradigm also stands by the notion that mental representations of abstract concepts are formed by simulations of perceptual experiences and bodily interactions with the environment (Barsalou, 1999). This argument is also supported by the work of Lakoff and Johnson (1999), who attempted to investigate why language is to a great extent, metaphorical. In their analysis, the use of a metaphor is much more than direct speech. A metaphor reveals how people represent and reflect on abstract concepts, that is, through real interactions of the body with the world.

Currently, stating that all cognition is embodied is open to debate (see Goldinger et al., 2016) and even embodied cognitivism has adopted a range of views, from the most simple (Clark, 1999) to the most radical (Kiverstein, 2012). However all approaches of embodied cognition agree that bodily experiences constitute an integral part in the construction of meaning, both for concrete and abstract concepts (Goldman, 2012). Likewise, in terms of educational contexts, its application is self-explanatory. It is therefore not surprising that recent reviews have called to further investigate the principles of body usage in an educational



context, explore its potential weaknesses, and the need to create a systematic inventory of its supposed usefulness in learning (Nathan & Walkington, 2017).

Leading educational theorists and more recent examples of pedagogues consider physical activity a prerequisite for effective learning, inextricably linked to cognitive processes (see Kolb & Kolb, 2009; Montessori, 1961; Dewey, 1916). In general, the inclusion of movement in the academic lesson is an effective means to promote a student's active engagement, (Sivilotti & Pike, 2007, Griss, 2013), improve academic achievement (Beaudoin & Johnston 2011, Bartholomew & Jowers, 2011, Brusseau & Hannon, 2015), and even benefits participants' health (Norris et al., 2015), all at the same time. However, the school remains a highly sedentary environment where the learning content is mostly conveyed by the teacher (Holt, Bartee, & Heelan, 2013). An analysis of 26 studies (Duijzer et al., 2019), revealed that learning environments with lower levels of physical involvement are considered less effective. Allowing students to even observe human movement has an overall positive effect on learning, compared to more static forms of teaching (Rueckert et al., 2017; Fiorella & Mayer, 2016; Brucker et al., 2015; Castro-Alonso et al., 2015). High-level bodily engagement does not always lead to knowledge acquisition, because complex demands can lead to an unnecessary cognitive load that ultimately acts as a barrier to learning (Skulmowski et al., 2016; Ruiter et al., 2015). For this reason studies favor simple bodily activities of short duration (see Song et al., 2014; Kalet et al., 2012).

The fact that much of physics' subject matter deals with the actions and interactions of objects at the scale of the human body makes kinesthetic learning activities i.e activities that physically engage students in the learning process (Begel et al., 2004) a fruitful approach. It seems that activities that allow interactions with materials or equipment, often referred to as hands-on activities (see Sliško & Planinšič, 2010), activities where students use their bodies as a sensor for physical interactions (see Bracikowski et al., 1998) or role-playing of natural phenomena much larger or smaller than the human body (see Singh, 2010; Morrow, 2000) all fall under this umbrella term, i.e. kinesthetic learning. Existing PER (Physics Education Research) work has, to a moderate extent, designed and implemented interventions over the years (see Richards, 2020, 2019; Mylott et al., 2014; Whitworth et al., 2014; Besson et al., 2007), but how these interventions affect understanding hasn't been extensively investigated (see Coletta et al., 2019; Herakeioti & Pantidos, 2015; Hadzigeorgiou et al., 2008; Levin et al., 1990).

This paper evaluated the implementation of a full-body intervention directed to 6th grade primary school students, to introduce the physics concept of impulse and gain clarity into the following research question:

Does participation in bodily-based activities help students acquire greater scientifically accepted reasoning?

## **Methodology**

### *Participants and procedures*

The subjects of this study were twenty-nine 6th grade students of a Greek elementary school, who had not previously been taught the concept of impulse. They participated in pre-designed bodily-based activities, and were administered a pre- and post-intervention test. Both the intervention and exploration of students' understanding lasted 20-25 minutes and the teaching process was carried out by the first author, who was granted the necessary license from the competent primary education administration office and as such permission to access the school's ground for research purposes. The school's principal, and the teachers' assembly also agreed to the research study. The parents of the students had previously filled out a consent form agreeing to their children's participation in the interventions and to recording the entire process.

### *Assessment procedure*

Structured one-to-one interviews were chosen as the evaluation method to provide a clear picture on each subject's understanding, the difficulties they encountered, and their held misconceptions.

The interview questions were formulated based on the following: (a) review of previous studies on the difficulties learners encounter in understanding the physics concept of impulse (b) create links to everyday situations and experiences and (c) provide a varied set of problems for which participants make predictions and assumptions, develop their reasoning and explain their answers. Students were asked three relevant questions; the first concerned a human-centered activity ("If you fall from a height, would you prefer to land on a thin or a thick mat and why?"), the second question involved objects present during the procedure ("Why is it more likely that the object will break when it falls on a table instead of a sponge?"), and the third interview question included an everyday condition illustrated on an image ("Why would the damage be greater if a go-cart accidentally lost control and hit a concrete wall, instead of running into a stack of tires?").

The three-fold interview was selected to understand the potential influence different contexts may have on students' performance, but also to minimize the difficulty on their part to imagine a situation being narrated to them, which would require an additional cognitive load.

### *Teaching intervention*

#### *Activity 1*

We asked students to stop a lightweight ball being thrown at them, however all the while keeping their hands outstretched. We replaced the ball with a heavier one and gradually increased the throwing speed. The students were able to discover that when stopping the heavier ball they unconsciously bent their hands to feel less pain. The aim was to conclude that the intensity of pain felt is proportional to the force exerted on the ball which also depends on how abruptly students stop the motion.

#### *Activity 2*

We asked students to climb to a height of about 70cm and jump, but initially they were requested to land without bending their knees. After this first attempt, students were asked to jump again but this time to land naturally, i.e. by bending their knees. We asked them to describe how they felt and students concluded that an abrupt or prolonged stop of a real time movement affects the force exerted on their body.



**Figure 1. Visual instances from activities**

### **Data Analysis**

In this paper, we incorporated conversation analysis techniques, which involve a close examination of the video-recorded conversations to determine how students construct meaning from sets of mutually elaborating semiotic resources (Euler et al., 2019). Based on previous classifications (Givry & Pantidos, 2014), we focused on spoken language, gestures (ergotic: manipulating, deictic: pointing, symbolic: representing), and body posture. Therefore, based on the multimodal transcript created, we categorized students' responses as inadequate, fair, or adequate. Students' performance was evaluated individually by the two researchers in line with the scoring framework (Table 1), and compared and reassessed until the degree of agreement between the two independent physics teachers-researchers was over 95%.

**Table 1. The scoring framework**

<b>Adequate</b>	<b>Fair</b>	<b>Inadequate</b>
As a moving object comes to a stop, the student understands that the magnitude of the exerted force is affected by the time interval over which the force acts	Student refers to correct elements but not to the time interval	Student makes no, or wrong reference to the time interval or to any other correct elements

### **Results**

For each assessment test, Table 2 provides the number of adequate and fair responses to the human-centered (HC), object-centered (OC), image-centered (IMC) questions of the assessment procedure.

**Table 2. Distribution of students' answers**

<b>Scoring</b>	<b>Context</b>	<b>f (%) pre-test</b>	<b>f (%) post-test</b>
<i>Adequate</i>	<i>HC</i>	2 (6.9)	13 (44.8)
	<i>OC</i>	0	12 (41.4)
	<i>IMC</i>	0	16 (55.2)
	<i>Total</i>	2 (2.3)	41 (47.1)
<i>Fair</i>	<i>HC</i>	27 (93.1)	16 (55.2)
	<i>OC</i>	29 (100)	17 (58.6)
	<i>IMC</i>	29 (100)	13 (44.8)
	<i>Total</i>	85 (97.7)	46 (52.9)

The activities were pre-designed for the students to experience that a similar change in momentum can be achieved with a large force over a brief period of time but also with a small force applied over a longer period of time. Apart from two students, it was observed that all

other participants did not mention the exerting time of the deceleration force before the intervention. In addition, no student response was assessed as inadequate. A fair score was granted when students made references to correct elements, such as the distance from a solid surface, the softness of the material on which the object landed, or the volume of the material on which the object comes to a stop. An example of a fair response is presented below, together with a screenshot from the videotaped assessment procedure:

“The thicker mat has a greater volume +s.g [demonstrates with hands spread apart] in terms of material so the fall is less painful.”



**Figure 2. A response based on the volume of the material**

After participating in the activities, there is a substantial shift towards students' adequate justification (47.1% of the answers), indicating significant progress. Around half of participants, depending on the question, continued to justify their answers based on more obvious features: For question one, 16 out of the 29 students based their explanation on the distance from the hard surface-ground (3 in number) and the volume of material in a thicker layer (13 in number). For question two, 17 students based their explanation on the difference in softness among the two surfaces on which the object lands. For question three, students relied on the flexibility property of rubber tires (13 in number) and again on the difference in softness among the two materials (13 in number). All answers pertaining to the contact time interval but not explicitly expressed were assessed as fair responses.

The not-so-mismatched number of adequate responses before and after the intervention cannot allow us to comment on any potential impact on students' understanding from the content of the questions. However, it is worth noting that in the pre-test, the human-based question was the only one for which students made reference to the time interval, but not to the extent that we could argue on the radical significance of the lived experience.

Due to the activities' distinct presentation of a time interval during which a force is applied, a sound number of participants managed to scientifically clarify and communicate, using a multimodal framework, the cause behind any damaging (or not) attempt of immobilization. The following sample of the multimodal transcript accompanied by screenshots of the videotaped procedure demonstrates the progress in a student's conceptualization journey (Figure 2):

“When I land on the thinner mat, I stop immediately + symbolic gesture [a closed fist representing the body coming to an abrupt stop], so it hurts more.”



**Figure 3. Posttest reasoning**

### **Discussion**

Kinesthetic activities are recommended as knowledge organizers and conceptual scaffolds, especially within the physics field, where theoretical perspectives can be difficult to grasp, as they are often separated from the tangible ways of the world (Bamberger & diSessa, 2003). Our research confirms that the increase in bodily engagement leads to an increase in knowledge acquisition (see Tran et al., 2017).

Apart from the positive learning impact where students were given the opportunity to add elements of scientifically accepted knowledge into their reasoning, a large number of students transferred their newly gained experiential knowledge to other contexts, e.g., students were able to answer an object-centered question drawing from the conclusions they made from their participation in the embodied activity. Knowledge transferability is the desired outcome because it contains elements of conceptual change since the subjects succeeded in restructuring, transferring, and applying their acquired knowledge to other settings (Herakleioti & Pantidos, 2016; Eraut 2009).

Irrespective of the subject matter or type of knowledge or skill, after one year, about 33% of the gained knowledge is lost, while after two years, this loss increases to about 50% (Custers, 2010). The long-term effectiveness of kinesthetic interventions has been previously confirmed (see Hadzigeorgiou et al., 2008) but requires further exploration to understand if and how the core components of such activities i.e. kinetic logic, kinesthetic memory and kinesthetic perception (Seitz, 2000) affect long-term retention of knowledge.

Further experimentation to measure the effectiveness of such interventions compared to others will surely build on initial findings (Levin et al., 1990). As we stated in the introduction, bodily engagement can vary from object manipulation, full-body movement, and even simply observing others' actions, thus further comparisons of these different types can shed light on weaknesses and benefits.

### **Conclusion**

Driven by our reflection on the gap that exists between experiential learning and conceptual understanding, we investigated whether solely participating in activities that discern a single critical aspect help students form conclusions and apply them when justifying their answers. The results showed that many of the participants moved from a superficial description of the concept of impact to its scientific justification, stating as a determining factor the time interval during which the force is exerted.

One proposal arising from our results is to introduce objects of learning with first-person experiences because it is easier to link desired knowledge to previous body-centered experiences and then restructure and apply it to other contexts.



While the number of participants in this study is considered sufficient to draw safe conclusions, a wider range of student ages could provide more information regarding the mechanisms of understanding of the concept of impulse and possible alternative ideas.

As participants took part individually in the activities, in the future it would be worthwhile to implement these within a classroom environment and redesign them to include group work. Finally, seeking the psycho-emotional effects of interventions is a legitimate argument, and can be achieved by investigating participants' attitude changes towards Physics and the students' perceived usefulness of the activities.

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## **Critical thinking in the first-class Informatics textbook of the Greek Lyceum: promoting the cultivation of its skills**

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### **Abstract**

There are problems societies and individuals have to deal with. To confront these problems, specific skills are needed. Critical thinking is indispensable in developing such skills. Critical thinking can contribute in improving problem solving skills and developing communication skills. Education of Informatics and critical thinking have a strong relationship since students cannot develop skills related to Informatics if they cannot think critically. Therefore, within the Informatics textbooks the cultivation of critical thinking skills should be promoted. The present paper aims to determine to what extent the cultivation of critical thinking skills is promoted in the Informatics textbook of the first class of the Greek Lyceum. The method that was used is the Quantitative Content Analysis. The present research revealed that within the examined textbook cultivating critical thinking skills is not promoted sufficiently.

**Keywords:** Critical thinking, critical thinking skills, Content Analysis, Informatics, textbooks

### **Introduction**

Critical thinking develops an ever more accurate worldview and using it well in all aspects of life (Jason, 2022). Thus, Critical thinking is essential in of life. Critical thinking is a tool for the interaction of information with thoughts (Erkinovna, 2022). A critical thinker understands how to use knowledge to solve difficulties Raj et al., (2022). There is a need to cultivate critical thinking skills in order to create effective individuals (Mihail, 2022). There are impacts of critical thinking on academic, professional and personal levels (Abasaid & Ferreira, 2022). Every individual need critical thinking skill to solve problems in everyday life (Laabidi, 2022). Critical Thinking plays a great role in teaching and learning process (Shamboul, 2022). Education systems have recognized the importance of developing students' critical thinking skills (Nor & Sihes, 2022). The benefits of the critical thinking are many. Critical thinking lessons sought to improve skills such as solving problems, gathering and analyzing information, drawing conclusions, communicating ideas with clarity and effectiveness (Bassham et al., 2011). Critical thinking is the key competency for economic survival in the 21st century (Matthews & Lally, 2010). The present study is one of the few studies exploring the extent to which the cultivation of critical thinking is promoted within the content of Informatics textbooks. It provides useful insights to authors who write textbooks where the cultivation of critical thinking will be adequately promoted.

### *Clarifying critical thinking*

Critical thinking encompasses philosophical, psychological and pedagogical approaches to it (Lai, 2011; Lewis & Smith, 1993; Moon, 2008). As far as philosophical approach is concerned, critical thinking is: a reflective and reasonable thinking which focus on what to believe or do (Ennis, 1985), a disciplined, self-directed thinking (Paul 1992). According to psychological approach, critical thinking comprises: the mental strategies and representations people use to solve problems and learn new concepts (Sternberg, 1986) or it is the use of cognitive skills

or strategies in order to increase the probability of an outcome (Halpern, 1998). Regarding the educational approach, the critical thinking is often considered to be represented by the levels of analysis, synthesis and evaluation of the Bloom taxonomy (Kennedy et al., 1991).

#### *Critical Thinking and Informatics*

Information management is essential in informatics. Some aspects of Informatics include: understanding and promoting effective organization, analysis, management, and use of information; decision making relying on knowledge or evidence; integration of data, information and knowledge (Collins & Weiner, 2010). To develop information management skills, information literacy is needed. Information literacy is a set of skills for recognizing, evaluating and effectively using necessary information (American Library Association, 1989). Students cannot cultivate Information literacy unless they have developed critical thinking skills (Paul & Elder, 2006). Therefore, critical thinking, Informatics and information literacy are strongly related.

Informatics is a science of computers, algorithms, data structures, mechanical symbol, data processing, computer automation, computer simulation, and mechanization of thinking (Rechenberg, 1999) and thus it has a very strong relationship with Computer Science. Problem solving is fundamental, both in Informatics and critical thinking. In Informatics, solving problems is linked to computational thinking. Computational thinking is strongly related to Computer Science (Dagiene & Stupuriene, 2016), and therefore it is related to Informatics. Computational thinking is a brain activity that facilitates problem solving by applying deduction, deconstruction, algorithmic design, generalization, and evaluation to the production of automation that can be implemented by a human or by a computing device (Selby & Woollard, 2014). Computational thinking can support learners' skills so that they become effective problem-solvers (de Jesus & Silveira, 2021). Computational thinking also facilitates the development of competencies related to problem-solving and decision-making (Cano et al., 2021). There are computational thinking skills and critical thinking skills which are similar and computational thinking complements critical thinking with regard to problem solving, decision making and interaction with the world (Kules, 2016). Critical thinking skills are essential for decision making and solving problems (Halpern, 1998). Critical thinking and computational thinking are necessary in solving complex technological problems (Voskoglou & Buckley, 2012). The aforementioned imply that there is a strong linkage between critical thinking and Informatics.

Logic is strongly related to many subjects of the Computer Science (Martel, 2018) and therefore it is related to Informatics. Critical thinking itself is a reasonable thinking (Ennis, 1985; Lipman, 1988) and logic constitutes an intellectual standard of critical thinking (Paul & Elder, 2013). Consequently, logic is a link between critical thinking and Informatics.

From all the above it becomes clear that critical thinking and Informatics have a very strong relationship. Due to this relationship within Informatics textbooks the cultivation of the critical thinking skills should be promoted.

