3rd International STEM Education Conference

Proceedings

July 2-3, 2022
Istanbul - Turkey

Editor: Assoc. Prof. Hasan Özcan

IBN HALDUN UNIVERSITY

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STEM Show Time / Playground /
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July 3, 2022-Sunday

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STEAM Approach to Implementing Neuroscience in Psychology and Education

Anna Budarina[1], Olesya Parakhina[2], Ksenia Degtyarenko[3]

Abstract

The implementation of cutting-edge issues in the system of higher education worldwide has led to the search for new forms and priorities for research and development in order to increase the scientific and educational potential of higher educational establishments to create new technologies, industries, and competitive products, integrate university research, expand inter-institutional networking within the regional, national and international social and educational systems.

The research examines the best practices of the Institute for Education and the Humanities, one of the largest structural divisions of the Immanuel Kant Baltic Federal University (IKFBU), that forms the "core" of the regional ecosystem of psychological and pedagogical education in the field of Neuroscience.

The aim of the study is to analyze the IKBFU experience of implementing STEAM approach in the field of Neuroscience in Education and Psychology, to present a description of the project, the conditions for its implementation and the results, the performance indicators of the project implementation and their significance, and to identify the positive effects of the project in the field of Neurocognitive Sciences, that ensure the development of a regional social and educational ecosystem in the framework of global educational agenda.

Research methods comprise analysis of results and modeling of development prospects and implementation of best practices, experience dissemination to other regions; reflexive-system analysis of the justified organization of pedagogical activities, taking into account the effects obtained from the results of the project implementation.

The conducted research allows to draw a conclusion about the strategic effectiveness of the implemented STEAM approach to the project at three levels: at the university level, at the regional level, at the national

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level, including the creation of a laboratory base that provides informative, material and technical platform for the implementation of the research conducted within the internship of Master's Degree students; the identification of new promising areas for training, retraining and advanced training of the faculty members involved in the implementation of the educational programme "Neuroscience"; increasing the quality of educational and research activities within the framework of the international educational programmes on Neuroscience in Education and Psychology; the modernization of the system for pre-service teacher training in the field of Neuroscience; the involvement of leading scientists in the implementation of educational programmes; ensuring the integration of science and education; attracting talented youth to the field of science and innovation; creating conditions for increasing the prestige of research and teaching activities; the modernization of the system for pre-service teacher training in the field of Neuroscience in terms of optimizing the content of educational programmes, internship and bringing the competencies of graduates in line with modern requirements; the promotion of the outcomes of university scientific and innovative activities; establishing sustainable partnerships with industrial organizations in terms of internships for undergraduates; joint implementation of innovative activities in the educational, scientific and industrial fields; development of an experimental and laboratory base for its joint use by scientists, faculty, students, postgraduate students of the university and the representatives of the industry community; pre-service teacher training to meet modern requirements within the subject area of "Neuroscience"; building scientific and educational teams to solve fundamental and applied research priority problems in the field of Neuroscience; the launch of joint laboratory research in focused collaboration with leading enterprises and research centers as well as educational institutions worldwide; the integration of leading expert experience and expertise in the field of Neuroscience to achieve the breakthrough scientific results; the development of priority integrated areas of STEAM education in the field of Neuropsychology, Neurolinguistics, Neurocognitivistics, Neuropsychiatry, Rehabilitation, Neuroclimatology, Machine Learning and Artificial Intelligence.

The results of the study can be used for designing a portfolio of effective and innovative educational programmes that comply with the core areas of the university development and the priority areas of modernization and technological development of the economy; for designing and implementing effective forms of educational activities in the higher education system; for designing educational programmes that meet the individual characteristics and students' needs ultimately leading to the improvement of the quality of life, and the level of satisfaction in the framework of lifelong learning and wellbeing.

Keywords

STEAM-practices; higher education; STEAM approach; Neuro Sciences; Neuro Psychology; Teacher Education; Teacher Training

Introduction

The implementation of the cutting-edge issues in the system of higher education worldwide has led to the search for new forms and priorities for research and development in order to increase the scientific and educational potential of higher educational establishments to create new technologies, industries and competitive products, integrate university research, expand inter-institutional networking within the regional, national and international social and educational systems.

Being well-recognised as a powerful driver of national economic growth, STEAM lies at the heart of calls worldwide for educational reform. Education for sustainable development remains a pressing priority. Thus, the educators are being challenged to design curricula to develop students' disciplinary knowledge and skills, as well as their abilities as critical consumers, creative and ethically astute citizens, innovative designers, good communicators and collaborative decision-makers. A key challenge is to implement STEAM approach to all spheres of education at all levels. Due to the development of a digital economy and the changing paradigm of industrial production this philosophy has become the core focus of the state national policies as well as the mainstream in most educational systems. World tendencies such as globalization, global economic integration underpin the necessity of meeting the requirements of brand-new career paths.

Having moved front, STEAM education is implemented in various projects and strategies at different state (national, regional), educational (school, University, professional development, supplementary, informal education), collaborative (government-business-University) levels.

STEAM-subjects are the basis for staff training of the scientific-technological elite for the innovative development in every country, as well as for the implementation of National programmes in the field of Education.

In this context, new requirements to curriculum development and syllabus design as well as implementation of new teaching methods determine continuous development of formal and non-formal/extracurriculum education practices in the following subject fields: Science, Technology, Engineering Creativity, Programming and Algorithms, Project Activities, etc.

Over the past few years, STEAM-related national policies and initiatives have been developed and implemented in the Russian Federation that, among other things, tend to meet the need to develop career and educational pathways that align with STEAM. The “Need for STEAM” trend in Russian educational policy is defined by various strategic concepts, executive orders and national programmes and projects: Priority National Project “Affordable Supplementary Education and Extracurricular Activities”, Federal Projects “Modern School”, “Success of Every Child”, “Digital Educational Environment”, STEAM-related Collaborative Projects (government-business-University) especially in Informal STEM Education like the NTI or National Technology Initiative (2014-2035): The NTI Contest (Olympiad), The NTI Class event and others.

The STEAM approach being an interdisciplinary philosophy can be implemented in various fields in the context of teacher training as well. Currently, the concepts of interdisciplinarity and metadisciplinarity play a key role in the educational process of teacher training at the Immanuel Kant Baltic Federal University (IKBFU). The integration occurs at the levels of disciplines, teaching methods, educational activities management as well as interaction modes of stakeholders in the educational process.

The educational and scientific cluster “Institute of Education and the Humanities”, one of the structural subdivisions of the IKBFU, being the “core” of the regional ecosystem in the field of teacher training implements a large number of Bachelor’s, Master’s and Postgraduate programmes for pre-service and in-service teachers in various fields: Maths, Foreign Languages, Psychology, Game Design, Neurosciences using the STEAM approach as the nucleus of the curriculum. In the context of this research we would like to highlight two specific Master’s degree programmes of the Institute of Education and the Humanities: Neuroscience in Education and STEAM practices in Education.

The complex of neurosciences is increasingly becoming an interdisciplinary field of research and interest in them is due to cultural transformations and features of integrated strategies for designing educational environments. Modern competencies of pre-service teachers and psychologists in the field of neurosciences are a factor in improving the quality of education in general and the level of well-being of students, as well as their educational success in the context of designing life-educational routes implementing the life-long learning concept.