#### *Critical Thinking and Informatics curricula*

The current education system is becoming more and more aware of the importance of training students' ability to think critically (Balercă, 2022). Modern education seeks to cultivate critical thinking (Kennedy et al., 2016). Due to the fact that critical thinking is strongly related to Informatics, the cultivation of the critical thinking skills should be promoted in Informatics curricula. In curricula of the primary, the secondary and the higher education, learning objectives underline the development of critical thinking (Thompson, 2011). Thinking skills or critical thinking programs have been incorporated into curricula of several countries (Matthews & Lally, 2010). As stated in the Analytical Curriculum for Information and Computer Technology in Education, critical thinking is one of the skills that should be promoted (Weert & Anderson, 2002). In Greece, the development of critical thinking is promoted in the new



curricula (Hellenic Pedagogical Institute, 2021). Consequently, in the Greek school textbooks of Informatics the cultivation of the critical thinking skills should be promoted.

#### *Research questions*

The purpose of the present research is to explore the extent to which the cultivation of the critical thinking skills is promoted within the Informatics textbook of the first class of the Greek Lyceum. In order to fulfill this purpose, the following research questions were posed.

Within the first-class Informatics textbook of the Greek Lyceum:

1. Are there critical thinking skills whose cultivation is promoted?
2. If there are critical thinking skills whose cultivation is promoted, does this promotion occur to the same extent per skill?
3. Is there a critical thinking skill whose cultivation is promoted to the same extent per sub-skill?
4. To what extent the cultivation of the critical thinking skills is promoted in the whole text?

#### **Method**

##### *Material*

In this research the examined material is the content of the first-class Informatics textbook of the Greek Lyceum. The aim of the examined textbook is for students to acquire knowledge, develop skills and shape attitudes related to the applications of Informatics (Aggelidakis et al., 2010). The textbook is divided into four thematic units: Hardware - Software and Applications, Programming Environments - Applications Development, Communication and Internet and Collaboration and Security within Internet. Each thematic unit is divided into chapters ranging from three to five. In the present research the parts of the textbook that were examined are the teaching objectives, the teaching questions, the main text, the side text and the activities.

##### *Research Design*

The method that was used in the present research is the Quantitative Content Analysis. The Quantitative Content Analysis is a systematic, objective and quantitative analysis of the characteristics of a message (Neundorf, 2002). Quantitative Content Analysis has been applied since the 1970 (Johnsen, 1993). The main idea of Content Analysis is the inclusion of elements of a text into categories (Creswell & Clark, 2007; Krippendorff, 2004; Huntemann & Morgan, 2001; Rustermeier, 1992). In order to encompass elements of the under-study text into a category system of categories should be established. This establishment was carried out as follows: firstly, an initial category system is used, secondly, it was defined the criterion that the parts of the under-study text must satisfy in order to fall into the category system and thirdly, it was examined whether the initial category system is suitable for the material of the present research and a final category system was emerged.

Taking into account the research questions of the present paper, the initial category system that was used consists of the following skills (categories) and sub-skills (sub-categories) of the critical thinking as defined by the American Philosophical Association (Facione, 1990):

1. Interpretation skill
  - 1.1. Categorization sub-skill
  - 1.2. Decoding significance sub-skill
  - 1.3. Clarifying meaning sub-skill
2. Analysis skill
  - 2.1. Examining ideas sub-skill
  - 2.2. Identifying arguments sub-skill
  - 2.3. Analyzing arguments sub-skill
3. Evaluation skill
  - 3.1. Assessing claims sub-skill

- 3.2. Assessing arguments sub-skill
- 4. Inference skill
  - 4.1. Querying evidence sub-skill
  - 4.2. Conjecturing alternatives sub-skill
  - 4.3. Drawing conclusions sub-skill
- 5. Explanation skill
  - 5.1. Stating results sub-skill
  - 5.2. Justifying procedures sub-skill
  - 5.3. Presenting arguments sub-skill
- 6. Self-Regulation skill
  - 6.1. Self-examination sub-skill
  - 6.2. Self-correction sub-skill

The above system of categories gathers advantages that are also the reasons why it was chosen to be used in this work. First of all, this system refers to critical thinking skills and this paper examines the promotion of their cultivation. In addition, this system provides a set of distinct categories and subcategories of critical thinking that can be used in Content Analysis. Furthermore, this category system is a consensus of forty-six critical thinking experts.

Subsequently, it was defined the criterion that the parts of the under-study text must satisfy in order to fall into the category system. This criterion determines whether or not a part of the under-study text belongs to a category. The recording unit determines which parts of the text fall into the category system (Krippendorff, 2004). Definition of the recording unit. In the present research the recording unit is defined as any part of the under-study text which contains exactly one message promoting the cultivation of a critical thinking skill. Every category corresponds to exactly one critical thinking skill and vice versa. Similarly, every sub-category corresponds to exactly one critical thinking sub-skill and vice versa. In particular, a part of a text which contains exactly one message expressing a teaching goal or a question or a learning activity about categorization, significance, clarifying meaning, examining ideas, identifying arguments, analyzing arguments, assessing claims, assessing arguments, querying evidence, conjecturing alternatives, drawing conclusions, stating results, justifying procedures, presenting arguments, self-examination, self-correction, falls into the corresponding sub-category and thus promotes the cultivation of the corresponding critical thinking sub-skill. If a part of a text falls into a subcategory, then that part also belongs to the basic category which is a superset of the subcategory.

Next, it was examined whether the initial category system is suitable for the under-study text. This text, was examined to see if there are categories that do not contain references promoting the cultivation of the critical thinking skills. Such empty categories were found and correspond to: the decoding significance sub-skill, the detecting arguments sub-skill, the analyzing arguments sub-skill, the assessing arguments sub-skill, the justifying procedures sub-skill, the self-examination sub-skill and the self-correction sub-skill. However, in a final category system to be used in the Content Analysis, every category should be not empty (Berelson, 1952; Rustermeyer, 1992; Holsti, 1969). For this reason, the above empty sub-categories were removed from the initial category system and a final category system emerged. The categories and sub-categories of this final system are:

- 1. Interpretation skill
  - 1.1. Categorization sub-skill
  - 1.2. Clarifying Meaning sub-skill
- 2. Analysis skill
  - 2.1. Examining Ideas sub-skill
- 3. Evaluation skill
  - 3.1. Assessing Claims sub-skill
- 4. Inference skill

- 4.1. Querying Evidence sub-skill
- 4.2. Conjecturing Alternatives sub-skill
- 4.3. Drawing Conclusions sub-skill
- 5. Explanation skill
  - 5.1. Stating Results sub-skill
  - 5.2. Presenting Arguments sub-skill

*Data collection and analysis*

In the under-study material, every part of the text that promotes the cultivation of a critical thinking sub-skill was noted and, according to its content, it was categorized into one of the sub-categories of the final category system. The elements of a basic category are the elements of all its sub-categories. After the categorization, any part of the under-study text that belongs to a category is characterized as categorized text otherwise is a non-categorized text. A categorized part of the under-study text is an element of a category.

In order to determine the extent to which the cultivation of a critical thinking is promoted within a text, the text should become measurable. In the present research, it was used the length of it to make a text measurable. In the present research, the length of a text (categorized or non-categorized) is defined as the number of the lines that the text covers. If a part of the under-study text belongs to a specific category, then the length of this part expresses the extent to which this part promotes the cultivation of the corresponding critical thinking skill. statistical processing was performed on: the lengths of the members of the sub-categories, the lengths of the members of the categories, the length of the non-categorized text, the length of the categorized text and the length of the whole under-study text. The results of the statistical processes were presented using tables.

**Results and discussion**

Table 1 displays the percentages of the length of the text promoting the cultivation of each basic critical thinking skill within the categorized text.

**Table 1. Distribution of promoting the cultivation of the critical thinking skills within the categorized text**

<b>Interpretation sub-skills</b>	<b>Length of the text %</b>
Interpretation skill	7,2%
Analysis skill	33,6%
Evaluation skill	0,9%
Inference skill	32,1%
Explanation skill	26,2%
<b>Total categorized text length</b>	<b>100%</b>

The skill whose promotion of its cultivation covers the largest percentage of the text length in relation to the other skills is the analysis skill, followed in descending order by the inference skill, the explanation skill, the interpretation skill and the evaluation skill.

The interpretation skill is represented by the categorization sub-skill and the clarifying meaning sub-skill. Table 2 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

**Table 2. Distribution of promoting the cultivation of interpretation skill, by sub-category**

<b>Interpretation sub-skills</b>	<b>Length of the text %</b>
Categorization sub-skill	31,2%
Clarifying meaning sub-skill	68,8%
<b>Total interpretation length</b>	<b>100%</b>

The analysis skill is represented by the examining ideas sub-skill. The text which promotes the cultivation of the examining ideas sub-skill cover 149 lines.

The evaluation skill is represented by the assessing claims sub-skill and the text promoting the cultivation of this sub-skill cover 4 lines.

The inference skill is represented by the querying evidence sub-skill, the conjecturing alternatives sub-skill and the drawing conclusions sub-skill. Table 3 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

**Table 3. Distribution of promoting the cultivation of inference skill, by sub-category**

<b>Inference sub-skills</b>	<b>Length of the text %</b>
Querying evidence sub-skill	12,0%
Conjecturing alternatives sub-skill	7,7%
Drawing conclusions sub-skill	80,3%
<b>Total inference length</b>	<b>100,0%</b>

The explanation skill is represented by the stating results sub-skill and the presenting arguments sub-skill. Table 4 displays the different percentages of the length of the text promoting the cultivation of each of these sub-skills.

**Table 4. Distribution of promoting the cultivation of explanation skill, by sub-category**

<b>Explanation sub-skills</b>	<b>Length of the text %</b>
Stating results sub-skill	44,8%
Presenting arguments sub-skill	55,2%
<b>Total explanation length</b>	<b>100,0%</b>

Table 5 shows that within the whole examined text, a small percentage of the length of the text promotes the cultivation of critical thinking skills.

**Table 5. Promoting cultivation of critical thinking skills in the whole text**

<b>Explanation sub-skills</b>	<b>Length of the text %</b>
Promoting	9,1%
Not promoting	90,9%
<b>Total examined text</b>	<b>100,0%</b>

The findings of the present research are consistent with the results of other relevant researches. These researches were categorized according to their findings. There is a category of researches which examine the promotion of the cultivation of specific critical thinking components within textbooks. Concerning of this category, there is one in which, materials analysis, teacher interviews and lesson observations were used as methods to analyze the content of textbooks and it was found little opportunities for self-regulated strategy application (Bogaerds-Hazenberg et al., 2022), there is another research, in which the revised two-dimensional classification table (Anderson & Krathwohl 2001) was used to analyze the content of textbooks and it was revealed that the examined material does not promote High Order Thinking Skills and consequently does not sufficiently foster the development of the critical thinking (Peyró et al., 2020). There is one more research of the same category, in which document analysis and descriptive analysis were used and it was concluded that the activities in social studies textbooks do not meet sufficiently the critical thinking standards (Aybek & Aslan, 2016).

There is another category of researches which examine the level of emphasis on the critical thinking in books. Regarding this category, there is one of qualitative type, in which C2 level books were examined and it was revealed that not all aspects of the perspective of thinking

were found in the statement of questions in the examined books (Ilmiah, 2021), there is another research, in which content analysis was used, a textbook was examined and it was found that the textbook contained a few critical thinking elements (Hestrian et al., 2021). In another research of this category, descriptive method and content analysis were used, high school textbooks and the corresponding teacher's guidebooks were examined and it was concluded that emphasis on the critical thinking was at a very low level in the content of the examined books (Khademi, 2020). Concerning the same category, there is another research, in which the purpose was to determine the level of attention to the critical thinking components in a school textbook, it was used content analysis as method and it was revealed that low level of attention to the critical thinking has been paid in the components of the examined material (Samiee et al., 2020). Regarding the same category of researches, there is one research in which documents analysis, contents analysis and questionnaire were used and it was showed that in the content of accounting textbooks used in universities, little attention to the critical thinking is paid (Irafahmi et al., 2018). In another research of the same category, content analysis was used, it was examined the extent to which the critical thinking is promoted within language school textbooks and it was revealed that the examined textbooks do not contain many tasks promoting the critical thinking (Solihati & Hikmat, 2018).

There is another category of researches which examine teaching materials for their sufficiency in improving students' critical thinking skills. Research of this category, aimed to analyze the need for developing teaching materials to improve critical thinking skills, used qualitative method, and showed that the teaching materials used have not led to improve students' skills (Perdanasari & Sangka, 2021). Another research of this category, used content analysis, examined the extent to which University textbooks help in enhancing student's critical thinking skills and found that the examined material is insufficient in helping students develop high level of critical thinking skills (Al-Qahtani, 2019). There is another research of this category in which content analysis was used as method, English textbooks were examined and it was found that these books do not contain all the critical thinking elements and also do not contain many questions that encourage students' critical thinking (Siahaan, 2021). With regard to the same category, according to research which used content analysis, the English-as-a-foreign-language textbooks that were examined do not foster sufficiently students' critical thinking (Sobkowiak, 2016).

In the present research it was found that within the examined textbook, the cultivation of the critical thinking skills is promoted in a very small part of the whole text and therefore is insufficient. This insufficient promotion of the critical thinking within the examined text could be attributed to some of the reasons that are mentioned below. Some reasons are the difficulties of the cultivation of the critical thinking (Brookfield, 2013; Willingham, 2007), the lack of training in the methodology of the critical thinking, the lack of information about educational material that promotes the critical thinking, the personal beliefs and prejudices of educators about the content of the curriculum and the way they teach it (Snyder & Snyder, 2008) and the fact that typical school teaching does not encourage high-level thinking skills (Paul, 1992).

Some other reasons are the teaching inefficiency and lack of knowledge about what is critical thinking and how it could be promoted (Yuan et al, 2022; Giacomazzi et al., 2022; Aliakbari & Sadeghdaghighi, 2013), the inefficiency of many adults to think critically in many cases (Halpern, 1998), the lack of fundamental reasoning skills from many adults (Kennedy et al., 1991; Gelder, 2005). Furthermore, there are the barriers to critical thinking such as egocentrism, sociocentrism, unwarranted assumptions, stereotypes, relativistic thinking and wishful thinking (Bassham et al., 2011).

#### Conclusions

The present research revealed that there are critical thinking skills whose cultivation is promoted within the examined text. These skills are: the interpretation skill, the analysis skill,



the evaluation skill, the inference skill and the explanation skill. On the contrary, it was found that within the examined text, there is a critical thinking skill whose cultivation is not promoted and this skill is the self-regulation skill. The critical thinking sub-skills whose cultivation is promoted are: the categorization sub-skill, the clarifying meaning sub-skill, the examining ideas sub-skill, the assessing claims sub-skill, the querying evidence sub-skill, the conjecturing alternatives sub-skill, the drawing conclusions, the stating results sub-skill and the presenting arguments sub-skill.

Regarding the skills whose cultivation is promoted, it was found that this promotion does not occur to the same extent per skill.

There is no critical thinking skill whose cultivation is promoted to the same extent per sub-skill.

The present research revealed that within the whole material, the cultivation of critical thinking skills is promoted in a small percentage of the text it covers. Consequently, within the examined textbook the cultivation of the critical thinking skills is not promoted sufficiently.

A limitation of the present research is that the findings cannot be generalized to refer to other textbooks. It is suggested that research be conducted where the content of the textbooks and a range of cognitive subjects are studied, with regard to the cultivation of the critical thinking skills within them. These types of research may shed light on the quality of the existing textbooks and how they can potentially be used concerning the critical thinking and the promotion of its cultivation, and also provide useful insights that may help the authors in compiling textbooks where the cultivation of the critical thinking skills is adequately promoted.

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## **Inclusive education: knowledge, perceptions and attitudes of parents of 4 to 8year old children**

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### **Abstract**

The present study investigated knowledge, perceptions, and attitudes of parents with children without special educational needs (SEN) regarding inclusive education. Thirteen parents of preschool and primary school children participated, who answered, through semi-structured individual interviews with 12 questions, divided into three categories (knowledge, perceptions, attitudes). The results showed that parents have good knowledge on Special Education structures and which children are eligible to attend them. They are positive about inclusive education, highlighting the advantages that both groups of students gain from inclusion, especially on emotional level. Parents' positive perceptions and attitudes depend on their prior experience with a person with SEN, the service of special education teachers in their child's school, the teachers' practices, the type and severity of the disability faced by their child's classmate. Finally, they are willing to develop relationships with parents with children with SEN depending on the type of the special need.

**Keywords:** knowledge, attitudes, perceptions, parents, inclusive education

### **Introduction**

The institution of inclusive education, which refers to the placement of students with SEN or disability in general education in order to ensure equal opportunities, has become prevalent in Greece, emphasizing even more the need for school-family interaction (Soulis, 2008; Tsididakis, 2012). The outcome of inclusive education depends on teachers' perceptions and attitudes towards it (Symeonidou & Phtiaka, 2009; Zoniou-Sideri & Vlachou, 2006), as well as parents of children with or without SEN (Epstein & Sheldon, 2006). In fact, parents, acting as role models for their children, also shape their own perceptions and attitudes. Young children are more resistant to changing the perceptions and attitudes they have adopted from their parents, which take the form of prejudices (Kohl et al., 2000; Miesera & Gebhard, 2018; Zanolini et al, 2017).

Relevant research has already been conducted in the Greek population, on the perceptions and attitudes of parents with children without SEN towards inclusive education, where it was found that parents are positively disposed towards the common attendance of students (Georgiadou, 2020; Thomidis, 2017; Bobota, 2015; Papanikolaou, 2018; Russo et al, 2014; Terzi, 2020). Similar results emerged from international research studies (Adiputra, 2019; Al. Neyadi, 2015; Aydin & Yamaç, 2014; Bhargava & Narumanchi, 2011; de Boer & Munde, 2014; Dimitrova-Radojicic & Chicherska-Jovanova, 2014; Doménech & Moliner, 2015; Paseka & Schwab, 2020; Sharma & Trory, 2019; Sosu & Rydzewska, 2017). The research by Vlachou, Karadimou and Koutsogeorgiou (2016) highlighted neutral towards positive perceptions and attitudes of parents concerning the institution of inclusive education, while hesitations were recorded in the survey by Hilbert (2014) Adiputra (2019), Sharma and Trory (2019) and Papanikolaou (2018).

Parameters that determine the formation of purely positive perceptions and attitudes of parents are the staffing of school units with qualified teaching staff (Adiputra, 2019;



Dimitrova-Radojicic & Chicherska-Jovanova, 2014; Hilbert, 2014; Paseka & Schwab, 2020; Papanikolaou, 2018; Sharma & Trory, 2019; Terzi, 2020), the cultivation of cooperative relationships between school and family (Georgiou, 2000; Paseka & Schwab, 2020) and the type and degree of severity of special educational needs faced by their child's classmate (Bhargava & Narumanchi, 2011; Paseka & Schwab, 2020; Vlachou et al, 2016). Also, the personal experiences of parents with a child with SEN from their close environment make them more positive towards inclusive education (Pijl et al, 1997), as well as their experiences of inclusive education (Bhargava & Narumanchi, 2011; Kontopoulou et al, 2007). In addition, another factor contributing to the positive attitude of parents is the belief in the benefits that children with or without SEN gain through inclusive education on an academic, emotional, psychological, and social level. Some of the benefits are learning progress, enhancing self-confidence-self-esteem, forming friendly bonds, cultivating respect and acceptance of others (Adiputra, 2019; Bhargava & Narumanchi, 2011; Georgiadou, 2020; Doménech & Moliner, 2015; Dimitrova-Radojicic & Chicherska-Jovanova, 2014; Sharma & Trory, 2019; Vlachou et al, 2016; Terzi, 2020). It is worth noting that in scientific studies with a mixed population sample (parents with children without and with SEN), parents with children with SEN are more supportive, supporting the social and academic benefits to be gained from inclusive education (Al. Neyadi, 2015; de Boer & Munde, 2014; Doménech & Moliner, 2015; Bobota, 2015; Paseka & Schwab, 2020; Sharma & Trory, 2019).

Based on the presentation of the theoretical research framework of the present study, it is evident that the perceptions and attitudes of parents of children without SEN are a formative factor in the successful course of inclusive-education in modern schools, determining at the same time the perceptions and attitudes of their children towards their peers with learning or behavioral problems (Darais, 2008; Paseka & Schwab, 2020). We wanted to investigate this important finding in the present research, the influence of parents' perceptions and attitudes on inclusion on their children's perceptions and attitudes concerning the same theme. We applied qualitative method for in-depth investigation of the research purpose and we addressed especially to parents with children without SEN aged 4-8 years, where the influence of parents in shaping perceptions and attitudes is very high, acting as strong role models. Research questions were:

1. Which is parents' knowledge on special education?
2. Which are parents' perceptions of inclusive-education?
3. Which are parents' attitudes towards children with SEN?

### **Research methodology**

The method chosen for this study was qualitative as the most appropriate, as it allows for the interpretation of each participant's personal viewpoint rather than generalizing the findings to the general population (Creswell, 2011). Structured individual interviews were the means of collecting the research data. Parents were asked to respond to 12 questions in order to capture their in-depth views on the topic under study and to enable greater understanding of the topic (Robson, 2010). The Quantitative Content Analysis was used to analyze the data of each interview. It's the method where each element of a text is included into categories (Creswell & Clark, 2007). The categories of the present study were: 1) parents' knowledge, 2) perceptions and 3) attitudes towards inclusive education, corresponding to the research questions. The interview questions were drawn from the Kalyva et al (2007) survey questionnaire.

Qualitative research does not require a large sample size, so 13 participants were selected on the basis of having children without SEN of preschool or primary school age. The selection was made by convenient sampling (those parents who wished to participate from the Ioannina area). In terms of demographic characteristics, there was uniformity in terms of gender (all women), educational level (graduates of higher education institutions, not pedagogical) and employment (all employed). The age of the sample ranged from 38-42 years old.

The interviews were conducted online due to the pandemic, and were recorded with the consent of the participants, who of course remained anonymous. The participants were in advance aware of the topic under study and the purpose of the research. Each interview lasted 30-40 minutes and took place in March 2021. The clarity of the questions was tested by initially involving two mothers who were not included in the survey sample. The following are the results of the survey, where the questions of the three categories are presented in detail with the verbatim quotation of parts of the interviews to enhance reliability.

## **Results**

### **A) Knowledge**

**1<sup>st</sup> question:** *What do you know about special education?* The majority of responses are distinguished by basic knowledge about special education. They described it as a supportive-helpful educational practice for children with problems in order to achieve their smooth integration into the school and social environment. Indicative responses from participants include: 1st parent's answers : "It helps people with special needs to integrate into the school environment and life in general." 3rd parent's answers : "Special education is a discipline that focuses on children with learning and other difficulties". 7th parent's answers: "That the children attend the same school as the others and are helped by the teachers in addition." 12th parent's answers: "A school where children with special difficulties can participate in order to move forward in their learning and become autonomous and independent and move on to integrate into society so that they are not marginalized". 9th parent's answers: "It functions as an integral part of integrated education and is provided by the state in public primary and secondary schools. Special Education deals with children for whom general and homogeneous education is presented as inappropriate and inappropriate".

**2<sup>nd</sup> question:** *Can you indicate which children belong to the category of pupils with SEN?* Most reported almost all known disorders, especially ADHD, dyslexia, mental retardation, and autism. Fewer reported visual, speech and language, motor, and behavioral problems. We would say that they covered the whole spectrum of disorders that are included in special education. Some indicative answers: 4th parent's answers : "Disabled people can be people with visual impairments, low intelligence, paraplegics, ADHD, but also people with behavioral problems, dyslexia, learning difficulties and others". 9th parent's answers: "Those children who have autism, ADHD, have dyslexia to an intense degree, those who have some kind of illness. Also, refugee pupils because they need special support for learning if they cannot be integrated into the mainstream classroom. " 10th parent's answers: "Autism, mental retardation, low-high intelligence, mobility problems. "

**3<sup>rd</sup> question:** *During your own schooling were there any support structures for children with SEN?* If so, can you mention some of them? The majority of their answers were negative, as most of them expressed ignorance on the present issue, such as 5th parent's answers : "I don't know, I don't remember". 6th parent's answers: "There was none, no, there weren't then". 1st parent's answers: "There was none and basically there was no assessment for special educational needs of children. Only the Sanctuary for the Young, which took in severely handicapped children. "

**4<sup>th</sup> question:** *Can you name support structures for children with SEN that are currently in place?* The knowledge of most parents about the current existing support structures for children with SEN that were recorded included all existing support structures: integration classes, parallel support in the general school, school units of Special Education and Education, the private therapeutic centers of speech therapy, occupational therapy, physiotherapy and psychologists, child psychologists and social workers, as well as the existence of the educational and counselling support center. Some indicative answers: 9th parent's answers : "Special schools, child psychologists, psychologists, social workers, speech and language therapists, physiotherapists, integration and parallel support departments". 2nd parent's answers: "Special school included in the primary school, kindergartens and primary schools,

or the ELEPAP (charitable organization) because it is state law and special law, the Special Vocational Education and Training Workshops schools included in the secondary school, the single vocational high school and high school". 6th parent's answers: "There are special schools, there are special educators in regular schools who either provide parallel support for the child (in the classroom during the lesson) or they gather children with different special needs in another place and create an integration department where they help these children to integrate into the school group".

### ***B) Perceptions***

5<sup>th</sup> question: *What is your opinion about the attendance of children with SEN in mainstream school?* and 6<sup>th</sup> question: *Do you think that the type and degree of severity of special needs affect inclusive education?* These questions are asked together as the answers given to question 5th also complemented question 6th. Specifically, through the responses, the importance of inclusive education was highlighted as the importance of learning to treat all individuals equally, the elimination of stereotypical attitudes as well as the smoother integration of children with SEN into society. Participants' references to the degree and type of disabilities demonstrate that parents of children without disabilities are more positive about inclusive education when students have mild difficulties as opposed to those whose disabilities are severe. Severe autism and mental retardation were the two disorders that were considered to be barriers to achieving inclusive education, as they indicate: 5th parent's answers: "I think that children with mild special needs should attend a formal school because they will grow up in the formal society. There would be no point in excluding them. However, children with severe autism with severe mental retardation I don't think the formal education system would help them. " 8th parent's answers: "I think it is necessary for both children with special needs and those who are developing normally to coexist in mainstream school. It is important that the first ones are not marginalised, that they are more social and happier and that they develop within a school group that includes all children without discrimination. This is one of the advantages of inclusive education for other children, a life lesson, so that they learn to accept and respect diversity, in the hope of becoming even more fulfilled human beings. " 2nd parent's answers: "If the cognitive need of the child allows it, if the mental retardation is very severe, there are special schools. However, if the condition allows it then inclusive education benefits children with special needs because they are socialized and those of typical development become more supportive and non-discriminatory. "

7<sup>th</sup> question: *What advantages do you think your child would gain from studying and interacting with a classmate with SEN?* Participants' responses were oriented towards the emotional benefits that their child would gain from living with children with SEN. Specifically, they mentioned joy, optimism, cultivating empathy, avoiding prejudice, fostering respect, accepting diversity, helping their peers and the possibility of creating friendly bonds with peers with SEN. Indicatively, they mentioned: 11th parent's answers: "Strengthening understanding, friendship and empathy, acceptance of diversity". 6th parent's answers: "In the kindergarten that has a child with autism (with absence of speech) she treats him as a normal child, who used to chase his classmates away because he didn't know how to play with them or was naughty sometimes and scattered the toys. So it seemed to my own child's eyes a little child like all the others. She perceives the same thing about the child with autism who is her friend, that her friend is fine. In the next levels of education, I believe that my child has things to gain from being around such children. First, it accepts difference as something natural to exist! So, he respects it. Moreover, she learns to be more helpful with such children and therefore more responsible. I believe that he would try to include it in the company and therefore to find ways that would help the child with special needs, to participate and therefore more empathy but would also find ways to solve the problem with respect and imagination!"

8<sup>th</sup> question: *What are the possible disadvantages of inclusive education?* The majority of mothers claimed that there were no disadvantages. However, they also expressed some reservations-concerns about the pace of their child's school progress (whether it will slow down) but also about the teaching work and the teacher's ability to manage any problems that may arise from inclusive education. Indicative answers of the participants are mentioned: 13th parent's answers: "If the condition has some characteristics such as ADHD that the child may have exacerbations, the lesson is interrupted, the flow, it delays the progress of the others, otherwise if the condition is mild and supported by teachers and my child is not affected, I do not see a disadvantage". 8th parent's answers: "No, there are no disadvantages. But it is necessary to have integration classes so that some teaching hours can coexist, or parallel support can be provided. " 12th parent's answers: "Not as long as there is a special education teacher, and he is watching the children with difficulties". 6th parent's answers: "Although I have no idea what happens in the higher grades, up to kindergarten I can know, but I believe that inclusion brings difficulties in the work of teaching. Sure, it is difficult to have children with SEN in your classroom, children of another culture who speak another language etc., but not that this makes education impossible etc. It is certainly difficult, but it can be done and can be done very well if the teacher has the appetite and the knowledge".

### **Conclusions**

From the detailed presentation of the participants' answers, regarding the category of knowledge of parents without special education about Special Education and the structures that staff it, it became obvious that their knowledge is basic, naming all existing support structures for children with special needs. Although they do not recall the existence of relevant structures during their own years of schooling, their range of knowledge about students with SEN who are included in special education is satisfactory, defining the children with SEN in line with the results of the studies of Bhargava and Narumanchi, (2011) and Vlachou, Karadimou and Koutsogeorgiou (2016). The issue of parental knowledge as a factor influencing inclusive education has not been extensively studied so it is a suggestion for further investigation to show the magnitude of the effect it may have. Considering that teachers' positive attitudes are influenced by the amount of knowledge they have about special education (Cameron, 2017; Forlin & Gajewski, 2017; Miesera & Gebhardt, 2018) then perhaps something similar could apply to parents.

On the next category of questions on parents' perceptions of inclusive education and whether the type and degree of special needs faced by children are factors influencing the joint attendance of pupils, the majority of parents were in favor of inclusive education, highlighting the benefits that both groups of children would gain. However, their attitude is encouraging on the condition that inclusive education applies to children with mild learning difficulties, while it is stressed that it is preferable for children with more severe disorders to attend special schools. The present results are in agreement with the studies where hesitations were expressed due to the concern about the possible manifestation of unacceptable behavior by their child's classmate (Hilbert, 2014; Papanikolaou, 2018; Sharma & Trory, 2019; Vlachou et al, 2016). In particular, the emphasis that their perceptions also depend on the child's type of disorder is consistent with the data of Dimitrova-Radojicic et al (2014), Bhargava and Narumanchi, (2011), Vlachou et al, (2016) and Paseka and Schwab, (2020) where severe autism, intellectual disabilities and behavioral dysfunctions are disorders that should not be included in mainstream schooling.

There are also research studies whose results showed the neutral attitudes of parents towards the joint attendance of children with SEN, which deviate from the results of the present study (Adiputra, 2019; Vlachou et al, 2016). Furthermore, in the research of Thomidis, (2017) and Rousso et al (2014), which dealt exclusively with the investigation of parents' views on the inclusive education of children on the autistic spectrum, parents were in favor, provided that there was no delay in the academic progress of their own children. The same

can be found in the research of de Boer and Munde (2014) who investigated the views of parents on the inclusion of children with intellectual/differential disabilities who expressed positive attitudes. These research disagreements lead to further research to clarify under what conditions inclusive education is most acceptable.

In the same category, parents' perceptions of the benefits that their children gain through joint schooling were explored. The key benefit that emerged was the emotional payoffs for all students. This finding is consistent with Adiputra, 2019, Bhargava and Narumanchi, 2011, Georgiadou, 2020, Vlachou et al 2016 and Sharma and Trory, 2019. Specifically, it was emphasized that students without SEN are given the opportunity to cultivate empathy, develop feelings of love and respect, learn to accept diversity and eliminate discrimination (Thomidis, 2017; Vlachou et al, 2016; Terzi, 2020), while as far as students with SEN are concerned, they argued that they are given the opportunity to develop friendly ties and the possibility of socialization (Adiputra, 2019; Georgiadou, 2020; Dimitrova-Radojicic & Chicherska-Jovanova 2014; Doménech & Moliner, 2015; Sharma & Trory, 2019; Vlachou et al, 2016; Terzi, 2020). Differentiation of results in terms of emotional rewards, especially of children with SEN is distinguished by the researches of Bobota (2015), Vlachou et al, (2016) and Papanikolaou (2018) with the latter recording that the common attendance of children will bring to children with SEN feelings of disadvantage.

As for the disadvantages that parents were asked to present based on their answers, most did not see any disadvantage. However, they also mentioned some conditions required to avoid disadvantages in inclusive education, such as the existence of special staff in the school unit and the abilities of the general education teacher to cope and at the same time manage both student groups (Thomidis 2017; Hilbert 2014; Rouso et al, 2014; Papanicolaou, 2018; Sharma & Trory, 2019; Vlachou et al, 2016). These conditions could also be characterized as concerns with the consequent delay in the academic progress of children without SEN (Bhargava & Narumanchi, 2011; Georgiadou, 2020; Thomidis 2017; Papanicolaou, 2018; Rouso et al, 2014; Sharma & Trory, 2019).

In the latter category, the attitudes of parents were studied based on their willingness to interact with both themselves and their children with children with SEN. The results of the responses demonstrate their positive attitude towards interaction, but dependent on the existence of pre-existing experience with children with SEN, a discredit that is in line with the results of the surveys of de Boer and Munde (2014) and Vlachou et al (2016). Pre-existing interaction is an incentive to adopt positive attitudes, because parents have been promoted to coexistence, have been confronted with the disadvantages and advantages of joint study and are settled in their beliefs (Paseka & Schwab, 2020; Terzi, 2020). The non-aggressive behavior of the child with SEN was also mentioned as another condition as well as the ability to communicate with him (Bhargava & Narumanchi, 2011; Paseka & Schwab, 2020; Vlachou et al, 2016). However, the high frequency of the answer "I would not have an issue" if there was also a student with an SEN in their child's class does not allow us to interpret the intentions of the parents with certainty.

From the whole presentation of the results, we would say that the parents and specifically the mothers of the sample are in favor of inclusive education, considering that this benefits both groups of children, with or without SEN. However, they also set certain conditions to have this mostly declared positive perception, such as the existence of a special teacher, the type of the disorder (not to be severe autism or mental disability, not to be the manifestation of aggressive behavior or communication problem), while the previous experience with children with SEN contributes to their positive attitude.

The data of the present thesis cannot be generalized because of the type of method (qualitative research, therefore, a limited sample) but they show the position of parents of young children towards inclusive education and the reasons why they are positive or have reservations about the participation of children with SEN in all aspects of school life. However,



the limitations of the survey on the sample (only mothers of young children, graduates of lyceum, with children without SEN) should be taken into account in case of a future study which should include fathers, parents with children with SEN or of higher classes, etc.. Despite the limitations, the conclusions of this research would be useful to diffuse to associations of parents and primary education teachers in order to show the positive mood of mothers towards inclusive education and which factors are reinforcing (e.g., the existence of a special education teacher, the teacher's ability to manage learning and behavioral problems, opportunities for coexistence) in order to take appropriate measures. The "one school for all" should become faith and practice on the part of parents, who certainly play an important role in the school scene.