In the process of professional training of pre-service teachers Neuroscience contributes to the disclosure of the heuristic abilities of students with its natural scientific, cultural and creative potential for designing educational environments. It becomes a powerful resource for the implementation of the anthropological mission of modern education, conditioning fundamental human needs and abilities like self-education, self-development and self-realization. The STEAM approach in the field of Neurosciences focuses modern professional psychological and pedagogical education on the search for means and conditions for the formation of a person as an individuality, aware of their own originality and uniqueness.

These principles of the STEAM approach to the training of pre-service teachers and psychologists in the field of Neuroscience can be implemented through the personalization of education, on the basis of building customized life-educational routes for students and the formation of modern professional competencies in the field of identifying cognitive and behavioral disfunctions, neuropsychological assessment and use neuroimaging methods, as well as knowledge of the psychological aspects of cognition (personal predisposition, decision-making features, empathy, metacognitive-executive functions, including social dynamics, neural correlates, etc.).

The application of the STEAM approach to the pre-service teachers and psychologists training in the field of Neuroscience contributes to their reaching the modern multidisciplinary systemic level of thinking and cultural development. Such training requires a dynamic resource of the individual, which is extremely important in innovative activity and in a comprehensive readiness for changes in the modern conditions of the society development.

The strategic effectiveness of the implemented STEAM approach in pre-service teacher training can be realized at three levels: at the University level, at the regional level, at the national level, including the creation of a laboratory base that provides informative, material and technical platform for the implementation of the research conducted within the internship of Master's Degree students; the identification of new promising areas for training, retraining and advanced training of the faculty members involved in the implementation of the in pre-service teacher training educational programmes in the field of STEAM ("Neuroscience un Education" and "STEAM practices in Education") and, thus, increasing the quality of educational and research activities; the involvement of leading scientists in the implementation of educational programmes; ensuring the integration of science and education; attracting talented youth to the field of science and innovation; creating conditions for increasing the prestige of research and teaching activities; the modernization of the system for pre-service teacher training in the field of STEAM in terms of optimizing the content of educational programmes, internship and bringing the competencies of graduates in line with modern requirements; the promotion of the outcomes of University scientific and innovative activities; establishing sustainable partnerships with industrial organizations in terms of internships for undergraduates; joint implementation of innovative activities in the educational, scientific and industrial fields; development of an experimental and laboratory base for its joint use by scientists, faculty, students, postgraduate students of the University and the representatives of the industry community and, thus, building scientific and educational teams to solve fundamental and applied research priority problems in the field of pre-service teacher education; the development of priority integrated areas of STEAM education in the field of Neuropsychology, Neurolinguistics, Neurocognitivistics, Neuropsychiatry, Rehabilitation, Neuroclimatology, Machine Learning and Artificial Intelligence, to achieve the breakthrough scientific results in the framework of global educational agenda.

Understanding of the nature and development of cognitive processes while implementing the students' educational routes is an essential competence of in-service teachers so building a new practice-oriented model of training pre-service teachers we incorporate the module of Neurocognitivistics in the Master's degree programme "STEAM practices in Education" as well. This programme provides systemic knowledge in the field of Teacher Education and Teacher Training with the intersection of technical sciences and creative activity.

The programme is aimed at training teachers-to be who are able not only to design basic and additional educational programmes, but also to develop high-tech ways of their implementation, such as the establishment of School Technoparks and Technopolises, STEAM Education Studios and Project Offices, working in the field of organizing cultural and educational activities in scientific museums, Innovation Centers for young learners, etc. The students mastering the programme get acquainted with the experience and best practices of national and international education systems. They are taught to create special educational spaces that allow teachers and trainers of all levels to implement STEAM approach and interdisciplinarity into teaching, launch high-tech educational startups and projects, organize and manage innovative research and project activities of students.

The purpose of the programme is in-depth training of a modern teacher-researcher and teacher-practitioner who is able to successfully design and implement STEAM technologies to stimulate students' interest in the study of Sciences and Arts, the development of creativity and technical creativity of the basic and core subjects at schools. The modules of the programme comprise innovative processes in education, methodology of STEAM education, methods and principles of life-long learning, current educational technologies (including STEAM methods, design thinking and visualization technologies, Art education in modern contexts, ecosystems of project activities in additional education, Educational Robotics) and Neurocognitivistics.

The syllabus is designed with offline and online lectures, seminars, e-learning technologies, design workshops, trainings, individual educational tracks, internships, training and immersion in industrial and scientific laboratories, public presentation of learning outcomes in microteaching formats, TED format project presentations, professional identity trainings within learning-by-doing environment.

To disseminate the experience of implementing the above-mentioned new practice-oriented model of training pre-service teachers, the Institute of Education and the Humanities has developed a project called "STEAMTeach: Management of Professional Development of Pre-Service Teachers". The project was presented for the competitive selection for the Immanuel Kant Baltic Federal University to acquire the status of a National Innovation Platform for the period 2020-2023.

The STEAMTeach Project developed by the Institute of Education and the Humanities as part of the strategy for the development of teacher training within the socio-educational cluster of the Kaliningrad region is focused on managing the professional development of pre-service teachers through the development, testing and implementation of new mechanisms, forms and methods for training teachers of a new type in the context of an innovative practice-oriented STEAM education model based on professional, educational and international standards.

The integrated practice-oriented teacher training approach encompasses, firstly, designing and modelling educational programmes according to STEAM-approach; secondly, modern educational environment design, including upgrading final assessment procedure through introducing demonstration exam framework with WorldSkills techniques and methodology, and thirdly, the development of a new School-University partnership model aimed at implementing new formats of educational practices through international, national, regional, network and inner integration educational projects.

Modelling the educational programme in the context of the STEAM-approach implies the design and development of educational modules for Bachelor's degree programmes in Pedagogy and introduction of such compulsory disciplines and courses as, for example, "The Ecosystem of Project Design", "Technical Creativity", "STEAM-Practices in a Modern School", "STEAM Robotics", "Pencil Programming", "Experimental Design", "Game Programming and Animation", "Neurocognitivistics" that enable pre-service teachers to gain competences in implementing STEAM education technologies in the educational process, effective designing STEAM environment for obtaining educational results, building customized life-educational routes for students, identifying cognitive and behavioral peculiarities of students as well as competences to apply methods of organizing research and project activities of learners. Educational modules "STEAM-practices in education" vary in their content depending on the training profile in basic educational programmes (pre-school education, primary education, supplementary education, etc.).

However, the concept of STEAM education requires the restructuring of the educational programme both in terms of its content and methods of its implementation in the framework of interdisciplinary integration, including wider use of case and project methods, inventive problem solving technologies and research experiment. It directs the educational process towards mastering competences in activating the imagination, creative potential and heuristic activities of learners, towards the creation of individual educational trajectories based on STEAM interdisciplinary and integration links.

The key concept of STEAM education is the design of a modern educational environment, which also implies new requirements for the State Final Certification in terms of its format, the assessment system, etc. The development and implementation of a demonstration exam in the WorldSkills format for State Final Certification for Bachelor's degree in Pedagogy is considered as an effective tool for determining the readiness of graduates to perform professional tasks. The demonstration exam allows to simulate real workplace conditions and, thus, to assess the compliance of the graduate's competencies with the existing requirements for the level of professional training of teaching staff. The introduction of the demonstration exam implies independent expert assessment of the level of knowledge, skills and abilities of graduates in compliance with international requirements.