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## **A quantitative research on teachers' attitudes towards Universal Design for Learning during COVID-19**

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### **Abstract**

As Universal Design for Learning (UDL) appears in the relevant literature as a pedagogical approach which responds to inclusive and equitable education, our research is an attempt to investigate teachers' attitudes of Greek secondary education towards UDL through a quantitative research method this of the questionnaire. More specific, 225 participants took part in our survey which was held from 01/03/21 to 30/06/21. Through our research we have highlighted key points regarding teachers' attitude towards UDL, such as the obstacles to its implementation as well as the effects of it. Due to the current conditions i.e. the implementation of online learning as an emergency measure due to COVID-19 a main question to answer was whether UDL is considered feasible even in online learning.

**Keywords:** online learning, teachers' attitudes, Universal Design for Learning

### **Introduction**

The educational reality in Greece, as in other countries too, is consisted of a significant heterogeneity regarding the student population. Students of all educational levels are characterized of different features and needs. Global geopolitical and financial conditions as well as the emergence of the pandemic COVID-19 affected deeply the social composition creating specific needs and requiring relevant management methods. As far as education is concerned, the effects of the above conditions are obvious and consisted of students' differentiation in demographic, socio-economic, cultural and ability level. School as the mirror of the wider society reflects new needs and requirements and is called upon to respond to modern circumstances.

As student population is highly differentiated according gender, culture, language and ethnicity, abilities, socio-economic background, students' needs are accordingly differentiated. Respectively teachers seek for pedagogical methods that correspond to students' needs. In this context Universal Design for Learning (UDL) appears in literature (Meyer et al., 2014) as an efficient philosophy that promises free, accessible and equal education for all. UDL is the educational framework that responds to the modern requirement for students' inclusion, regardless of differentiating characteristics, aiming to equal access to learning without any exclusion (Pace & Schwartz, 2008; Rose & Meyer, 2002).

Especially during the school years 2019-2020 and 2020-2021, when the presence of COVID-19 was dominant, teachers and students had to deal with new challenges with prominent this of online learning and the difficulties which entails as schools of any level were closed for long periods. Issues such as equal access and equal opportunities for all were raised (Markou & Noguera, 2020) since online learning was an emergency measure and it was not the required time to be organized on the basis of inclusive education (Mavrou, 2020). Also the learning environments (educational platforms) were not accessible to all (McCall, 2020). In addition, 10% of the student population belonged to the category of children with special needs/disability and it was the need for facilities that were not planned in the context of such an emergency implementation (Armitage & Nellums, 2020; Petretto et al., 2020).

Consequently, the education system needs radical reforms and the UDL framework supports the most viable foundation for beginning this redesign process (Basham et al., 2020).

#### **UDL context**

UDL is a philosophy that started in the field of architecture and was extended to the field of education, which advocates that all contexts are designed in such a way as to empower students regardless of differentiating characteristics to participate in the learning process as much as possible (Izzo & Baker, 2015), eliminating any obstacles regarding infrastructure, educational material, curriculum or teaching methods (Arabatzis et al. 2011).

The element that differentiates UDL from other educational approaches is that recognizes and accepts diversity a priori, so that no retrospective adjustments or modifications are required. UDL does not claim that there is a universal solution that works for everyone. Instead, it is based on the design of learning that addresses the different needs of all students through the integration of alternative and flexible proposals and practices. It can be applied in every learning process, in every educational level and subject without exception, in special education, intercultural education, adult education, both in live and distance education.

It is an organized framework of educational practices which is based on three main pillars according to CAST (2011):

- Multiple ways of representing information
- Multiple means of action and expression
- Multiple means of engagement

UDL is based on neuroscience findings on how the human brain works and is related to the learning process (Meyer et al., 2014). It therefore focuses on the networks of the brain that are connected to the learning process, namely the emotional networks, the recognition networks and the strategy networks, to which the three pillars of the UDL correspond to.

UDL as an educational approach provides the right framework to meet the different needs of all students, not just those with special educational needs (King-Sears, 2009) based primarily on the need for respectively flexible learning environments and secondly on the different learning styles. Online education with a variety of digital tools auxiliary for students ensures the required flexibility and is a fertile ground for the implementation of UDL (Dawson et al., 2019; Ok & Rao, 2019). In particular, nowadays due to COVID-19 pandemic, the application of effective pedagogical practices in online education becomes imperative (Rao & Meo, 2016). UDL can benefit students not only in a traditional classroom but also can provide high challenges to maximize online teaching and learning (Coombs, 2010; He, 2014; Lancaster, 2008).

#### **UDL in Greece**

For the Greek government, inclusion in education is a matter of policy and a key pillar and strategic goal (Eurydice, 2020). Accordingly, the relevant Greek ministry, this of education, proceeded to a series of laws aiming to ensure inclusion (Eurydice, 2020) favoring UDL in the Law for special education (Law 4415/2016). However, as far as the Greek educational system is concerned we cannot claim that UDL holds the appropriate position in pedagogical issues despite the fact that it is acknowledged as an effective, inclusive practice in the international literature (Al-Azawei et al., 2016; Dymond et al., 2006; Lieberman et al., 2008; Rose & Meyer, 2002; Sailor & McCart, 2014; Shogren & Wehmeyer, 2014; Thoma et al., 2009). The relevant Greek studies and the recorded UDL implementations as well are incredibly limited (Akogiounoglou et al., 2019; Chalkiadaki & Akogiounoglou, 2019; Riviou et al., 2014; Tzivinikou, 2014).

At this point, it is worth mentioning two projects concerning UDL in Greece. We refer to UDLnet (<http://www.udlnet-project.eu>), funded by the European Union, aiming to develop a systematic methodology and good practice criteria around UDL (Giannelos & Mathioudaki, 2017). Furthermore, the project "Universal Design and Development of Accessible Digital



Education Material” (<http://www.prosvasimo.gr>), funded by the European Union and national financial resources as well, provided for the development of universally designed printed and digital educational material for students with special educational needs/disabilities (Gelastopoulou & Kourbetis, 2017).

### **UDL and online learning**

There is confusion as regards definitions and distinction of the terms e-learning, distance learning, online learning and other related but it is something that does not concern the present work. However, we will refer briefly to the above terms. When we talk about distance education we are referring to courses that are studied without being necessary for teachers and students to be physically present at school or college or other educational institute (Guilar & Loring, 2008; Volery & Lord, 2000), while existing distance is overcome by using technological resources (Casarotti et al., 2002). So, we can perceive it as “a process to create and provide access to learning when the source of information and learners are separated by time and distance, or both” (Honeyman & Miller, 1993). Online learning, e-learning and similar terms refer to 100% online courses taking place over the internet (Oblinger & Oblinger, 2005). It is a type of distance learning, so we understand that distance learning functions as an umbrella for any learning process that takes place across distance and not in the context of a physically classroom (Stern, n.d.). Therefore, we can claim that distance learning is simply a wider term that includes among other and e-learning.

During the COVID-19 pandemic, a rapid online teaching and learning transition become a common reality for many countries including Greece (Bartlett, 2020; UNESCO, 2021). The COVID-19 pandemic has affected and resulted in schools and educational institutes’ closure as well as in online learning rise, recognizing it as the only feasible measure for the continuum of education. As a result, education reality has changed dramatically as well as the whole reality. The consequences of corona virus might stay as it is unlikely to return to the past way of life, before COVID-19 (Daniel, 2020). The adoption of online learning will continue to persist post-pandemic but it should be adjusted to educational and pedagogical terms in order to be an effective and quality way of education. It should follow the relevant policy, this of inclusion, that is not only a social imperative but also a political issue for Greece (EURYDICE, 2021). We seek for inclusive classes where equity and fair are the dominant axioms.

In this context UDL comes to the fore as an educational framework that embraces inclusion maximizing learning and minimizing barriers for all students (Bernacchio & Mullen, 2007; Rose & Mayer, 2008). UDL creates fair and equity providing multiple equal opportunities for all students according their needs (Black et al., 2014). In fact, UDL, according the relevant literature (Coombs, 2010; He, 2014; Lancaster, 2008), responds to the challenges of distance learning and can be implemented effectively not only to face-to-face environments but as well in entirely digital environments of education. Of course, UDL cannot address all the obstacles of online learning but can motivate learners to achieve the learning goals in a more effective or enjoyable way (Al-Azawei et al., 2016).

The potential and effectiveness of designing accessible curricula by using online learning has been discussed in literature concluding that e-learning ought to be blended with pedagogical contexts in order to ensure access for all students and meet their needs (Bongey et al., 2010; Seale & Cooper, 2010). As far as UDL is concerned, many researchers identify the effect of using educational technologies on designing and implementing UDL courses (Bühler & Fisseler, 2007; CAST, 2011; He, 2014; Kumar & Wideman, 2014; Rose & Strangman, 2007; Smith & Harrey, 2014). Technology based environments and digital tools provide effective means to put UDL into action (Meyer & Rose, 2005; Ok & Rao, 2019). And vice versa, UDL based blended e-courses can lead to positive effects for the learning procedure and the students as well (Dallas et al., 2016; Morra & Reynolds, 2010).

### **Methodology**

The current research aims both to analyze attitudes that teachers of Greek secondary schools have towards UDL as well as to identify the variables that affect these attitudes. The research method is quantitative; a questionnaire is used as a research tool.

#### *Necessity and usefulness of the educational research*

This educational research contributes significantly to the development of the relevant educational scientific fields, as the use of its findings can lead to further development by the responsible educational organizations and the teachers themselves (Altricher et al., 2001). In fact and given the very limited research activity in this area the usefulness of the current research is even greater.

#### *Research questions*

The research is guided by the following research question: What is teachers' attitude towards UDL in Greek secondary education? Subsequently the following sub-questions emerge:

- Do teachers know the most current educational terms, these of UDL, intercultural and inclusive education?
- To what extent do teachers consider UDL as a necessity nowadays?
- Do they implement UDL in their instruction?
- What are the obstacles for UDL implementation?
- To what extent are they personally satisfied from its implementation?
- Under the special conditions of the research, i.e. the complete provision of distance learning due to the pandemic Covid-19, do they consider UDL implementation feasible in a digital environment as well?

#### *Research design and data analysis*

For our research we used as a quantitative tool the questionnaire choosing simple random sampling. It is about a web-based surveying on the advanced online *survey* system of lime survey (<https://www.limesurvey.org/>). After the questionnaire's initial design and before its distribution, issues of validity and reliability were examined. More specific we tried to access the validity of our questionnaire through face validity in order to detect errors and proceed to modifications in a quick way. Then the questionnaire was distributed to a convenience sample (25 respondents) in order to confirm whether

- The terms used are easy to understand
- The order of the questions does not cause tendencies of possible confusion
- The wording of the questions allows the collection of the desired data
- The estimated time to complete the questionnaire
- The reliability of the questionnaire.

The first sector of the questionnaire included seven questions of demographic interest, while the second one titled "*The views of secondary school teachers on UDL and its contribution to the promotion of intercultural and inclusive education*" included twenty-five questions. The questionnaire consisted of questions that were closed, of single or multiple choices, with predefined answers leading to data collection.

In order to encode the data and analyze / interpret the results we used the statistical package of SPSS (Statistical Package for Social Sciences). We also used descriptive statistics to present the data of the statistic research and conduct relevant conclusions. The presentation of the quantitative data was performed through graphs.

#### *Sample and data collection*

To select the sample, we addressed to secondary schools and Second Chance Schools having received the relevant permits from the competent bodies, i.e., IEP (Educational Policy Institute) and INEDIVIM (Foundation for Youth and Lifelong Learning). To be more specific, a total of 101 secondary schools and 19 SCSs, from the regional units of Attica, Peloponnese, Central Macedonia and Central Greece, participated in the survey. The sample was made up of a total of 225 teachers of secondary education that work either in lower secondary education (gymnasium), either in upper secondary education (lyceum) or in SCSs, adult schools that provide a diploma equivalent to this of secondary education. Of these, 149 teachers serve in general secondary education, 38 in special education as parallel support or in integration departments, and other 38 in SCSs. The most of them are women while the majority of the whole participants are 20 to 45 years old. In addition, in a very satisfactory rate and more specific 57, 8% have a master's degree.

**Table 1. Demographic Summary of Study Participants**

Sample data			
Total Sample		n=225	100%
		n	%
Gender	Women	162	72%
	Men	63	28%
Age	20-45	131	59,2%
	Over 45	94	41,8%
Teacher of	General education	149	66,2%
	Special education	38	16,9%
	SCSs	38	16,9%
Educational level	Diploma	78	34,7%
	Master's degree	130	57,8%
	Doctoral	17	7,6%

#### *Implications and limitations*

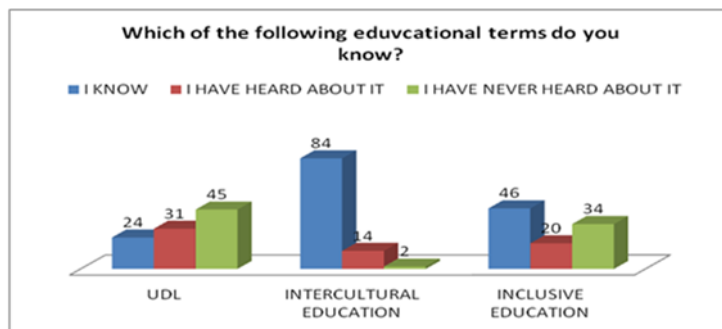
Our survey was completed according to the original schedule without any problems. The candidates were informed about the research (information protocol) as well as about issues of anonymity and security of personal data (Cohen et al, 2008). The protocol and the questionnaire link were sent via email as an attached file accompanied by a brief information material related to the UDL philosophy. We considered necessary to send this material in order to have answers to basic questions, e.g., necessity of UDL even by respondents who did not know the term.

The participants answered the questionnaires from 01/03/21 to 30/06/21 without any problems. However, the small sample size does not allow for generalizations to the wider population of teachers which is much larger. So, we avoided generalization for reliability reasons.

#### **Findings**

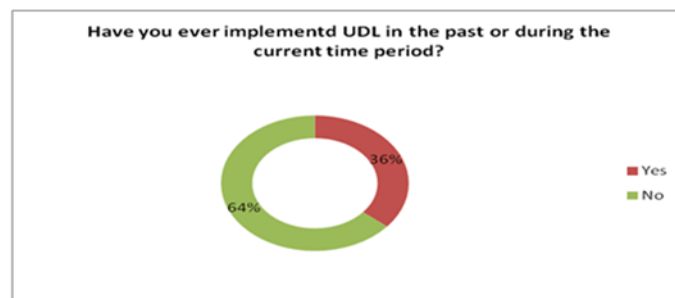
##### *Teachers' attitudes towards UDL*

The research data demonstrate teachers' attitudes towards UDL which is the main issue of our research. On the one hand, we find out that there is a difficulty in adoption and implementation of new educational philosophies by teachers. It is worth noting that most of them (98%) know or have heard about intercultural education, while to a lesser extent (66%) inclusive education and UDL (55%). The percentage of 55% corresponds to 123 participants from the total number of 225.



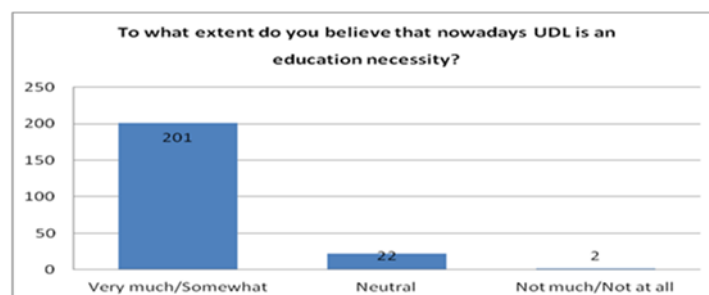
**Figure 1. Teachers' knowledge for UDL, intercultural and inclusive education**

The 123 participants were asked whether they have ever implemented UDL in the past or during the current time period, this of school closure due to COVID-19 (school year of 2020-2021). The 36% of them (44 participants) answered positively while the other 64% (79 participants) responded negatively.



**Figure 2. Teachers' percentage of implementing UDL**

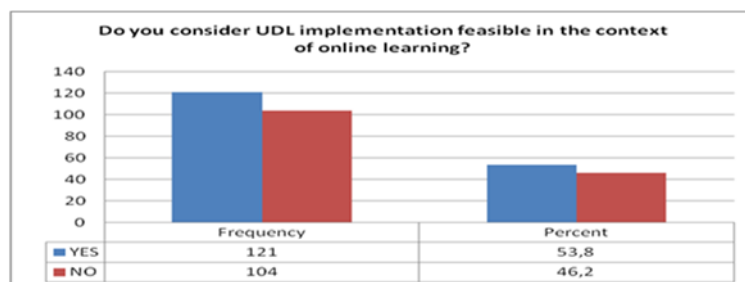
On the other hand, despite the fact that only the 55% of the sample knows/has heard about UDL, an overwhelming number, 201 out of 225 teachers, believes that UDL is an educational necessity against 22 teachers who answer neutrally and 2 who do not consider it necessary. Their opinion is based on the information material that was at their disposal from the first moment and they were asked to study it before completing the questionnaire.



**Figure 3. UDL as an education necessity**

Despite that fact that not all the participants know UDL and consequently are not able to implement it even in a physical class, they all asked to answer the question "Do you consider UDL implementation feasible in the context of online learning?" with the rationale that it is an educational philosophy and as they are aware of digital learning environments due to current

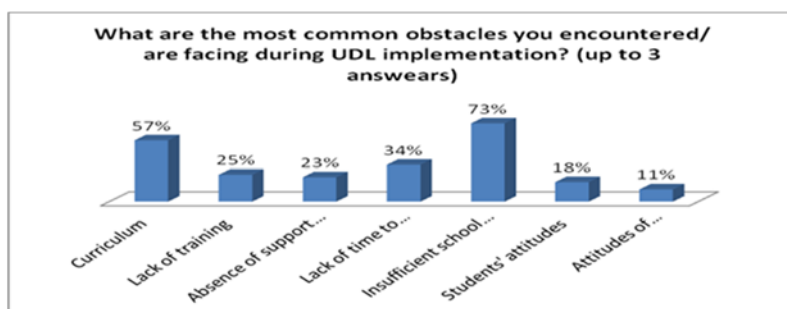
circumstances they can form a relevant opinion from their experience. From the total number of 225 participants, 121 responded positively while the other 104 negatively.



**Figure 4. UDL in online learning**

#### *Obstacles in UDL implementation*

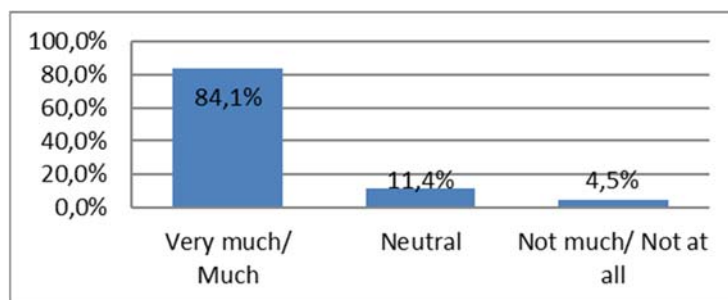
According to teachers' answers on the question "What are the most common obstacles you encountered/ face during UDL implementation?" the majority of them claims that the insufficient school infrastructure (facilities, technological equipment) and the current Curricula are the main difficulties they face. "Lack of time to prepare", "Lack of training", "Absence of support (from PEKES / PRINCIPAL OF SCHOOL UNIT / COLLEAGUES)", follow as answers in the above question. A smaller percentage refers to students' attitudes or their guardians' attitudes as a difficulty in implementing UDL.



**Figure 5. Obstacles in implementing UDL**

#### *UDL impact on teachers and students*

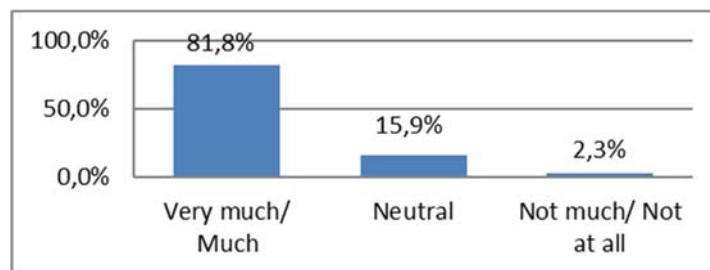
The 44 teachers, who have implemented UDL, answered the question whether the application of UDL provides them with personal satisfaction and a sense of self-esteem. In percentages, the 84,1% claimed that yes, UDL implementation gives them satisfaction and a high sense of self-worth.



**Figure 6. Teachers' personal satisfaction by implementing UDL**



Likewise, as regards UDL effect on the students, positive data were drawn from the teachers' responses to the relevant question "Does the implementation of UDL contribute to the motivation/participation of all students and improve their performance?". The majority (81, 8%) claimed that UDL implementation contributes to students' motivation and participation as well as to the improvement of their performance.



**Figure 7. Students' motivation/participation and performance**

### Discussion

Studying the data of our research we interpret them as follows. The teachers of our sample are more acquainted to practices such as intercultural and inclusive education while are not too keen on new philosophies like UDL. Certainly this attitude is attributed to the fact that UDL is not promoted as much as the other terms and it also requires some perquisites, compatible curricula and relevant training. The teachers of our sample refer to several factors that function as obstacles to UDL adoption and implementation, which are also recorded in the international literature. To be more specific, the lack of infrastructure, the incompatible to UDL curricula, the extra required planning time as well as the lack of relevant training are recognized as main barriers to UDL adoption and implementation (Cooper et al., 2008; Kumar and Wideman, 2014; Markou & Diaz-Noguera, 2022; Mavrou, 2012; Rose et al., 2006; Riviou et al., 2014; Tzivinikou, 2014;).

It is worth mentioning that teachers are amenable to UDL as a significant percentage, who have implemented UDL, claim that have a high sense of personal satisfaction and recognizes positive effects to student's performance as well. Therefore, even teachers that they are not acquainted to UDL accept that UDL is a necessity for educational systems like the Greek one. Probably teachers, evaluating the educational situation and mainly students' diversity, look for new teaching methods that meet the contemporary educational requirements. However, the adoption of new pedagogical approaches also requires a corresponding cognitive background, compatible curricula and infrastructures. So, reforms are required, radical reforms consistent with UDL framework for a well-organized and systematic adoption in the Greek educational system. Until now, the necessary decisions and actions have not been made by the relevant Ministry for both the systematic training of teachers and curricula adaptation in this direction (Markou & Diaz-Noguera, 2022).

Encoding our research data and interpreting the findings we reach the conclusion that there is an oxymoron as despite the fact that almost half of the teachers know/have heard UDL and even a smaller percentage implements UDL in Greek secondary education, in their overwhelming majority they believe that UDL is nowadays an education necessity. As it was mentioned our sample relied on information related to UDL that was received before filling in the questionnaire.

The low percentage of teachers who know and therefore implement UDL as extracted from the survey data is due to insufficient training and the other mentioned obstacles, i.e. the existing curricula, the lack in school infrastructure and the lack of a well-coordinated effort by the Ministry of Education in this direction.

The fact that the majority of teachers, who have implemented or implement UDL, feel satisfied, it also indicates the positive impact of UDL to teachers themselves. As regards UDL in online learning, teachers are divided. A bit more than the half has a positive attitude while the corresponding percentage answers negatively. So, the very close percentages require further investigation.

### **Conclusions**

UDL is an educational framework that addresses the current demand for inclusion. Due to its characteristics, those of variety and flexibility can be an effective learning approach. Even in special conditions like digital educational environments or blended courses (face to face and online learning) UDL can be implemented providing equal access to learning for all despite any differentiating characteristics.

Our research comes to confirm the positive impact of UDL both for teachers and students. Furthermore, according to our sample answers we come to the conclusion that UDL is feasible in online learning. However, in Greece, based on our research findings, we conclude that UDL implementation is in an embryonic stage as only a low percentage of secondary teachers, who participated in our research, really knows and respectively implements UDL. Of course, due to the small sample we cannot proceed to arbitrary generalizations. On the contrary our conclusions concern only our sample and we consider necessary a further research on the subject.

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## **Teaching about the persistence of vision and the sampling rate of the human eye using STEM methodology: An empirical study**

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### **Abstract**

Many things around us make sense through the illusion of motion. This fact is based on a 'rawback' of the human eye's function, referred to as '*persistence of vision (POV)*'. This paper focuses on the design, implementation, and evaluation of a project for teaching and experimentally explaining this phenomenon using Arduino and S4A as learning tools in a STEM education framework. Thirty-two (32) pre-service teachers, fourth-year university students, voluntarily participated in the research. The aim of the study was to investigate the effectiveness of such educational activities in a STEM methodology framework, the suitability and usability of the tools used as well as the intention of pre-service teachers to adopt such tools and methods in their teaching practice. The results highlight the effectiveness of the tools and the method to achieve the expected learning outcomes as well as the positive views of the participants towards Arduino and S4A as teaching and learning tools in a STEM methodology context and their willing to adopt them in their classroom.

**Keywords:** STEM Education, Arduino, S4A, persistence of vision, eye sampling rate

### **Introduction**

Nowadays it is commonly accepted that children of 21<sup>st</sup> century need to be equipped with a variety of skills such as critical thinking, creativity, and innovation to become technologically literate individuals, creative minded persons, and capable solvers of real problems. For this, it is necessary modern teaching methods and tools to be adopted modifying the role of the teacher and the student. The center of such methods needs to rely on interdisciplinary as well as student-centered approaches. The teacher of today is a well-educated person ready to support and promote students' self-action and initiative through creative activities (Karatrantou & Panagiotakopoulos, 2012).

STEM methodology in education serves this learning philosophy and teaching approach and supports the new roles for teachers and students (Lesseig, Slavitt, & Nelson, 2017). Within this framework, a particularly useful tool that emerges, is educational robotics along with the different educational packages that are used for the construction and programming of simple automatic control systems (McDonald, 2016). The Arduino platform is an open-source platform with a range of uses and applications including educational activities (Przybylla & Romeike, 2015; Omar, 2017).

For the purposes of the present study, simple circuits and constructions with Arduino were designed, constructed, and used to experimentally explain the '*Persistence of Vision (POV)*' and the '*sampling rate*' of the human eye. Primary school pre-service teachers were participated in this attempt working in a STEM education framework. Specially formulated

worksheets were used during the project and cognitive tests and evaluation questionnaires were used before and after the process.

### **Educational robotics & STEM Education**

#### *STEM Education*

STEM the acronym that derives from the four areas: Science, Technology, Engineering, Mathematics, was first introduced by the Natural Science Foundation. For an educational environment to meet the STEM philosophy, features as the following are needed (Karatrantou & Panagiotakopoulos, 2012): *a content that concerns and finds application in the real world, a student-oriented environment that strongly engages students with the content, a challenging learning process based on research to solve a problem, a Project Based methodology, a learning process inside a collaborative learning model, a process could take place in a controlled and safe environment for students, such as a laboratory, a connection of the four STEM areas making use of knowledge, tools, and methods of them.*

At least during last two decades, worldwide there is a growing concern about science learning in schools. Usually, science curricula are failing to engage students with STEM subjects and STEM careers or develop the critical problem-solving skills needed in professional and everyday life today. There is an emerging recognition of the need to develop authentic school practices in science. STEM and STE(A)M methodology offers possibilities of knowledge transfer between the four disciplines emphasizing disciplinary knowledge as relevant to solving problems. STEM methodology is consistent with competencies that include critical and creative reasoning, complex and collaborative problem-solving, and student agency (Tytler et al., 2021).

#### *Educational Robotics*

A particularly important practice, that can combine, make use of, and promote most of what has been mentioned above, is the educational robotics. Students through educational robotics are offered the opportunity to participate in projects and to explore and learn how technology works. As they are engaged in an activity where planning, construction and programming are necessary, students do not only improve their respective skills but at the same time they apply knowledge in practice coming from the subjects of Physics and Mathematics (Omar, 2017). Educational robotics is directly related to STEM philosophy both from a pedagogical point of view and through its direct connection with the two areas of STEM, Technology and Engineering. Educational robotics can also positively contribute to the increase of students' motivation, their engagement in learning, their creativity as well as their positive attitude towards education (Stergiopoulou, Karatrantou, Panagiotakopoulos, 2016).

Many research papers present empirical evidence to support the efficiency of robotics as a complementary tool to learning. The results of learning robotics indicate that students can build computational thinking skills, teamwork, communication skills and collaborative interaction between students and teachers. Educational robotics can offer and support increased student motivation, a sense of fun, enthusiasm, and participation. The literature review present studies that promote the inclusion of programming and robotics in the school curriculum, describing their benefits in terms of motivation, commitment and problem solving. Some studies underline the problems in implementing robotics and programming in schools such as teachers' attitudes, teacher training, logistical issues, and the school resources available (Sáez López et al., 2021).

#### *Arduino platform*

Arduino is an open-source hardware platform, which incorporates a microcontroller and consists of input and output ports. Arduino could be an important educational tool, as it can support the construction of simple automatic control systems and physical computing. Physical computing is the programming of objects interacting with the natural environment,

which in recent years is widely used in all levels of education (Przybylla & Romeike, 2015; Omar, 2017).

S4A is a version of MIT's scratch programming environment, adapted to be able to control the Arduino microcontroller with appropriate commands. In this study Arduino UNO with 'Arduino Starter Kit' and S4A as the programming environment were used. Visual block programming enables experimentation with computational methods that contribute to problem solving, fostering the development of logical thinking skills. Programming is a fundamental science skill, an essential tool to support the cognitive tasking involved in computational thinking, as well as a demonstration of computer competence (Sáez-Lopez et al., 2021).

### **Human eye and persistence of vision**

#### *Persistence of Vision*

Persistence of Vision (POV) refers to the ability of the brain to retain a visual stimulus for a short period of time after the stimulus has been lost or altered. Due to POV and to a combination of cognitive functions of the brain described as '*phi phenomenon*' and '*beta movement*' humans can watch animation or cinema, perceiving a sense of motion (Barker, 2009; Cook, 2016). This sense of motion is also known as *apparent motion*. Any image that the human eye receives can be remained for about 1/15 of a second. Thus, if another image is projected during this time, the human brain cannot separate the two images and '*sees*' them as a single image or a visual continuum. Examples where the phenomenon can be observed is the '*visual trace*' which is left behind a lightened object which is being circularly rotated, thus, composing a single circular contour. Another example is '*Newton's disc*', in which a viewer can see the composition of its colors when the disc is being rotated. Moreover, an example of this phenomenon is the experiment of the '*narrow slit*'. More specifically, if an observer looks through a narrow slit to see an image, he/she can only see a portion of the image at a time. However, if he/she moves the slit quickly, then he/she can get a complete picture of what he/she is looking at, as the visual stimuli received each time through the slit are retained and linked. Some of the constructions built in the 19th century and to which the phenomenon applies are: Thaumatrope, Phenakistoscope and Zoetrope (Cook, 2016).

#### *Sampling rate of human eye and flicker fusion threshold*

The term '*Flicker Fusion Threshold*' refers to the rate at which if a light source blinks its flicker is not visible to the observer, but it looks constantly on. This phenomenon can be observed in a range of frequencies and depends on a set of parameters, such as brightness, retinal position that is stimulated, magnitude of the light source etc. A different frequency of the fusion threshold is observed for different eye cells, rods and cones and their peculiarities. The frequency of the fusion threshold of the rods is estimated at about 15 Hz, whereas this of the cones, depending on the intensity of the light, at about 60 Hz (Cook, 2016). It is, therefore, a phenomenon that substantiates the sampling function of the human eye, since at these frequencies the eye can not perceive the '*off*' mode. This phenomenon is important as it is used in various ways in everyday life technologies. It is directly linked to the projection of static images like, for example, in the cinema. If the rate at which images are displayed is lower than the one required, then the flicker will be apparent. As a result, the movie will not flow smoothly, and the movements will look choppy (Mineault, 2011).

### **Aim of the study and research questions**

The aim of the study was to investigate the effectiveness of the implementation of STEM education methodology using Arduino and S4A as tools to teach the '*Persistence of vision phenomenon*' and the '*sampling rate*' of the human eye. For this purpose, simple circuits and constructions with Arduino were designed and programs in S4A environment were developed to experimentally these phenomena be explained by Primary school pre-service teachers

working in a STEM education framework. The research questions were formulated as:

- How Arduino platform can effectively be used and support learning activities in a STEM education context for teaching concerning the persistence of vision and the sampling rate of the human eye?
- What is the intention of future primary school teachers to use Arduino and S4A environment as teaching and learning tools in a STEM methodology framework?

### **Methodology**

The project was carried out in the Computers Laboratory of the Department of Educational Sciences and Social Work, University of Patras. A total of thirty-two (32) pre-service teachers, students of the Department of Primary Education, participated. Ten of them (10) were men and twenty-two were (22) women. The project lasted ten hours in total, consisted of two sessions of five hours each. The thirty-two (32) participants worked in groups of four (4) and the following tools were used for the data collection: *a short questionnaire concerning the characteristics of the participants, paired pre- and post-cognitive tests, an evaluation questionnaire, analyzing data from the four (4) worksheets given to students during the implementation of the project, monitoring and personal notes by the researchers.*

The short questionnaire was consisted of questions concerning sex, age, year of studies, and seven (7) questions with answers in a Likert-type scale concerning students' existing knowledge and skills on computer use, Arduino platform and coding (programming).

The pre-cognitive test consisted of five (5) open-ended questions aiming to assess the existing knowledge about the POV phenomenon, the sampling rate of the human eye and their effect in everyday life.

The post- cognitive test consisted of eight (8) open-ended questions. The first five (5) questions were identical with the questions of the pre-test. The other three (3) questions were focused on the understanding of the activities participants carried out and on the examples of application of POV. The post-test was answered by the participants at the end of the project and after one month as well (follow-up).

The evaluation questionnaire was consisted of thirteen (13) questions. Six (6) questions were open-ended and were concerning students' difficulty while working, their satisfaction with the activities, the knowledge they gained, and the sciences related to this knowledge. The other seven (7) questions were Likert-type with a five-point scale from "None" to "Very much". Students had to answer about their interest in the project, the degree of difficulty of the activities, the educational usefulness of the activities, and their intention to use similar activities in the future for teaching. They also had to answer about the degree of difficulty using the S4A Programming environment and their impressions of the Arduino microcontroller concerning its usefulness and their intention to use it in the future.

The validity of the questionnaires as well as their suitability for the certain project were checked by one expert in STEM methodology in education and one expert in educational technology and appropriate corrections were made.

Four worksheets were constructed and used during the project. The suitability of the worksheets according to the purpose of the project and the research was checked by one expert in STEM methodology in education and one expert in educational technology and appropriate corrections were made.

A pilot implementation of the project with a group of four (4) students took place to check the appropriateness of the worksheets, the applicability of the designed activities, the duration of all the appropriate activities as well as the understandability of the questionnaires by the students.