The creation of a new model of network School-University interaction within the educational ecosystem STEAM Community, on the one hand, will significantly strengthen the practice-oriented component in teacher training through introducing new innovative interaction modes of stakeholders in the educational process, creating innovative educational products and developing modern technologies for schoolchildren's support in the field of engineering and technical creativity; on the other hand, it will help to support the professional development of teachers in the context of CPD programmes and obtaining new competencies in the field of STEAM education.

The main participants in the proposed educational network STEAM Community are the Resource Centers of the Institute of Education, that form a wide net for creating an educational and scientific cluster and maintaining the educational ecosystem balance in the region. These are 18 leading institutions of pre-school, primary and secondary education of the region: gymnasiums, lyceums, comprehensive schools and nursery schools, which function as structural subdivisions of the University. Within the framework of the designed project, the Resource Centers act as partner organizations that carry out an expert assessment of the content of the developed STEAM educational modules, the assessment of the compliance of the graduate's competencies with modern requirements within the framework of the demonstration exam and perform the role of agents in introducing and promoting new formats of STEAM-education practices.

This model assumes several trajectories within students' internship, such as introduction of practice-oriented educational events into educational modules, in particular, through a system of professional competitions and qualifying competitions within the framework of the Junior WorldSkills Russia movement where pre-service teachers can act both as participants and as tutors for schoolchildren; development of technologies for schoolchildren's support in the field of engineering and technical creativity, which can be implemented within the project work of pre-service teachers.

Thus, the creation and implementation of a network partnership model in the University system advances STEAM education at various levels, creating conditions for the introduction and promotion of new professional educational practices. It contributes to improving the quality of education and the professional growth of teachers through the generalization and dissemination of international experience in organizing the educational process based on the STEAM-approach. The designed programmes for professional retraining and continuous professional development of in-service teachers in the field of STEAM education consider modern requirements and standards of the national education system and innovative international experience and is widely used by educational authorities to improve the quality of education.

Nevertheless, a number of challenges for implementing this model in our region is visible. In-service teachers are not always ready for the transition to STEAM, since they themselves have not been trained according to this approach. Lack of motivation and initiative on the part of teachers to implement STEAM-approach and to organize after-school club activities can be caused by the deficiency in teaching aids and the inconsistency of national curricula and educational programmes with a new type of education, which complicates interdisciplinary collaboration in the educational process at school. Smaller challenges can also include undeveloped criteria for assessing student achievement and lack of innovative and accessible measures of learning, shortage in flexible and inclusive learning spaces as well as limited space within the school territory. STEAM education research as a national research priority could foster STEAM scientific background and give a boost to the appearance of innovative educational experiences that include interdisciplinary approaches to solving "grand challenges". Inconsistency in continuum of education at different levels disrupts the unity of training system in STEAM which results in the absence of engaged and networked communities of practice. Direct collaboration among the university and the schools of the region allows to provide methodological support to teachers through a line of ongoing CPD programmes in the field of STEAM education and advanced training programmes, to develop supplementary education, to intensify after-school-club movement in educational organizations through organizing and holding regional festivals of ideas and technologies in cooperation with the university. The University in this case can act as an educational center and a multiplier of innovative products, and also as a platform for training schoolchildren under highly qualified faculty (as mentors) and a resource base with a wide range of methodological and technical support.

As for the positive effects, the implementation of an innovative educational project has raised the prestige of the teaching profession, promoted the formation and development of the regional educational ecosystem, innovated the training system for pre-service teachers in terms of optimizing the content of educational programmes and internship as well as bringing the competencies of graduates of pedagogical training fields in line with the modern requirements of the labor market and employers.

To support the new approach to pre-service teacher training within the structure of the Institute of Education and the Humanities, the Center for Natural Science, Technological, Engineering, Artistic-Aesthetic and Mathematical Design STEAM-PARK has been established. Its main lines of action are to conduct applied scientific research in the field of theory and practice of shaping, developing and transforming modern approaches in education; to create new and modernize existing training courses and modules related to didactic engineering, methods and techniques of STEAM education, to transfer supplementary education technologies to the educational process of a comprehensive school; to implement educational robotics practices; to coordinate and shape regional innovation platforms.

The complexity of professional objectives that educators are currently facing is linked to the number of political, socio-economic factors as well as the transformation of the mission of education. It has resulted in the awareness of the need to revise the existing teacher training models. The promotion and implementation of the STEAM-approach in education as the leading approach to teacher training at the Institute of Education and the Humanities, in the IKBFU, within the social and educational ecosystem of the Kaliningrad region is due to its internal potential to the integration of all strategies and methods aimed at designing a cutting-edge educational environment. It is the STEAM approach, that can serve as the conceptual basis for an innovative model of training a new type of teachers-to-be.

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Transforming smartphones into microscopes for teaching anatomy

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Abstract

A group of prospective biology teachers were given the task of building a microscope out of home appliances and a smartphone. At the end of the course, they built their own microscopes in different designs and took photos of different animal tissues and other material objects. They showed great creativity and tested a variety of solutions. Their work can be seen as a model for their future work with students during their professional careers. An important point is that applying the principles of smartphone microscopy to other school and extracurricular activities can be considered a lifelong skill not only for prospective teachers but also for their future students.

Keywords: Biology education, Human anatomy, Microscopy, Prospective teachers, Smartphone,

Introduction

Human anatomy and physiology are standard topics in biology and are most likely part of the general science, biology, and health curricula in all elementary and secondary schools worldwide. The knowledge acquired in this area is important for students not only to pass school exams, but also to acquire skills and attitudes essential for health and healthy lifestyle as a lifelong competency. However, despite the relevance to personal and public levels, the relevant topics are often taught without reference to out-of-school contexts and hands-on activities, and students are asked to memorise facts (Michael, 2006; Prokop et al., 2007; Tranter, 2004).

Because all students have firsthand experience with humans, it is not surprising that they construct naïve interpretations and develop a set of misconceptions about the structures and functions of the human body. These interpretations may be the result of their own cognitive efforts, but are more likely to be adopted from informal sources such as family, peers, the media, and teachers and textbooks, which can be seen as counterintuitive. Therefore, the role of teachers should not only be to add missing parts to students' existing knowledge, but also to help them correct faulty parts. Considering that

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elementary and secondary students start anatomy and physiology classes with many misconceptions and naïve interpretations (Bahar, 2003; Mintzes, 1984) and finish them with fragmented and deficient knowledge (Šorgo, & Šiling, 2017), all efforts must be made to improve the accuracy of their knowledge. Due to the stability of misconceptions and resistance to change, it is not surprising that they persist not only among lay people but also among professionals, even in faculties where human anatomy and physiology are core knowledge (Yip, 1998). The additional problem of teachers and prospective teachers is that their own misconceptions may be passed on to generations of young people. Based on this perspective, it becomes clear that prospective teachers need to be taught how to introduce methods into their future teaching that create as few misconceptions as possible and how to correct them when they occur.

One of the problems that almost every student faces in anatomy classes is the visualization of structures, since dissecting human cadavers is not possible at these school levels, and graphical representations and virtual and real 3-D models are only an approximation of reality. Further problems arise in visualizing submicroscopic structures of tissues and cells, which cannot be viewed without magnifying instruments such as magnifying glasses and microscopes, which are only accessible to most students in schools. In summary, teachers usually rely on the representation of real objects using figures, 3D models, and videos, and very rarely on dissecting animal organs and exploring their structure and functions, leading to the construction of faulty concepts and misunderstandings of the processes (Lindsay, 2021; Utilizando, & Escala, 2015).