Three researchers were observing the discussions, activities, and reactions among the students during the whole project. They kept notes and made interventions when students needed help, adopting a supportive and facilitative role of students' work and learning.

For data analysis purposes descriptive and inferential statistics for the quantitative data



and content analysis of the answers to the open-ended questions were used for all questionnaires and cognitive tests (Panagiotakopoulos, & Sarris, 2016).

The cognitive tests were analyzed using both qualitative and quantitative data. The content of the answers of the students for each question was analyzed in order to different aspects of their responses to be emerged. Additionally, the answer to each question was graded based on a scale of 1 to 10 according to its correctness. Summing the grades of the questions a total score for each test was derived. The total scores were 50, 70 and 70 points for the pre-test, the post-test after the end of the project and post-test one month later respectively. The tests were graded by two researchers each time to enhance the validity and reliability of the scores based on certain criteria. For the analysis the average scores of the two researchers for each test were used.

### **Ethics**

The research was conducted based on a permit issued by the competent bodies (Council of the Department of Education and Social Work, University of Patras and Region of Western Greece), as provided for by law and the relevant provisions. Students of the Department of Education and Social Work were voluntary participated in the study. During a meeting before the start of the project the purposes and the procedure of the research were analyzed. In any case, the data collection was anonymous, the ethics of the research were fully respected, and the privacy of the participants maintained.

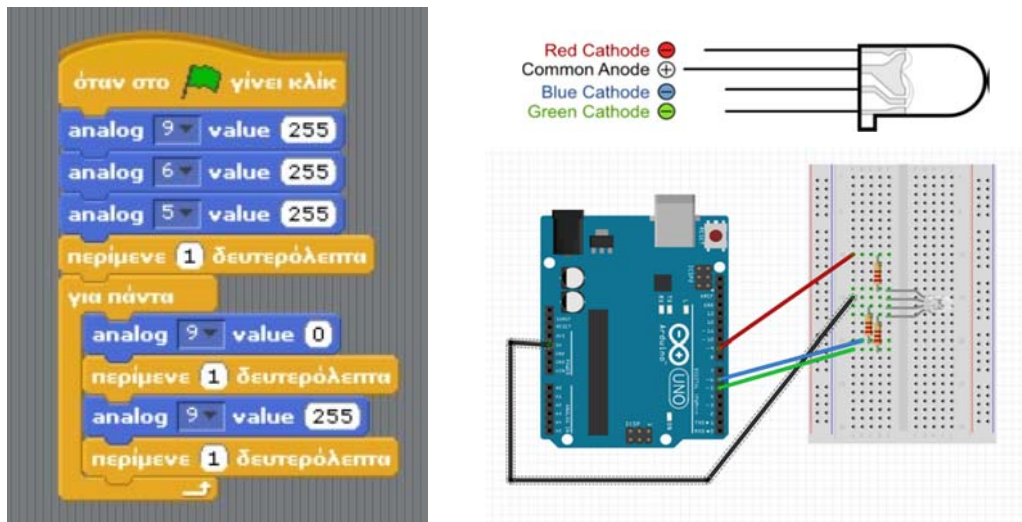
### **Description of the project**

At the beginning of 1st session of the project, the participants answered the short Questionnaire for data collection concerning the characteristics of the participants and the cognitive pre-test. After that, they worked based on the 1<sup>st</sup> and 2<sup>nd</sup> worksheet.

Working based on the 1<sup>st</sup> worksheet students used the Arduino platform and simple electrical and electronic components to create a circuit. The purpose of the 1<sup>st</sup> worksheet was students to be familiarized with the Arduino, the S4A Programming Environment and to make their 1<sup>st</sup> experiment as well (Figure 1). They used an RGB LED, a LED that incorporates the three colors: red, green, and blue (Red Green Blue). They designed and created a program in the S4A environment to turn on one of the three colors and then modify it appropriately, reducing the duration of the “on” and “off” state (the blinking frequency). The cognitive goal was to prove and document the sampling rate of the eye, observing that at a certain blinking frequency of the LED the ‘off’ state was no longer perceptible by the eye.

Working based on the 2<sup>nd</sup> worksheet students had to use the same circuit turning ‘on’ and ‘off’ two colors of RGB LED, the red and the blue one. Students had to create a program to turn ‘on’ and ‘off’ the blue and red color successively and reduce the duration of each state until they cannot separate the two colors observing a purple color (the mix of red and blue). The purpose of this worksheet was to drive students to observe and experimentally be introduced to the phenomenon of POV and the sampling rate of the eye.

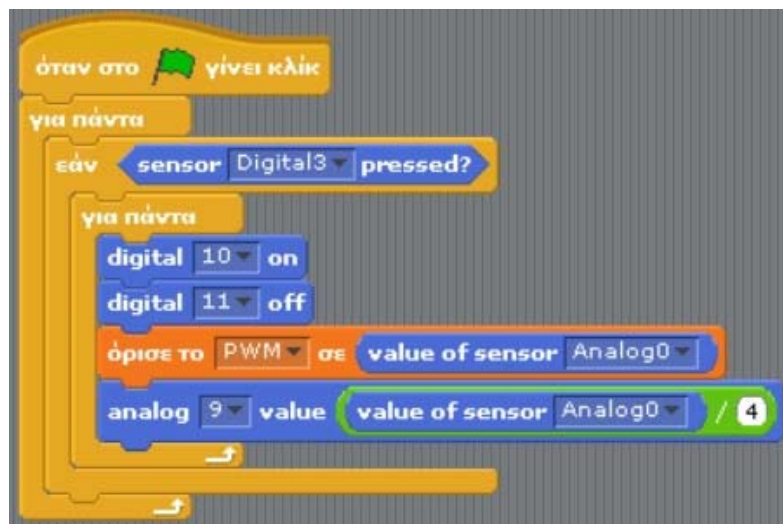
During the second session students had to work on the 3<sup>rd</sup> and 4<sup>th</sup> worksheet. According to the 3<sup>rd</sup> worksheet, the participants had to create a more complex circuit using a motor whose rotation frequency was controlled by a potentiometer.



**Figure 1. The RGB LED, the circuit and the program for the 1<sup>st</sup> experiment of the 1<sup>st</sup> worksheet**

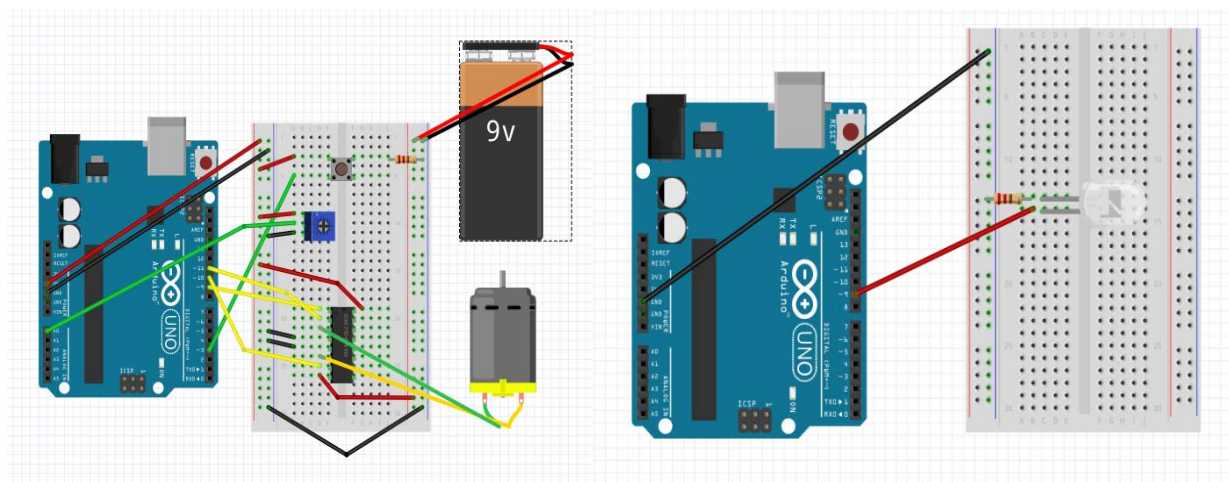
As a first task, they had to stick a small thin strip of cardboard onto the motor, put the motor into operation and write down and explain what they observe. In fact, this was an application of POV, during which at a certain rotation frequency of the motor, each position of the rotating strip is held in the observer's brain giving the visual result of a circular disk.

As a second task, students had to simulate the function of the *stroboscope* aiming to be able to calculate the rotation frequency of the motor. The *stroboscope* uses a light source that blinks at a varying and known frequency and at the same time projects its light on a rotating object. When the blinking frequency of the lamp and the rotation frequency of the object are equal the object is perceived as immobile. In this way knowing the blinking frequency of the lamp it is possible to calculate the rotation frequency of the object.



**Figure 2. The program for the 3<sup>rd</sup> worksheet controlling the function of the motor**

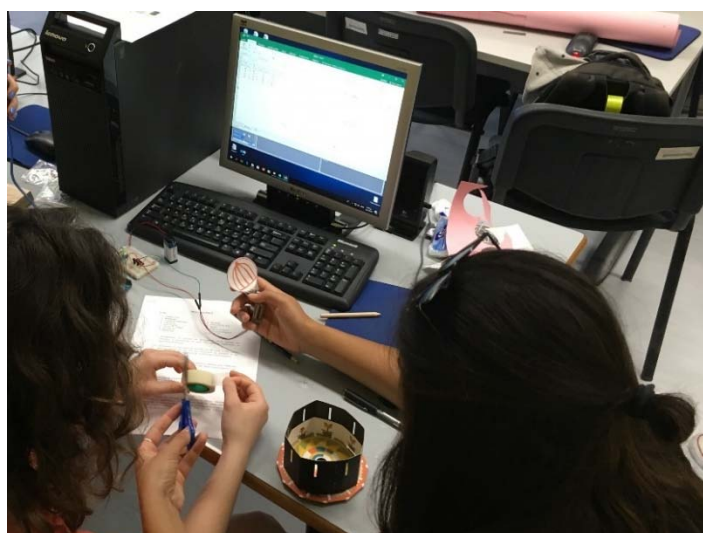
A simple circuit with a LED and the above-mentioned circuit with a motor used to simulate a *stroboscope* (Figure 3). Students had to change the blinking frequency of the led and write down the value of the voltage at the ends of the potentiometer (that controls the rotation of the motor) at which the strip looks immobile. These values were stored and edited in an Excel file in order to a scatter plot be created. Using this scatter plot participants could calculate the motor's rotation frequency knowing the values of the voltage at the ends of the potentiometer.



**Figure 3. The circuits simulating the *stroboscope* for the 3<sup>rd</sup> worksheet**

At the end of 3<sup>rd</sup> worksheet, the participants had to reflect on observations they made during the experiment.

Working based on the 4<sup>th</sup> worksheet, the students use a *Thaumatrope* and a *Zoetrope* with the help of the circuit with the motor (that of the 3<sup>rd</sup> worksheet). *Thaumatrope* is a circular disc with two different images; one in each side and when it rotates it gives as a visual result the composition of the two images. The *Zoetrope* is a cylinder, inside and in the periphery of which there is a series of representations (images) and above them there are narrow slits. When the *Zoetrope* is rotated if someone look through the slits can observe a coherent flow of images taking place, as if watching an animation story. Students using the results of the experiments of the 3<sup>rd</sup> worksheet carried out experiments with the *Thaumatrope* and the *Zoetrope* trying to experimentally calculate the rotation frequency at which the above-mentioned phenomena happens and the relation among this frequency, the number of the images on the rotating devices, the sampling rate of the eye and the POV phenomenon (Figure 4).



**Figure 4. Students working with the *Thaumatrope* and the *Zoetrope***

At the end of 4<sup>th</sup> worksheet, students were asked to create their own animation on a roller. This was an opportunity to create an authentic product using the knowledge they gained.

At the end of the project the cognitive post-test and the Evaluation Questionnaire were distributed. One month later students came to the laboratory to answer the cognitive post-test again.

## Findings

### *Short Questionnaire for data collection concerning the characteristics of the participants*

All students had basic knowledge and skills on computer use. Nineteen (19) students had not been involved with coding in the past, while the twelve (12) had been involved with simple programming languages. Most of the students (17) thought that coding is quite difficult (17) and eleven (11) students thought that it is much difficult. Only two (2) students had a previous experience with Arduino (Table 1).

**Table 1. Basic characteristics of the sample**

	Not at all	Little	Quite	Much	Very much	Sum
Knowledge of Computers Use	1	4	18	9	0	32
Coding experience	19	12	0	1	0	32
Difficulty in coding	0	4	17	11	0	32
Arduino experience	30	2	0	0	0	32

### *Cognitive Pre-test*

Analyzing the answers of the students the following findings were derived.

None of the participants gave a correct answer to what the POV phenomenon is. Only nine (9) students described how an animation works in a way close to the correct one *'animation is a succession of images that have small differences among them and the one comes after the other in a certain rate'*. Six (6) students mentioned only the succession of images. None mentioned that every image remains in the human's brain for a certain period. Most students answered that the eye has a 'rhythm' (20 participants), but without being able to argue this answer or to give an example to prove it. Twelve participants answered that *"the eye is constantly watching"* or noted that they did not know the answer. Students asked about the visual trace that can be observed in an object moving rapidly (application of POV) but none of them could answer correctly: *'It is due to the fact that our eye cannot clearly see an object that runs rapidly and sees only a trace of the object'*. Students called to explain why sometimes *'a wheel rotating in one direction at a certain speed can be perceived rotating in the reverse direction'*. Seventeen students answered in a wrong way or did not know the answer. Five students (5) reported that *'this is an illusion'* and four (4) students mentioned that *'this is due to the speed of the object'*. Six (6) of the participants mentioned that *'the eye cannot follow the speed of the object'* but failed to explain the role of the sampling rate of the eye.

### *Analysis of the worksheets*

Analyzing the data collected from the answers of the students on the worksheets useful findings were derived.

Working with the 1<sup>st</sup> worksheet, all the groups of students observed that at a specific rate of blinking the RGB LED seemed constantly on. They estimated that this rate is about 50 – 60 Hz. Trying to give an explanation, five of the eight groups explained that *'the RGB LED blinks at such a rate that our eye cannot see the time it is off'*. One team used as an explanation *'the transmission time needed to decode a signal in the brain'*, while another combined this explanation with *'the inability of the eye to keep up with the blinking rate of the RGB LED'*. One team mentioned that *'the frequency with which the eye sees is lower than the blinking frequency of the RGB LED'*.

Working based on the 2<sup>nd</sup> worksheet students had to create a program to turn 'on' and 'off' the blue and red color successively and reduce the duration of each state until they cannot separate the two colors observing a purple color (the mix of red and blue) constantly on. They estimated that this happened when the blinking rate of each color is about 50 – 60 Hz. Trying to give an explanation most teams noted that *'the eye had not enough time to realize the speed of color change'*. The answer of one group managed to approach the

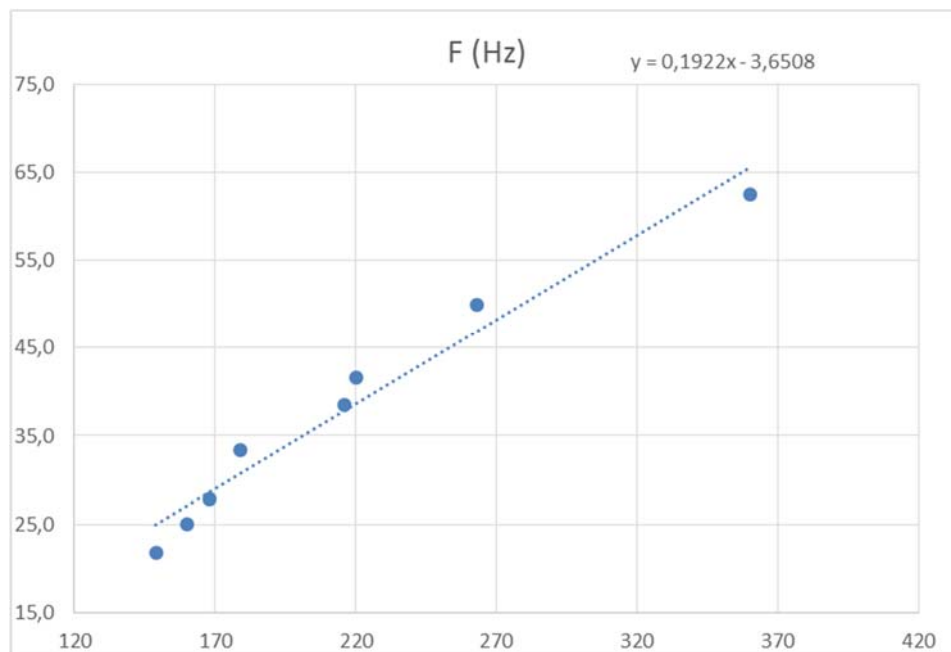


phenomenon of POV writing that: "... the blue color reaches our eye before the red color disappears from our brain and so we see the purple color." Two of the groups mentioned that: "That the LED stops flickering in our eyes is due to the sampling function of the eye ..." and "the sampling rate of the eye is equal to the succession rate of the colors".

After discussing the phenomena and based on their experiments students calculated the sampling rate to be 50Hz and the duration of the POV more than 20ms.

Working on the 3<sup>rd</sup> worksheet, the participants had to create a circuit using a motor whose rotation frequency was controlled by a potentiometer. As a first task, they had to stick a small thin strip of cardboard onto the motor, put the motor into operation and write down and explain what they observe. At a certain rotation frequency of the motor students could see a circular disk. The explanation that was mostly given by the students contained the term of POV (7 groups) and six (6) were able to better understand the phenomenon and explain it.