The power of computers and their usability in the classroom were recognized early on, and today it is hard to imagine biology classrooms without computers and the devices directly and indirectly associated with them. From the early days of their use, when computers were rare and expensive and student use was limited to schools, to the more recent stationary and mobile Internet-connected computers, there has been a long road of improvement, both in technology and in didactics. However, some of the basic principles of a good education have remained the same. One of the most important is that students can only acquire knowledge and skills through their own efforts. Teachers can help, but they cannot replace students' own learning.

Since the invention of smart pocket devices with the power of supercomputers from the past, we can observe that young people organize their lives around these devices (Boyd, 2014). Therefore, it would be unwise not to use familiar technologies in the biology classroom. While smartphones are regularly used (if not banned) for computation, communication, and tasks requiring information literacy, their use in hands-on science labs is not as common. While the use of smartphone sensors has easily taken hold in physics classrooms (e.g., Hochberg et al., 2018), this is not the case in biology practice, where such experiments are rare. The most commonly reported use of smartphones in biology and environmental education is for plant identification (Jones, 2020) and, in the context of physical activities, for counting steps and heartbeats (Morgan et al., 2003). Even when their use as microscopes has been suggested (.e.g. Kim et al., 2016; Maeda et al, 2020), such practices have not found their way into school biology labs, and if they have, it has not been in human biology.

Thus, the basic idea was to use and adapt smartphones and tablets as magnification tools, as a hands-on activity by prospective teachers in biology didactic course. The prospective teachers were instructed to find suitable objects in their home environment to build microscopes and document objects such as visible parts of the human body, animal organs, tissues, etc., to be used as models in the prospective anatomy classroom. They were given only general instructions, and it was left to their imagination and creativity to complete the task. The hidden curriculum of this assignment was to teach the prospective teachers how to use curiosity and creativity as missing components of teaching biology (Šorgo, 2012) and important so-called 21st century skills (e.g. Rotherham, & Willingham, 2010).

STEM Activity

Participants and description of the course

The participants were prospective teachers of biology and some other subjects. Eight students participated (5 women and 3 men). Chemistry was the second subject of four students, technics and technology of two and also mathematics of two students. The activity was part of a course in the subject called Biology Didactic Practicum, where part of the mandatory 60-hour course is a 15-hour course devoted to individual practical work. In previous years, their task was to prepare their own experiments in alternative forms such as traditional and computer-based laboratories in the department's laboratories. Since the course was held during the time when the faculty was closed for classes due to COVID -19 restrictions, the students were guided to prepare their experiments as homework. Since it was not possible to provide them with data loggers and other lab equipment such as microscopes, the smartphone-based lab was an option. The format of the course was mixed, with regular student-faculty meetings via online platforms and a final presentation as the restrictions ended near the end of the course.

After deciding to build their own microscopes from smartphones, the process involved several steps:

1) Students were asked to create preliminary plans for their microscopes. The plans were later discussed by the whole group and some improvements were suggested. These suggestions included, for example, adding a light source if it was missing, or where to find a suitable lens. In this part of the course, references to the existing solutions were collected and links to the common learning platform were saved. The second step after the discussion was to revise the original plans and create the technical documentation.

2) A phase followed in which they were left to their creativity and skills to implement their ideas in the real world. During this time, they discussed many things mainly related to optics. One example of a problem that came up was how to find the focal point of an unknown lens.

3) When the microscopes were ready, they were to use them. Animal tissues and organs were used as models for human anatomy. They prepared a series of microscopic slides, which was not always an easy task.

4) At the end of the course, the faculty was reopened so that they could discuss live the pros and cons of smartphones for home use, present their solutions, and comment on their usefulness for classroom work.

To obtain more detailed information beyond the level of anecdotal evidence, students were given a short questionnaire asking them about:

(a) how they perceived the usefulness of smartphones in the biology classroom?

b) Views on the perceived ease of using smartphones in the biology classroom?

(c) enjoyment of using smartphones in biology class?

d) Their satisfaction with using smartphones as a teaching tool in biology class?

e) their intentions to continue using the smart mobile device as a teaching tool in biology class?

The questionnaire has a 7-point Likert format with anchors at "I strongly disagree" and "strongly agree" and was adapted from the work of Šumak and Šorgo (2017), Šumak et al. (2018), and Chroustova et al. (2017). Due to the small number of participants, the results can be considered informative and can only be used for guidance purposes.

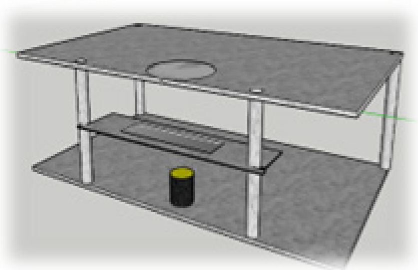
In parallel with the course, one student worked on her master's thesis on the use of smartphones in the biology classroom. The thesis was successfully defended and the results of the work, which includes smartphone-assisted microscopy, are available online (Gorenjak, 2022).

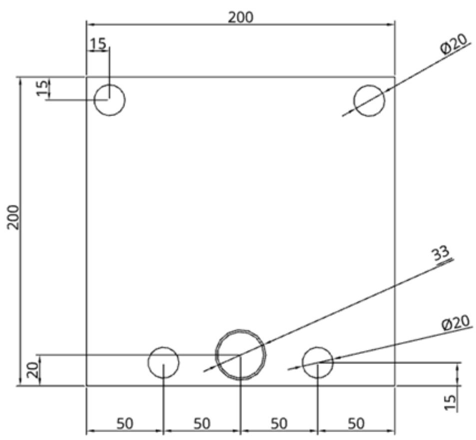
Outcomes of the course

Examples of the results of some construction phases and solutions are shown in Figures 1 and 2. The intended outcome of the first phase was technical documentation and a blueprint for the microscope. Each student had to create this plan individually and get permission from the teacher to proceed with the work. This was followed by building and testing the solutions and reflecting on the work.

During the course, students built a vibrant social network in which they shared ideas and solutions, extending the time for formal meetings with the teacher. The overall impression of the work on the assignment was positive, as indicated by personal conversations. However, we would like to extend our findings beyond the confines of one assignment, so in a second part we surveyed course participants with a questionnaire about their attitudes, perceived usefulness and satisfaction, and the broader purpose of using a smartphone as a teaching tool in a biology class. As mentioned above, the results can only be considered as a guide for future work and are by no means to be considered statistically validated.

In terms of perceived usefulness, respondents most often indicated that they find smartphones useful in teaching and learning biology and that using smartphones in biology classes can make many things more convenient. However, they disagree with the statement that using a smartphone helps them achieve their goals faster. When asked about the perceived ease of use of smartphones, they indicated that they could easily learn how to use a smartphone for teaching biology and that they found it clear and understandable. However, they were less in agreement about their ability to use a smartphone as a learning tool. When asked about their perceived enjoyment of smartphone use in class, they responded that using a smartphone for instruction can be interesting, enjoyable, and fun, but were less enthusiastic about their own enjoyment of smartphone use. When asked about their overall experience, they expressed mostly enjoyment and satisfaction in using a smartphone but were not very impressed with its use. When reflecting on their own experiences in the course, students expressed surprise that their experiences with smartphone use in biology classes were better than expected, and they also found smartphone services to be more accessible than expected. When asked about their future intentions regarding smartphone use, most of them expressed a positive attitude towards such work in class.





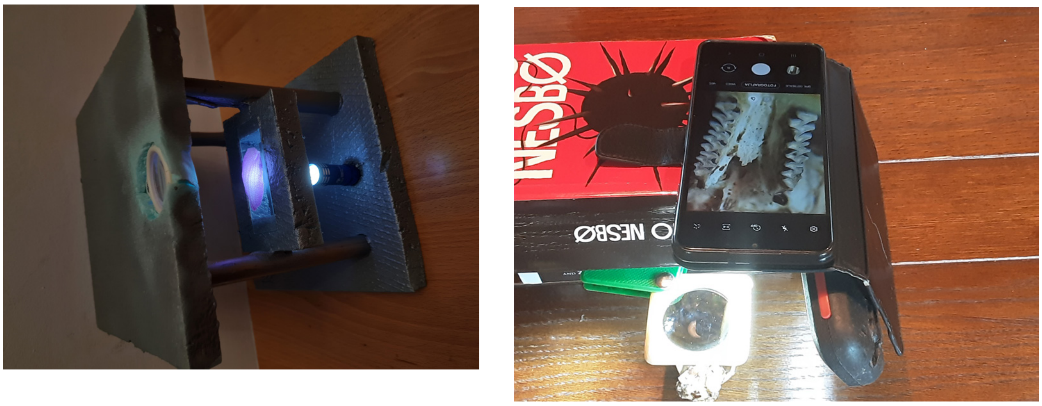


Figure1: Construction of the microscopes (authors of the images: Lara Voler, Andrej Šorgo)

Figure 2. Students' presenting their microscopes (photo Andrej Šorgo).

Discussion and suggestions

At the end of the course we realized, that we worked with a group of prospective teachers who were able to build their own microscopes and take photos of various animal tissues and other material objects. They showed great creativity and built their own microscopes from household objects. Their work can be seen as a model for their future work with students during their professional careers. An important point is that applying the principles of smartphone microscopy to other school and extracurricular activities can be considered a lifelong skill not only for teachers but also for their students. Due to the novelty of our approach, we cannot compare our work to the references, but we were able to see that the prospective teachers developed a positive attitude towards the future application of this work in a real classroom. They were able to identify many positive aspects of such work but noted that they may need more experience, so they showed some reluctance before introducing such work in their future careers. We hope to succeed in conveying the message that the best thing that can happen to students is the challenge of solving interesting problems with the help of teachers.

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Indispensable Skills in Distant Education

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Abstract

This study was carried out to solve the problem of 'inadequate digital skills of teachers and students in distance education during the pandemic period and developing students' critical, creative thinking, collaboration. The inevitable need for distance education materials, the insufficient use of web 2.0 tools, and low coding skills were the main problems being tried to overcome with this study. 85 students from different countries, cities, high schools involved. The main activities are preparing digital presentations, animations, group coding activities, virtual exhibitions with AR&VR, the animated digital book, the usage videos of some certain web 2.0 tools. During the project, the students used various innovative digital tools to enhance their creativity and collaboration. In the project, the joint products such as project calendar, coded virtual exhibition, joint coding activities, project final video, animated book were done by the students in mixed groups. Presentations of web 2.0 tools have improved their creative thinking and entrepreneurial skills. The results of the project were effective so it was started to be implemented by other group teachers in the project schools. The project reached wider people by publishing it on school websites, magazine news, project blog page, Facebook group, and via online meetings.

Keywords: Digital skills; creative thinking; cooperation; innovative technologies

Introduction

Due to the Covid19 outbreak, it has become inevitable to improve the digital skills and competencies of teachers and students. New methods and techniques that will enable teachers and students to use their lesson time in the most effective way have become a necessity in distance education. For this reason, creating an interesting virtual classroom will enable students to learn and use distance learning tools. Teaching the lessons equipped with suitable web2.0 tools will enable students to participate in lessons and achieve the necessary gains.

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Thanks to this project, which will be carried out as an international project, the digital skills of each student and teacher will be developed and the necessary curriculum acquisitions will be achieved with digital learning tools. In addition, by using 21st century skills and digital skills, lessons will be taught in an enjoyable way and permanent learning will be achieved.

To gain Digital Skills for teachers and students;

- Learning and using distance education tools; Learning to create virtual classrooms with bitmoji and nearpod.
- Preparing logo, poster using appropriate web 2.0 tools like canva, postermywall etc.
- Using coding tools like Scratch, Cospaces Edu
- Various Web 2.0 tools for lesson activities were used.

If we hadn't done this project, students and teachers wouldn't have gained digital skills and the lessons would have been traditional way. The fact that teachers teach their lessons only through zoom does not increase their digital competence. Therefore, this project was made to meet these needs of students and teachers. With distance education, not only the training material prepared with the classic PowerPoint type is sufficient, but also the materials and digital measurement tools prepared using different web 2.0 tools have become a necessity.

Theoretical Framework

In these times of global tragedy due to the pandemic that caused COVID-19, distance learning relies on the resources of the digital field, as well as on the management of ICT and the development of digital skills (Chavez et al, 2020). With this quarantine period, teachers and students have started to search for methods and tools that they can use in distance education. New pedagogical methods became mandatory in distance education, due to the pandemic. For this, high-tech web 2.0 tools should be preferred with a student-centered approach.

Digital skills are the perspective of the new educational training, with a clear objective of educating and preparing students, allowing them to appropriate themselves of new ICT knowledge, tools that serve to include them within the educational system (Lévano, Sánchez, Guillén, Tello, Herrera and Collantes, 2019). With Bitmoji classes and nearpod lessons flipped learning is used. By using different learning apps, game-based learning is also an important part of the project.

The incorporation of new technological structures facilitates the incorporation of new approaches to teaching and evaluating students with ICT, for observing the progress they have made; that is, these competencies develop planning and organizational skills in education, which aids the construction of new knowledge, using technologies as tools in new scenarios (Jiménez and Gijón, 2016). Therefore, new technological tools like Cospaces Edu tasks in mixed school teams, being a part of the team and taking responsibility have been gained.

In today's technology age, being digital literate is an important skill needed in people's workplace and social lives beyond educational institutions. The increased focus on the development of digital literacy should be a policy priority, especially for educational institutions. Because education, which includes the learning and teaching process, is an area where digital media are used (Eguz, 2021). The Project activities are compatible with the European framework key competences like literacy, digital, multilingual, science, technology, engineering and entrepreneurship.

STEM Activity

11 partner schools from Konya, Istanbul, Ankara, Kocaeli and Macedonia came together to develop and use the digital skills and competencies of teachers and students, which have become a priority with the Covid19 epidemic, and to enable teachers and students to use their class hours in the most effective way. The project was created in order to create a virtual classroom to adapt new methods and techniques in distance education, to enable students to learn and use distance education tools, to teach courses equipped with appropriate web 2.0 tools, to enable students to attend classes and achieve the necessary gains.

Since the project was multidisciplinary (English, B.I.T. and chemistry), the general achievements of the English course; students are encouraged to participate in task-based, collaborative and project-based language activities; For the B.I.T course, students; add an audio, video, table and graph from the computer to the slide; For the chemistry course, students can organize, present, report and share in accordance with the symbolic language of chemistry and scientific content with the knowledge they have acquired using information technologies; learning such gains has been provided. The students and teachers worked collaboratively in our project. The studies were completed with the motivation of working together and producing a joint product.