During the 2nd task students constructed a *stroboscope* to create a graphical representation of the correlation between the voltage at the ends of a potentiometer that controls the rotation of a motor and the rotation frequency of the motor. All the groups reached the conclusion that the relationship is approximately linear, and a straight line could describe this relationship satisfactory (Figure 5).



**Figure 5. One of the graph representations of the relation between the voltage at the ends of a potentiometer and the rotation frequency of the motor**

Working on the 4<sup>th</sup> worksheet most of the groups (5 groups) were able to explain the function of the *Thaumatrope* using the terms of sampling rate of the eye and POV phenomenon. Experimenting with the *Zoetrope* all the groups watched the 'animation' story, and four 4 groups were able to give a good explanation.

Each students-group calculated the frequency of the motor at which they were observing the above-mentioned phenomena and calculated the number of images perceived per second by the human eye. Thus, the sense of motion or apparent motion was discussed.

The last task of the worksheet concerned the construction of a personal animation on a cylinder by each group, which, due to lack of time was not completed. However, all the groups designed heir animation and explained the way that it would be working.

#### *Cognitive Post-test*

Analyzing the students' answers at the cognitive post-test after the end of the project



interesting findings were derived. Twenty-three (23) students described correctly or almost correctly what the POV phenomenon is. Characteristic answers are: *'is the ability of the brain to hold an image for some time', 'is the process whereby, in our vision, we see an image we retain and then a second image is added, and so we see them mixed or in continuity'*.

Thirteen students answered correctly about the function of animation and most of the others enriched their answers in the correct direction in comparison with the ones in the pre-test. Characteristic answers are: *"Animation is a series of successive images with small differences between them which are projected at such a rate that we can see them clearly and, at the same time, taking advantage of the effect of POV, to perceive a flow, a story onwards"*. All students answered correctly about the rate of eye sampling and its documentation. Eighteen (18) of the students answered by giving an explanation and nine (9) of them documented their answer with an example or made references to numbers that were calculated in the experiments. Ten (10) of the participants explained the visual trace that can be noticed in a fast-moving object referring to POV or its description. Characteristic answers are: *"Because of the fast motion, the eye's frequency sees the subject at various points, and because of its presence it retains previous images, and instead of appearing as an object at every point it seems unified."*

Students called to explain why sometimes *'a wheel rotating in one direction at a certain speed can be perceived rotating in the reverse direction'*. Although few (7) of the participants responded correctly according to what was discussed, most of them tried to give an explanation thinking in a correct way but ending to wrong results. Indicatively: *"When the motor's frequency is greater than that of the eye, then the impression of the reverse motion is given."* Fifteen students correctly explained the phenomenon of mixing colors in the RGB LED and seventeen (17) mentioned the term of POV without giving a further explanation. Eleven (11) students correctly described the function of the *Zoetrope*. Most of the participants (27) mentioned at least one example of application of the POV phenomenon and fourteen (14) mentioned examples linking the phenomenon to everyday life. Indicative answers: *"movies, cinema, moving electronic labels..."*.

The answers of the students at the cognitive post-test one month later (follow up) were similar with the ones just after the end of the project. Based on this we might support that student retained the knowledge and experience gained during the project supporting this way the educational value of the method and the tools used.

#### *Evaluation Questionnaire*

Answering the questions of the evaluation questionnaire participants had to write down what difficulties they faced, what they like more during the project, what new they think they learnt, how interesting and useful they found the project and the tools they used as well as their intention to use them in their teaching practice.

Almost all students liked the project and the tools used. They liked the way they worked combining theory and practice using experiments. Many students answered that they needed more time for the project. Most participants answered that they learnt about new concepts concerning the physiology of the human eye and applications of them (80.65%). Many participants answered that they were familiarized with coding (58.06%) and making constructions (41.94%) either Arduino circuits or animation applications. Some of them answered that they gained knowledge about the teaching approach (9.68%) used (STEM methodology) as well as the importance and applicability of educational robotics (6.45%). Most students mentioned that they used knowledge mainly from the fields of Physics, Technology and Mathematics. Some of them mentioned Engineering. Most students answered that the new knowledge gained concerns Physics and information Technology, while some others mentioned Mathematics and Engineering as well.

Participants had also to express their opinion about the project by answering questions with answers in a range of *'Not at all'* to *'Too much'*. Most students found *'much'* to *'very much'*

interesting the activities they carried out, although about half of them described the activities as quite difficult. The majority of the students also answered that the activities had a 'much' to 'very much' educational value and that they would adopt such activities in their teaching practice. Many participants noted that they had a little difficulty with the Scratch for Arduino programming environment (S4A) and seemed particularly keen on using Arduino as a useful educational tool (Table 2)

**Table 2. Evaluation questionnaire**

Questions	Not at all	A Little	Quite	Much	Very much	Sum
Activities were interesting	1	2	2	10	16	31
Activities were difficult	2	9	16	2	2	31
Activities were useful in teaching	1	3	6	10	11	31
Adoption of activities in teaching practice	1	4	6	11	9	31
Difficulties using S4A environment	3	19	7	2	0	31
Usefulness of Arduino in teaching practice	1	1	8	13	8	31
Intention to use Arduino in teaching	0	7	3	13	8	31

#### *Comparison between pre and post tests*

As it is described in the Method section, the answer to each question of the cognitive tests was graded based on a scale of 1 to 10 according to its correctness. Summing the grades of the questions a total score for each test was derived. The total scores were 50, 70 and 70 points for the pre-test, the post-test after the end of the project and post-test one month later respectively. The tests were graded by two researchers each time to enhance the validity and reliability of the scores based on certain criteria. For the analysis the average scores by the two researchers for each test were used.

The Shapiro-Wilk test was used to check the normal distribution of the data. Based on the results of the Shapiro-Wilk test the data of the cognitive tests were normally distributed so the paired student's t test was used to compare the mean values of pre and post tests and the student's t test for independent samples to compare the mean values of the tests for men and women. The scores of the post-test after the end of the project were statistically significant higher than the scores of the pre-test (mean difference = -18.0726;  $t(30) = -10.993$ ;  $p < 0.001$ ). The scores of the post-test one month later are not statistically significant different than the scores just after the end of the project ( $t(26) = -1.264$ ;  $p > 0.05$ ). Comparing the scores between men and women no statistically significant differences found concerning the pre-test ( $t(30) = .866$ ;  $p > 0.05$ ), the post-test after the end of the project ( $t(29) = .892$ ;  $p > 0.05$ ) and the post-test one month later ( $t(25) = -0.603$ ;  $p > 0.05$ ).

#### **Discussion and Conclusions**

The aim of the study was to investigate the effectiveness of an educational project in the frame of STEM education methodology using Arduino and S4A as tools to teach the 'Persistence of vision phenomenon' and the 'sampling rate' of the human eye to primary school students. For this purpose, simple circuits and constructions with Arduino were designed and programs in S4A environment were developed to experimentally these phenomena be explained by Primary school pre-service teachers. A total of thirty-two (32) pre-service teachers, students of the Department of Educational Sciences and Social Work, participated in the research. The project lasted ten hours in total, consisted of two sessions of five hours each. The research was aiming to give answers to two research questions:

According to the 1<sup>st</sup> research question: *how Arduino platform can be effectively used and support learning activities in a STEM education context for teaching concerning the persistence*

*of vision and the sampling rate of the human eye?*

Based on the results of the data analysis coming from all the research tools of the study it can be supported that the participants familiarized with the POV phenomenon and the description of it as well as with the sampling function of the human eye. They recognized applications of POV phenomenon and sampling function of the human eye and were able to give examples from everyday life. It is important that they were able to recall the knowledge they had acquired when asked again in the follow-up questionnaire. Thus, it seemed that what they learnt during the project was maintained at least for this period. We can therefore argue that the specific educational activity using Arduino platform and S4A programming environment can support the achievement of the expected learning outcomes. Participants' answers on the questions of the cognitive tests have shown that they have gained a good understanding of the concepts and the phenomena as well as of their explanation, description, and applications.

Pre-service teachers familiarized with the use of the Arduino platform, the design and construction of circuits and systems and its applications as well as with the programming environment of S4A. Although, participants had not used the tools in the past, it seemed they did not face any difficulties concluding that the tools were particularly supportive of the educational process. Participants using Arduino platform and S4A programming environment manage to carry out experiments, collect numerical data, process the data, and link theory with praxis proving phenomena, procedures, and applications.

According to the 2<sup>nd</sup> research question: *'what is the intention of future primary school teachers to use Arduino and S4A environment as teaching and learning tools in a STEM methodology framework?'*

The answers of the participants - as future teachers, show their attitudes to be positive in adoption such teaching approaches in their classroom. Both in their written responses as well as in their oral discussions they expressed a very positive attitude towards the educational intervention they carried out and seemed willing to adopt similar practices. Having this experience, they seemed enthusiastic and willing to be engaged in the future with similar activities recognizing the educational value of STEM education methodology and Arduino platform with the S4A programming environment particularly important.

The conclusions of the research agree with other research studies concerning STEM methodology and educational robotics (Alimisis, Karatrantou, & Tachos, 2005; Karatrantou, & Panagiotakopoulos, 2012; Tytler et al., 2021).

The results of this research indicate that the use of robotics in primary schools can well contribute to the learning environment. According to the literature, teachers in accepting new technologies have both attitudes, positive and negative. At the same time, epistemological design challenges and key pedagogical design features are emerging as necessary to support the adoption and integration in school practice (Sáez-Lopez et al., 2021).

The present research aims to contribute to the debate regarding the impact of STEM methodology on school performance in primary schools focusing on the use of educational robotics. STEM Education methodology gradually is exploited in all educational levels worldwide. However, in Greece there are still many obstacles regarding the adoption of both STEM methodology and educational robotics in school practice. Although the findings presented in the study are promising, it is important to point out that the results should be considered under certain restrictions, due to limited sample size. It is important in the future to conduct similar research studies with a larger sample of participants from both populations of pre-service and in-service teachers, so that the generalization of the results to be possible and the results to be more valid and reliable. Further empirical research must be conducted to examine matters related to the obstacles for the integration of educational robotics and STEM methodology in teaching and learning science.

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## **Self-regulation and Self-efficacy as learning motivation factors of Natural Sciences**

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### **Abstract**

In today's highly scientifically-based society, scientific knowledge is essential for every individual. However, its proper development requires a response to the individuals' requirements and prior experiences, which are represented in their effort to acquire Natural Science-related knowledge and skills. Consequently, it is of the utmost importance to examine students' learning motivation factors, and specifically those concerning learning Natural Sciences, which is the focus of this study. The research approach for measuring this motivation was based on the adaptation of a research tool (questionnaire) in the Greek language, administered to a research sample of 187 Junior high school students, aged 13 to 15 years. The results of the research showed the existence of a high correlation between the individual motivational factors for the learning of Natural Sciences.

**Keywords:** Natural Sciences, Learning Goal Orientation, Task value, Self-efficacy, Self-Regulation

### **Introduction**

Reviews of modern scientific education in many parts of the world highlight the current dilemma of low student achievement and enrollment in science courses and argue for fundamental reforms aimed at enticing all young people to study science (Osborne & Dillon, 2008; Sjøberg & Schreiner, 2010; Tytler, 2007). Specifically, in the Greek educational system, Science classes make up only a minimal portion of the primary education curriculum, while their practical value predominates in secondary education. This means that Science classes in secondary school level are viewed as primarily relevant to students because of the evaluation of their performance in these classes, prior to their advancement to higher education (Tsihouridis et al. 2020).

Students' perspectives on learning, coursework and their own academic potential are crucially important (Guido, R. M. D., 2018). People's attitude is the way they tend to organize their feelings, thoughts, and actions in relation to some sort of mental object. Attitudes are something that people acquire through life experience, rather than being innate. People's perspectives are formed in a variety of ways, some from introspection and reflection on their own experiences, knowledge, and abilities, and others from exposure to new information and ideas.

There are two main tracks of inquiry regarding how the psychological term 'interest' should be conceptualized (Djudin, 2018). As a first step, interest is defined as a personal characteristic or a strong and abiding fondness for a specific area of study or activity (known as individual or personal interest). Secondly, interest is understood as a state associated with the unique appeal of a certain scenario (termed situational interest or interestingness) (Hausler, et.al., 1998). Personal interest, which is always unique to the individual and which endures over time and can be differentiated into latent and actualized interest (Schiefele, 1999), evolves slowly and typically and has long-lasting effects on the learner's knowledge and values (Schraw, Flowerday, & Lehman, 2001). According to the literature (Schiefele, 1999), situational interest



is an "emotional state" that is evoked suddenly by something in the immediate environment and that may only have a short-term effect on an individual's knowledge and values and is aroused as a function of the interestingness of the content and context and partially under the regulation of a teacher (Schraw, Flowerday, & Lehman, 2001).

The importance a trainee places on completing a task is a driving force behind the level of dedication and commitment to seeing it through to completion. It was found that students who thought their learning work was interesting and important were more motivated to understand and learn more about it, and this was also confirmed by Tuan et al. (2005) in the context of science learning, based on research conducted by Pintrich and De Groot (1990) and Wolters, Yu, and Pintrich (1996) (as reported by Velayutham et al., 2011). Attainment value, intrinsic value, utility value, and cost are the four subsets into which Eccles et al. (1983) classified the subjective task value of a desired outcome (Wigfield et al, 2009). To emphasize the uniqueness of each aspect, i.e. the fact that they vary amongst learners, it is important to note that the aforementioned categories are not completely independent of one another, but rather are connected and complete the personal adding value to a goal or project.

Student's motivation is directly proportional to the degree to which they are goal oriented. This goal may pertain to learning, i.e., in-depth comprehension of the course material, or it may pertain to performance, i.e., the assessment and the overall picture formed in others. The first scenario, known as goal orientation, is a potent motivator, but the second, known as performance orientation, can inhibit a student's motivation. The role of science teachers, who must guide their students toward the proper learning objective, is also important by contributing to the development of adaptive behaviors, the growth of their interest in science, and their performance. The availability of a clearly articulated goal that also takes into account the individual's interests and experiences, together with a disciplined approach to the work required to accomplish this goal, is a significant determinant for improved commitment to this aim.

Motivating pupils to engage in learning is one of the most difficult tasks for educators at all levels. Typically, reference to learning motivation is made by defining two forms of motivation: endogenous and extrinsic. However, learning motivation is a continuous spectrum, not a binary state. According to Deci et al. (1991), the distinction between autonomous and regulated behavior is based on the locus of causality. Endogenous motivation results in autonomous behavior, whereas external motivation results in controlled behavior. The classification of motivation is similar, as endogenous motivation leads to autonomous behaviors, while exogenous to controlled ones. There is a spectrum of conditions ranging from the total association of a person's values and desires with the behavior or act in question, to the complete absence of such identification and the presentation of conduct or action as a result of external factors and other individuals. In this spectrum, distinct degrees of a person's own adoption of the ideals underlying particular behaviors or acts are delineated. One can fully identify with them, identify with the result of them, adapt said behavior or act according to one's own values, agree with a behavior due to the environment without embracing its values, or act based on specific conditions of remuneration or punishment, whether external, such as reward, or internal, such as guilt (Deci et al, 1991). In conclusion, in addition to evident endogenous reasons, one's motivation may be derived from balancing a peoples' values and aspirations with the demands coming from their environment, a state that typically develops after adulthood. After reviewing the current research, Velayutham et al. (2011) identified four characteristics that influence a person's motivation for science learning: orientation to the learning objective, value of the target object, self-efficacy, and self-regulation.

In the context of education, self-regulation refers to a students' predisposition to engage in the learning process autonomously, based on their emotions and desires. In self-regulated or self-controlled learning, the students select not only their objectives, but also the

techniques and procedures that will lead to their success. According to Pintrich and De Groot (1990, cited in Velayutham et al, 2011), the three fundamental parts of self-regulated learning are the metacognitive management of knowledge, the use of cognitive strategies, and the control and management of effort for the learning task. Individuals who orchestrate their own learning in physical education discovers ways to learn more efficiently and retain the abilities they gain while displaying prolonged determination and dedication to the goals they establish. Simultaneously, this perseverance leads to the maintenance of interest and systematic efforts, as well as the efficient management of disruptive elements (Kryona, 2020).

Self-efficacy was first defined by Bandura as "a person's belief in his skills to arrange and execute a predetermined course of action in order to solve a problem or successfully accomplish a task." In addition, is considered as self-efficacy as "a multidimensional construct that varies in terms of strength, generalizability, and level (or difficulty)". In simpler terms, self-efficacy is a facet of a person's self-belief, which refers to the belief that one can generate the desired results through the appropriate application of one's abilities and skills. The enhancement of self-efficacy is a result of the individual's positive experiences, i.e., success in physical education courses. This will result in future higher levels of self-confidence in their physical education learning abilities. There is a correlation between students' self-efficacy and their performance and displayed the tenacity to succeed, while this element influences their career choices, according to research findings (Schunk & Pajares, 2009).

Tuan, Chin, and Shieh (2005), who designed a six-factor questionnaire for high school students, conducted a significant study on student learning motivation in the context of the scientific course (SMTSL questionnaire). According to the findings of this study, there is, in general, a steady and dynamic relationship between students' achievement, their enthusiasm to learn in Science, and their scientific attitude. In 2009, Glynn, Taasobshirazi, and Brickman did a noteworthy study on the motivation to learn science; they examined the motivation of college students who had not chosen science as their major but were attending the required university Science course. This study's questionnaire focused on five motivation "dimensions" and three external factors that were demonstrated to be related to the motivation dimensions. In this study, gender variations in the degrees of some dimensions of mobilization were observed. Later, Bryan, Glynn, and Kittleson (2011) investigated the perspectives of high school students on Science classes. The research was based on socio-cognitive theory, and student motivation was defined by three individual criteria that were examined in relation to students' performance and inclination to enroll in higher-level elective Science courses. The results of the study demonstrated the existence of a relationship between the three motivational elements and the students' performance, as well as their intention to enroll in more Natural Science courses, whereas there were no significant gender differences.