The students understood the importance of teamwork and learned to care about different ideas and suggestions. They developed their sense of responsibility. With the e-Twinning project, the students and teachers have integrated project-based and distance education tools into their teaching methods. They have also learned to use computers and the internet outside of their leisure time activities. With the project, the teachers and students were provided with the opportunity to learn about project-based learning and teaching methods, and to adopt new generation web 2.0 tools in an enjoyable and entertaining way. An ecosystem established for the development of digital skills.

The cooperation started with the first meeting in October by revising the draft project plan and project targets. Tasks were distributed according to the interests and abilities of the partners. A students' webinar was held in November to discuss the use of Twinspace platform, the plan, goals and activities. Pupils' wishes were considered. In December teacher webinar, preparations for the Nearpod lesson and Bitmoji Class, and the blog page were discussed.

In the January teachers' webinar, forming the mixed school teams for the poster, web 2.0 tools for lessons were discussed and the innovative tool; Cospaces Edu was introduced. In the January students' webinar, a common word cloud was created for the web 2.0 tools, the students were divided into groups, and task distribution was done willingly. It was decided to prepare a usage video and an example compatible with the curriculum. On February 9, a presentation about safer internet was conducted and a joint word cloud was created collaboratively. Our joint poster was prepared by my mixed school team at the meeting in February.

In March, teachers' and students' webinars were held, and the augmented reality education application Cospaces Edu, chosen for the virtual museum by a forum survey. First it was introduced and Cospaces Edu classes were created for training. Then individual and group tasks were given to pupils. For group coding, they prepared a common coding using Scratch. In April, blog design and uploading training was given to the students. Project evaluation and kahoot competitions were held in the teacher and student final webinar in May. Monthly meetings were held to ensure coordination and cooperation between teachers and pupils throughout the project. The joint products; calendar work, project final video, virtual museum prepared with augmented reality application (Cospaces Edu) and animated e-book were prepared in full cooperation. Online meetings, eTwinning forum discussions, chat rooms, twinmails, mails and WhatsApp Groups used to communicate.

Considering the project objectives, the students chose the ICT tools for the project studies through online meetings with teachers and students, and the surveys in the forum area. Canva and Logomaker are used for the project logos. Canva, selected through a forum survey, was used to create a joint poster. Concept maps are prepared with Mindmeister and Buble.us. Teachers used the interactive Nearpod tool in distance education, the Padlet for performance assignments, and the Bitmoji Classroom for repetition. Students in the group chose Plotagon to create animations, Hihaho to edit videos, and Learning Apps to create educational games. After researching, usage videos and examples from the curriculum were prepared. For the virtual museum, a distinctive and creative tool, the augmented reality application Cospace Edu, was chosen with the forum survey. Cospaces Edu classes were created and necessary training was given, and then individual studies were carried out. The museum has been designed in 3D and the necessary coding has been made for functionality. It is projected to the desired location with the augmented reality application. Scratch is used in group coding activities. Canva was preferred in our common product calendar work. Adobe After Effect Templates were used for the animated e-book. Blogger was used to prepare the Project Blog page (https://ourinternationalvirtualclass.blogspot.com), and separate pages were created with the logic of the website. So, it is easy to follow.

In order to measure the impact of the project on education stakeholders, first and last surveys were applied to pupils, teachers and parents. According to the analysis, while most of the students participate in an eTwinning project for the first time, most of them want to participate again. 98% of the students stated that the project met their expectations. With the project, participation rate and interest in distance courses increased. Thanks to the project, more fun lessons were taught. The use of Web 2.0 tools has also increased. Students and teachers have started to use concept maps, word clouds, educational games, Padlet, Nearpod Lesson and Bitmoji Class more frequently in lessons. Students have started to send their performance assignments and projects mostly through applications such as EBA and virtual classrooms. As for the impact of the project on teachers, most of them stated that their aim of participating in the project was to learn new methods and techniques in distance education. All of these expectations were met with the project. The digital competencies of all teachers have increased. With the project, teachers are able to prepare their own digital course materials. Teachers mostly use web 2.0 tools in their lessons. In the parent survey, it was seen that the rate of their children spending time on the internet and in the game decreased, they were more interested in the lesson, parents were satisfied with their participation in the project, their self-confidence increased, they became socialized, their digital and language competences increased, especially in distance education, which was very beneficial for their children. In order to disseminate the project, the results and effects of our project were shared with all teachers and students at various eTwinning zoom meetings at school in the district. The project blog page, the school website, the Facebook group, the EBA platform were used for dissemination.

Discussion and Suggestions

This study can be used in all branches due to its interdisciplinary nature. It can be applied not only in distance education but also in face-to-face education. The need for getting socialization should always be taken into consideration. The educational-platforms like e-Twinning made the interaction easier. Distant education should include small group works. The collaborative work in the breakout rooms during zoom meeting rooms were productive as the group members had the chance to express their idea freely. Every student felt more comfortable and creative in the small groups. The same implications were done face to face at school but the expected outcome was not observed. The students cooperated with high motivation at home and more effectively during covid19 than at school.

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The Role of Computerized Laboratory Exercises in Development of Key Competences

Andrej Šorgo[1,2] & Vida Lang[3]

Abstract

Over the past 20 years, the first author and numerous collaborators have attempted to introduce computer-based laboratory exercises in science, particularly in biology classes. While working with secondary and post-secondary students, it was realised that it was possible to simultaneously develop cross-cutting competencies that bridged several key competences of the European framework of eight key competences for lifelong learning. These were (a) Collecting, analysing, and organising information; (b) Communication of ideas; (c) Planning and organising activities; (d) Working with others in teams; (e) The use of mathematical ideas and techniques; (f) Problem solving; and (g) The use of technology. When inquiry and problem-solving strategies are used, student achievement is much higher compared to explanatory and expository labs.

Keywords: Biology education, Computer based laboratory; Key competences, Laboratory work; Science education

Introduction

Over the past 20 years, the first author and numerous collaborators have attempted to introduce computer-based laboratory exercises in science, particularly in biology education, both in schools at the pre-college level and in the education of prospective teachers. Computer-based laboratory exercises should be divided into two groups. The first group includes laboratories in which the objects of observation are material objects and/or processes and in which computers equipped with a data acquisition system are used as measuring devices, while the second group includes virtual experiments in which objects and processes are digitized and all observation takes place "in the computer" (Kocijančič & O'Sullivan, 2004). In this paper, only the first group is considered. After years of work,

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starting with now obsolete data acquisition systems, to virtual laboratories, to recent attempts to test smartphones as laboratory tools, one problem remains the same. Consistent with the revised TPACK model (Mishra, 2019), the key finding was that while instructional content, technology, and context may change, basic instructional practices remain mostly the same and ineffective. It seems that the shift toward education whose main outcomes follow what have recently been called 21st century skills should follow a bottom-up approach in which teachers do not wait for others to introduce more intellectually demanding and challenging practices. One such useful framework that any teacher can adopt has been identified in the concept of competences as a combination of knowledge, skills, and attitudes in a particular context. The context described in this paper is computer-based laboratory work in science (biology) classrooms.

Having acknowledged the importance of competences, the question of how to implement them in schools and other lifelong learning institutions remains mostly unanswered. For a practicing teacher, there is probably only one way: to exercise his or her right to choose teaching methods, which may be a path marked by a number of obstacles. One of the possible, however not easy, routes for simultaneous inclusion of multiple competences is laboratory work, particularly computer-based real laboratory (Kocijančič, & O'Sullivan, 2004; Špernjak, & Šorgo, 2009a).

Theoretical Framework

To be innovative, productive, and competitive in the global context, the European Union has recognized that the knowledge, skills, and abilities of the European workforce are an important factor. Due to increasing internationalization, rapid change and the constant introduction of new technologies, it has been recognized that the goal of education should not only be to train citizens to keep their specific job-related skills up to date, but also to ensure that they have the generic competences that enable them to adapt to change, which can also contribute to their motivation and job satisfaction and thus influence the quality of their work (European Union, 2007).

Against this background, the Council and the European Parliament adopted a European Framework of Key Competences for Lifelong Learning at the end of 2006. This framework identifies for the first time at European level the key competences that citizens need for their personal fulfilment, social inclusion, active citizenship and employability in a knowledge-based society. Member States' initial education and training systems should support the development of these competences in all young people, and adult education and training provision should provide real opportunities for all adults to learn and maintain these skills and competences. The list was updated in 2018, however the basic message stays the same. These initial eight key competences recognised by the European Parliament are: Communication in the mother tongue; Communication in foreign languages; Mathematical competence and basic competences in science and technology; Digital competence; Learning how to learn; Social and civic competence; Initiative and entrepreneurship; and Cultural awareness and expression.

All the listed competences are considered interdependent and equally important. However, this does not mean that each school subject or each teacher can contribute equally to the development of each competence. In science subjects, we can divide the listed competences into three groups (Špernjak, & Šorgo, 2009b). The first group includes the core competences: mathematical competence and basic competences in science and technology, as well as digital competence, in the development of which the science subjects play a dominant role. The second group includes the competences in which science subjects are on par with other subjects. Such competences are learning to learn, and initiative and entrepreneurship. The third group includes competences in which science subjects play a minor role compared to other subjects: communication in the mother tongue, communication in foreign languages, social and civic competences, and cultural awareness and expression.

Before their implementation in the classroom, all of these competences need to be operationalized. For operationalizing competences in science education, a different list proposed by the Mayer Committee (1992) is proposed. This report identified seven key competences that people should acquire before entering the workforce: (a) Collecting, Analysing, and Organising Information; (b) Communicating Ideas and Information; (c) Planning and Organising Activities; (d) Working with Others and in Teams; (e) Applying Mathematical Ideas and Techniques; (f) Solving Problems; and (g) Using Technology. There is much overlap between the two lists, but Mayer's list of general competences is more appropriate for science classrooms. In addition, Mayer's list better fits with the idea of transversal competences embedded in the European framework, and lists fashionable named 21st century skills.

The problem with the recommendation to include any set of competences for a teacher of a regular subject (e.g., science) is that competence-based didactics is still at a very early stage and lacks models that can be directly applied to actual teaching. While it is assumed that all competences are equally important, it is very unlikely that every teacher contributes equally to the development of all eight competences when teaching their subject. Therefore, interdisciplinary and transdisciplinary collaboration among multiple teachers is a plausible solution. This strategy is most often used in the context of project days or specially designed events that constitute only a small part of the curriculum. While such an approach can lead to some plausible outcomes, it does not readily translate to prevailing traditional schools. Due to organizational problems, it is almost impossible to organize such a strategy in traditional schools with fixed daily schedules on a daily basis.

Consequently, activities must be developed that are embedded in the science curriculum and regular classes that follow the traditional schedule and enable the teacher to teach the multicompetency approach. The problem is that teachers of a particular science subject may have extensive pedagogical content knowledge in the subject they teach, but not in the core disciplines needed to develop other competences. For science teachers, the core competences are "Mathematical competence and competence in science, technology and engineering" and "Digital competence" while they need to support the development of the other competences. Therefore, helping students develop creativity, problem solving, and critical thinking as transversal and cross-cutting skills not only brings digital literacy and science and scientific literacy (competences) to a higher level, but also the other competences as well. The best part is that such strategies can be combined in the regular classroom by one teacher, and without need to reorganize the schedule.

With the ubiquitous use of computers, and more recently with the advent of smart portable devices (smartphones and tablets), it has become possible to incorporate many experiments into science lessons that were unthinkable in traditional school labs. As shown in previous analyses of hands-on work, it is possible to teach students how to collect, organize, analyse, and report data and results while developing problem-solving skills and critical thinking through the use of computer-based labs. While experiments with computers and data loggers are confined to the classroom, the use of cameras and sensors embedded in smartphones allows students to experiment on their own and apply what they learn in new contexts. Opening new window to made school science a lifelong skill.

STEM Activity

In this paper, we do not refer to a specific laboratory activity, but we would like to summarise the findings on the acquisition of key competences through the use of data acquisition systems that have been collected over the years. Several dozen different experiments have been tested over the years, and many of them can be tracked on the Internet under the last name of the first author.

In any scientific subject, there are many opportunities for preparing activities related to the competences. However, the first step is to reduce direct instruction in favour of active teaching methods based on inquiry and problem-based teaching and learning (Michael, 2006; Šorgo,2010). In (science) biology education, we recognised early on that a whole range of competences can be developed in students through the introduction of computer-based laboratory exercises (Šorgo, Hajdinjak & Briški, 2008; Šorgo & Kocijančič, 2007; Šorgo & Kocijančič, 2004; Špernjak & Šorgo, 2009a), although it has never been said that this always works easily and smoothly (e.g., Šorgo & Kocijančič, 2012).

Recently, attempts have been made to test smartphones in (science) biology classes. The work is still in the early stages, but there are good indications that it is possible to introduce such labs in biology classes with a view to developing key competences (e.g., Lang & Šorgo, 2022a; Lang & Šorgo, 2022b).

Findings

After years of testing computer-based real laboratory, which should be distinguished from virtual laboratory, it was realised on the basis of accumulated experiences that such well-designed laboratories allow acquisition of key competences. To be more precise, competences as defined by Mayer's committee, in a framework of Digital competence, and competence in Science and Mathematics, as proposed by the EU, and supporting the other competences for lifelong learning as well. Because there are many overlaps between transversal competences from EU framework and frameworks of 21st century skills, it is possible to acquire them as well, even if not directly mentioned. The arguments are as follows:

1. Collecting, analysing, and organising information requires the ability to evaluate the information itself and the sources and methods used to collect it. In particular, when students have to define units of measurement and ranges of measurement or plan the time needed to conduct an experiment in the preparation phase of an experiment, the impact of such work on the development of this competence is much greater.
2. Communication of ideas and information is about the ability to both communicate with others within a group and present ideas in public. The impact of computerized real laboratory depends largely on how students presents their findings. If all they must do is to follow directions, show a diagram or picture it in an empty frame, or respond with short statements in the boxes on their worksheets, the lab will have little impact on this skill. If we want to teach them to communicate effectively with others, we should encourage internal communication in a group about their work and allow them to report on their work using written, graphic, verbal, and even nonverbal communication.
3. Planning and organising activities is a skill that can easily be transferred from laboratory work to almost any other area of life. If a teacher wants to improve his or her students' ability to plan and organise their work, he or she must involve students in preparing laboratory exercises from the beginning. However, we cannot expect much effect if the laboratory work is purely expository. In this case, the result will not be an improvement in planning, but an increased ability to follow the guide.
4. Working with others in teams is a common side effect of other competences, even if it is not planned, because schools are not equipped with enough materials to allow students to work individually. Therefore, students must work effectively both individually and in groups to achieve a common goal.
5. The use of mathematical ideas and techniques in learning outcomes depends largely on the type of engagement, with problem- and inquiry-based activities being superior to expository ones. Because the use of data acquisition systems allows the transition from qualitative observation to quantitative measurement, a range of calculations is almost always possible, e.g., calculating statistical values such as means, errors, ranges between extremes, etc., and investigating graphs

is an activity appropriate even for younger students.