### **Methodology**

The research approach of this study was quantitative, and the research strategy aimed mainly at finding relationships between the variables examined (Cohen, Manion & Morrison, 2008). It was also a sampling based research, using a basic data collection tool, an appropriately structured questionnaire and the research strategy followed the stages as reported by Cohen, Manion & Morrisson (2008).

### **Purpose of the Research**

The purpose of this research was to investigate whether there is a correlation between the four pillar factors of Learning Goal Orientation, Task value, Self-efficacy, and Self-Regulation as that were analyzed above.

### **Research Sample**

The research sample consists of 187 junior high school students who participated voluntarily in the survey. The distribution of participants was 96 male and female participants

while regarding the class of attendance they are divided into three groups. The first group consists of 42 students in the 1<sup>st</sup> grade, the second group consists of 75 students in the 2<sup>nd</sup> grade, and the third group consists of 70 students in the 3<sup>rd</sup> grade.

### **Research Tool**

The collection and processing of research data is a very basic element of a research. A common and effective data collection tool is the use of a properly structured questionnaire with specific axes, reliability and validity. Due to the many parameters taken under consideration, the creation of a reliable research-diagnostic tool is laborious and time-consuming so a good way to conduct a research is to look for an already tested tool, that will, of course, be tested again for its validity and reliability in the specific research sample. For data collection in this specific research, a questionnaire that covers the research objectives of this study was sought. The questionnaire developed and implemented by Sunitadevi Velayutham, Jill Aldridge & Barry Fraser (2011) was found to be the most appropriate for this purpose. According to Sunitadevi Velayutham, Jill Aldridge & Barry Fraser (2011), this tool was created in order to collect data on students' motivation on learning science. It consists of 32 questions, each of which has been created in such a way as to be associated with a motivational factor.

The 32 questions were divided into 4 broad categories based on the 4 pillars of motivation: Learning Goal Orientation, Task value, Self-efficacy, and Self-Regulation (Tsihouridis, Kryona & Vavougios, 2020).

### **Translation of the questionnaire into the Greek language**

The translation of the questionnaire from the English language to the Greek language was performed by following a predetermined specific three-step process that has been extensively studied by previous research. Briefly, the translation steps were as follows: a) forward translation b) back translation and c) application of the translated questionnaire to a small sample (Ioannou et al. 2020, Salehpoor, Latifi & Tohidast 2020, Andayani, Kristina & Endarti 2019). In order to avoid misunderstandings and difficulties when completing the answers by the respondents, attention was paid to the form and language of the questionnaire (Makrakis, 2005). Therefore, initially, a simple translation (forward translation) of the original questionnaire was carried out. After the simple translation, the Greek version of the questionnaire was back-translated. The final step for the final formatting of the questionnaire was the collection of answers from a small sample (8 students) in the context of a pilot study, in order to evaluate the clarity of the questions and to establish whether the language level used is the appropriate one. Taking into account the observations of the sample and making the corresponding necessary language modifications, the final form of the questionnaire, that was used in the research, was created.

The questionnaire consisted of 32 five-point Likert scale questions. The 32 questions were divided into 4 categories, of which the first measured the orientation towards the learning goal (Learning Goal Orientation) (questions 1-8), the second one measured the Task Value (questions 9-16), the third category measured Self-efficacy (questions 17-24) and the fourth one measured Self-regulation (questions 25-32).

### **Validity and Reliability of the Research**

The internal reliability of the questionnaire was tested with Cronbach's Alpha Coefficient of Internal Consistency (Howitt & Cramer, 2003). In the present research, the reliability check after administering the translated questionnaire was  $\alpha = 0.927$ , an indicator that is considered high for the humanities sector (Roussos & Tsaousis, 2011) therefore deleting a question does not contribute substantially to the reliability of the tool. The Likert scale used is a Norm-referenced psychometric scale. This is commonly used in questionnaires and is widespread in research in which participants are asked to select the degree to which they agree or disagree

with a topic (Roussos & Tsaousis, 2011). In the present survey, respondents had to answer the questions based on a five-point Likert scale (1: Strongly disagree, 2: Disagree, 3: Not sure, 4: Agree and 5: Strongly agree). The validity and reliability of the research lie primarily in the voluntary participation and random selection of research subjects. As mentioned above, the voluntary and random participants of the research consist of a total of 187 students divided into three groups. The first group consists of 42 students in the 1<sup>st</sup> grade, the second group consists of 75 students in the 2<sup>nd</sup> grade, and the third group consists of 70 students in the 3<sup>rd</sup> grade.

**Table 1. Reliability Statistics**

Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	N of Items
0,927	0,928	32

### Research Ethics

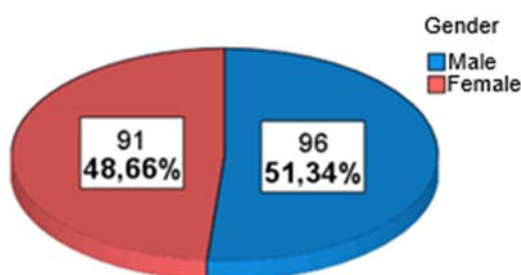
The goal and objectives of the research were explained in detail to the participants, and they were informed that their participation was voluntary. It was clarified that their name and personal information would not be mentioned anywhere in order to avoid creating uncomfortable circumstances or negative feelings due to their identity being revealed. Finally, the participants were provided with the necessary explanations and clarifications regarding the questionnaire questions, so that none remained unanswered.

### Analysis of Research Data

The statistical analysis of the questionnaire was performed using the SPSS statistical package and Excel application.

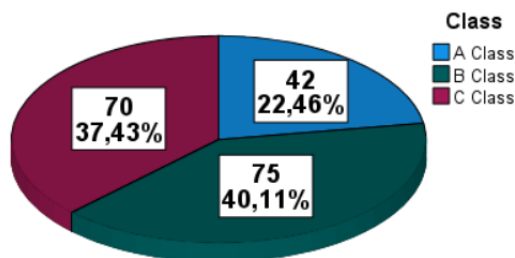
The analysis and demographic characteristics of the research sample data, the average values, and the standard deviations of the levels of the Learning Goal Orientation, the Task Value, Self-Efficacy and Self-Regulation are presented below along with the correlation between these variables.

The first statistical analysis refers to the basic statistical indicators concerning the independent variables of the present research: gender (male, female) and students' high school grade (1<sup>st</sup>, 2<sup>nd</sup> and 3<sup>rd</sup> grade of High School). The results of these analysis are presented below:



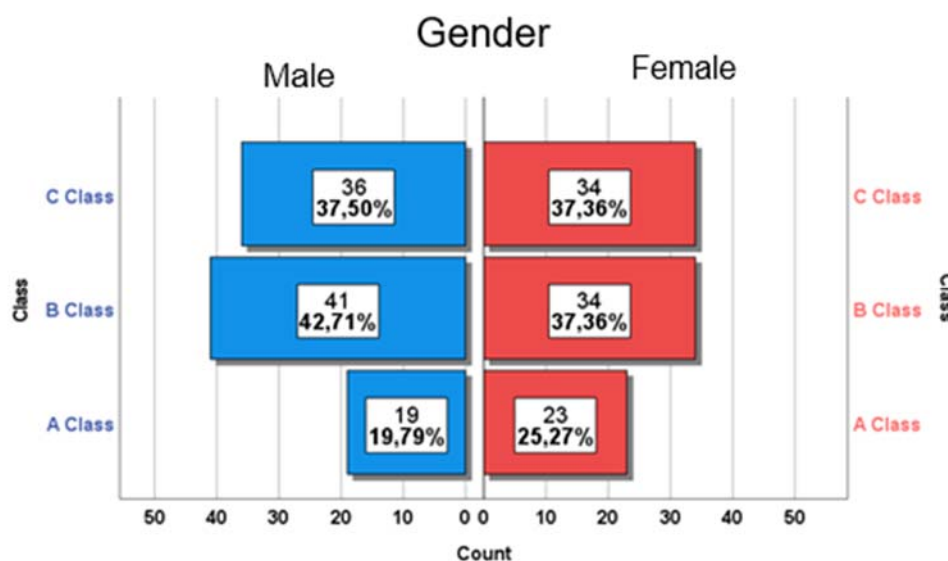
**Figure 1. Students' gender**

According to the above data, 48.66% of the research participants are female and 51.34% are male. We notice that the percentage of male participants in the research is similar to that of the female ones.



**Figure 2.** students' class attendance

Based on the above data, 22.46% of the research participants attend the 1<sup>st</sup> grade (A Class ), 40,11% attend the 2<sup>nd</sup> grade (B Class) and 37,43% attend the 3<sup>rd</sup> grade (C Class).



**Figure 3.** Students' gender-class diagram

#### **Characteristics of dependent variables: Learning goal orientation, Task value, Self-efficacy, Self-regulation**

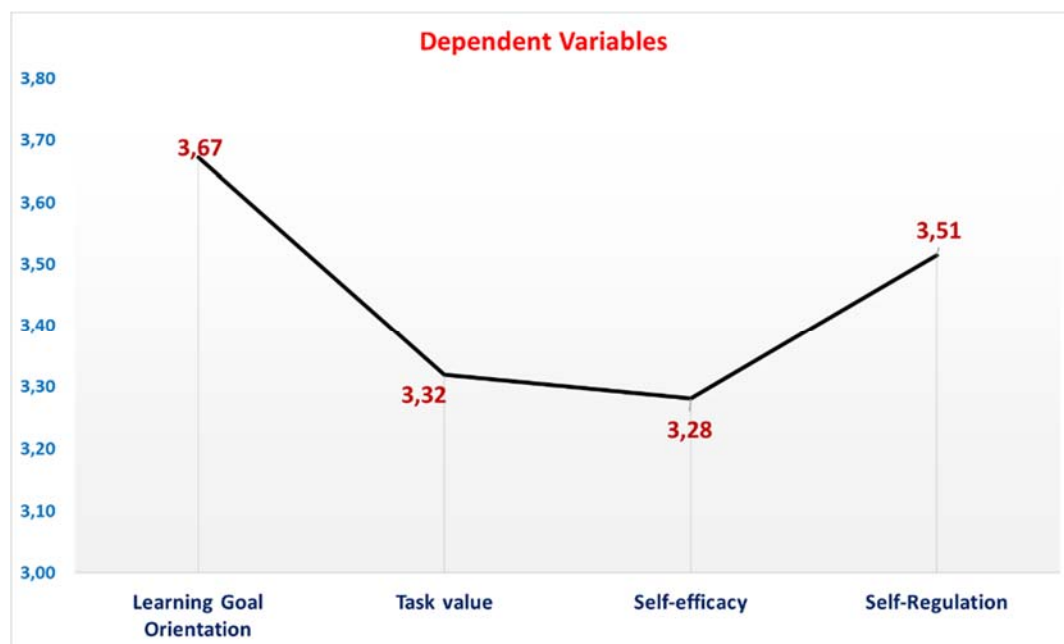
The results of the analysis concerning Learning Goal Orientation, Task-value, Self-efficacy and Self-regulation are presented below. Table 2 presents the Means and Standard Deviations of the levels of the dependent variables. We can observe that the mean value of levels of Learning goal Orientation for all participants is  $M=3.67$  ( $S.D.=.61$ ), of Task-value for all participants is  $M=3.32$  ( $S.D.=.75$ ), of Self-Efficacy for all participants is  $M=3.28$  ( $S.D.=.72$ ), and of Self-Regulation for all participants is  $M=3.51$  ( $S.D.=.78$ ) . The above values are reported on a scale from 1 to 5. This means that the students who participated in the research consider the levels of the dependent variables fairly good.

**Table 2. Means and Standard Deviations of the levels of Learning Goal Orientation, Task-value, Self-efficacy and Self-regulation**

	N	Mean	Std. Deviation
Learning Goal Orientation	187	3,67	0,61
Task Value	187	3,32	0,75
Self-efficacy	187	3,28	0,72
Self-regulation	187	3,51	0,78



The chart below (Figure 4) summarizes the mean values of the dependent variables for direct comparison



**Figure 4.** Dependent variables diagram

We observe that students effectively focus on the orientation of learning goals more than on self-regulation, on task value and even less on self-efficacy.

*Correlation study between the dependent variables (Learning goal orientation, Task value, Self-efficacy and Self-regulation).*

The dependent variables of Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation, are measured on a five-point Likert scale (1 = Strongly disagree, 2 = Disagree, 3 = Neither agree nor disagree, 4 = Agree, 5 = Strongly agree) which is mainly considered as a hierarchical scale (but also in several cases as a scale of equal intervals). In this case, Spearman's rho correlation coefficient is considered the most appropriate one for studying the correlation between the variables. These scales are also usually considered as "interval scales" and therefore can have numerical values (Krowinski & Steiber, 1996).

It should also be noted that in order to measure these variables eight questions were used and for this reason the final value of each dependent variable was considered as the average of these questions. Consequently, the Pearson r correlation coefficient, which is used when the measurement scale is either proportional or of equal intervals, can also be utilized in this case, as can Spearman's rho correlation coefficient.

Before calculating the correlation coefficient using the statistical package SPSS, the following assumptions are formulated:

H0: There is no correlation between the variables: Learning goal orientation, Self-regulation, Task Value and Self-efficacy.

H1: There is a correlation between the variables: Learning goal orientation, Self-regulation, Task Value and Self-efficacy.

As mentioned above, we can study the correlation between dependent variables using the Pearson r coefficient. Results are given in the table below (Table 3).

**Table 3. Table of Pearson r correlation coefficients between dependent variables**

		<b>Learning Goal Orientation</b>	<b>Task value</b>	<b>Self-efficacy</b>	<b>Self-Regulation</b>
<b>Learning Goal Orientation</b>	Pearson Correlation	1	,638**	,540**	,515**
	Sig. (2-tailed)		<,001	<,001	<,001
<b>Task value</b>	Pearson Correlation	,638**	1	,567**	,459**
	Sig. (2-tailed)	<,001		<,001	<,001
<b>Self-efficacy</b>	Pearson Correlation	,540**	,567**	1	,528**
	Sig. (2-tailed)	<,001	<,001		<,001
<b>Self-Regulation</b>	Pearson Correlation	,515**	,459**	,528**	1
	Sig. (2-tailed)	<,001	<,001	<,001	

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

Based on the data of the table above:

a) learning goal orientation shows a strong correlation with task value, self-efficacy and self-regulation

$r(187) = 0.638$ ,  $p < 0.001$  ( $0.50 \leq |r| \leq 0.75$  strong correlation)

$r(187) = 0.540$ ,  $p < 0.001$  ( $0.50 \leq |r| \leq 0.75$  strong correlation)

$r(187) = 0.515$ ,  $p < 0.001$  ( $0.50 \leq |r| \leq 0.75$  strong correlation)

b) the task value variable shows a strong correlation with self-efficacy [ $r(187) = 0.567$ ,  $p < 0.001$ , ( $0.50 \leq |r| \leq 0.75$  strong correlation)], while with self-regulation a moderate correlation [ $r(187) = 0.459$ ,  $p < 0.001$ , ( $0.30 \leq |r| \leq 0.5$  moderate correlation)]

c) self-efficacy shows a strong correlation with self-regulation [ $r(187) = 0.528$ ,  $p < 0.001$ , ( $0.50 \leq |r| \leq 0.75$  strong correlation)]

### Conclusions

In the present research, it was attempted to study motivation and its individual factors of learning natural sciences. The sample group of the research was male and female high school students in Greece, who answered questionnaires based on the tool of Velayutham et al (2011) that was translated into the Greek language and checked for its validity and reliability for the particular sample. The corresponding Greek version of the questionnaire in the present research gave a high Cronbach's alpha internal consistency coefficient ( $\alpha = 0.927$ ). The weighting of the specific tool in Greek data is considered particularly important and necessary, as a study by Dermitzaki et al (2013) points out the weaknesses of the SMTSL tool, an older questionnaire for measuring students' motivation in learning science.

The research questions were related to the correlation of the four motivational factors: Learning goal Orientation, Self-regulation, Task Value and Self-efficacy.

After the appropriate processing of the research data, the results in terms of student motivation showed an above-average motivation for learning natural sciences, and particularly high levels in the "Learning goal orientation" factor. This means that the male and female students of the specific sample have a high understanding and identification with the objectives set in the natural science courses they have attended. On the other hand, the students' self-efficacy factor was above average, but was also the lowest of the four factors. This means that, despite the fact that students demonstrate strong motivation for their education in the natural sciences, a stronger enforcement of their self-belief regarding their abilities is needed, and of course appropriate teaching for their substantial improvement.

Apart from the association between the Task Value and Self-Regulation, strong correlations were found between all of the motivational pillars that comprised the subgroups of questions

on the instrument in regard to the primary research question. These correlations demonstrate the validity of the tool's theoretical foundation, as the constituent elements are actually interconnected and produce a highly organized final result, the mobilization of the student.

### Research limitations

The results of the present research should be evaluated based on some important limitations, which are mainly related to its sample. A major limitation appeared to be the number of participants, as it is relatively small to be able to draw unequivocal conclusions. Another limitation regarding the sample of the research is that the participants were purely students of lower secondary education, therefore the conclusions refer to a very specific set of people and it is not possible to be generalized.

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