6. Problem solving is a skill in which Slovenian students are weak but it is only occasionally on teachers' lesson plans (Šorgo, Vrčkovnik & Kocijančič, 2008). If a teacher conducts lab work in an explanatory manner, then the introduction of computers will only lead to a transformation of cookbook lab exercises into computer-based cookbook exercises. In our experience we know that the development of problem-solving skills can only be achieved when students are exposed to the sometimes stressful situation of solving real problems, starting with an idea, followed by planning, conducting the experiment, and the final presentation.
7. The use of technology, i.e., the ability to apply and handle equipment while understanding the underlying technical and scientific principles, is a competence that is severely neglected in general education in Slovenia (Šorgo & Kocijančič, 2004). Technologies are deeply rooted in the development of our civilization, and their understanding can contribute to solving current problems such as climate change, energy consumption, or ecological impact. By working with data acquisition systems and interpretation of the findings students would recognise some basic principles similar to those in science or industry. One example is analogue-to-digital conversion, which can be explained and applied to everyday applications such as digital TV, computers, cell phones, etc.

Discussion and conclusions

Competences are a mix of knowledge, skills, and attitudes that are a prerequisite for integrating young people into the real world of work and study, therefore, schools should help young people to develop them. Based on our work with students, we can see that by using the computer-based lab in science classes, even a single science teacher can help students develop such competences without having to wait for curriculum changes to be approved by authorities. The computer-based lab can be used with students as young as 10 years old. When it comes to competences, inquiry and problem-based methods based on a constructivist paradigm are superior to direct instruction. With such an approach, it is possible to simultaneously influence the development of probably the largest group of competences, making computer-based labs the most important tool for developing competences. However, the recognised problem with introducing such labs in schools is not with the students, but with the teachers (Špernjak & Šorgo, 2009), a problem recently recognised with the use of smartphones in the classroom. The good news is that with the near ubiquity of smartphones and the sensors built into them, the argument of a lack of appropriate technologies for use in the classroom or in the field no longer applies.

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Micro:bit; cheap and simple hardware for coding

Armin Ruch[1]

Abstract

Coding becomes an important aspect of STEM education as well as a general soft skill for life. In order to implement a curriculum to teach children coding skills, educators need to find appropriate software and hardware. That, however, has been very difficult, as most software and hardware was developed for other purposes than K-12 education. The Micro:bit, developed in England, is the first system that was specifically created for education. This article will explain why the Micro:bit is also a very good alternative for coding-education in Türkiye. Further, it will demonstrate with one exercise, how children can be led to a successful coding experience that will also help them to understand the combination of hardware and software, as well as the necessary thinking process. The article has to understood as an initial introduction to the potential that the Micro:bit offers to STEM-education in Türkiye. Both authors are happy to get in contact and networt with educators that also want to further the coding-education in Türkiye on the basis of the Micro:bit. As this article focuses mainly on educational questions, the authors recommend the Turkish language book by Orhan Celep (2020) for detailed instructions on how to use the Micro:bit.

Keywords: Coding; Micro:bit; Digitalization; Skills

Introduction

It is undisputed that an understanding of Information Technology (IT) and basic coding skills are essential for the general education of today's children (Dworschak & Zaiser, 2019; Ruch et al., 2019; Windelband & Dworschak, 2018). While the digitalization of work and private life sweeps across Europe (Buhr, 2019; Hirsch-Kreinsen et al., 2018), Turkey's youth has to aquire these skills, too, to be on top of the transformation and not lack behind. However, as the transformation is rapid, concepts for the inclusion of IT into general education are needed. These concepts face a huge difficulty. It is rather uncomplicated to introduce a new English book to English teachers, as the subject English Language stays unchanged. In IT, however, concepts need to be found that honor the fact that IT is a new subject that most teachers have no experience in and might even feel uncomfortable teaching ("Passionate Turkish

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engineer promotes coding for children," 22.08.2022). Further, it is a particularly challenging situation that most IT-systems are extremely expensive and thus cannot be purchased by schools and students easily. Other systems might be available for lesser prices but are very complicated to use, especially in a context where students and teachers are not very experienced (Stratmann & Müller, 2018). This article will introduce the Micro:bit, an IT-system that was explicitly developed for the use in secondary school and that is cheap in comparison with other comparable systems (Micro:bit Educational Foundation, 2022). Futher, this article will provide a short insight in how the Micro:bit can be used in school to help students acquire basic programming skills and an understanding of how digital systems work.

What is a "Micro:bit"?

Information Technology is evolving rapidly (Raitner, 2019). Luckily, within this evolutionary process, an IT-system for the use in school has been developed in England. In the following, this system – Micro:bit – will be described and compared to the well-known Arduino system. Even though both are normally referred to as "Micro Controllers" (MC), this terminology is wrong. It would be the same mistake to refer to humans as "brains". While without a doubt the brain controls the rest of the human being, there is more to a human than the organ in its head (Bartmann, 2015). Similarly, the MC is the brain of the IT-systems Arduino and Microbit. Yet, besides the MC, there is quite a lot of additional technology necessary and included. While the MC in the Arduino and the Micro:bit is identical, the additional technology makes a big difference.

To understand the difference between the Arduino and the Micro:bit, one has to look into why the two systems were developed. The Arduino was made for people who wanted to take their electronics-skills one step further. Therefore, the Arduino is constructed to allow the addition of further electronic components of all sorts. The Arduino carries all the hardware to attach external circuits. However, to do so, more than basic electronic skills are needed (What is Arduino, 2018). As the Arduino was designed for people who already know their electronics, little thought was given on how easy the Arduino can be used. Still, for a long time the Arduino was the only option for schools, due to its price. While it looks very complex today, to pair an Arduino with a computer, this process used to be very simple in comparison with other technology from that time. However, when used in class, the Arduino requires very high skills from the teachers and most of the time is spend with troubleshooting the electronic circuits and less time is spend on coding.

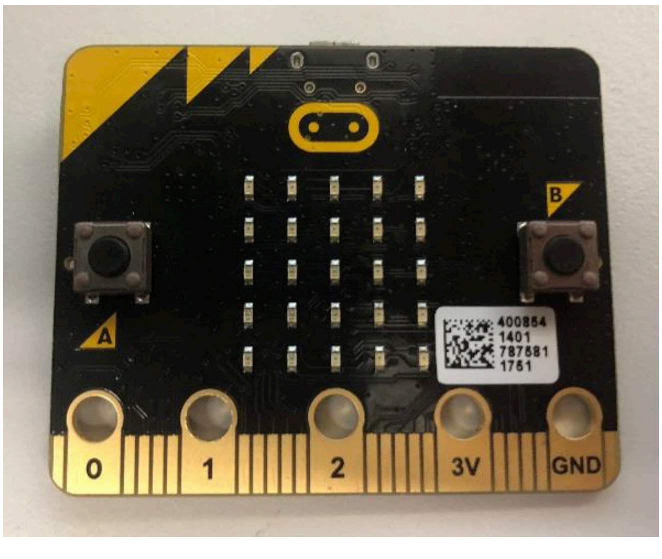

Image 1: The front side of the Micro:bit. The 5x5 LEDs, the two Buttons A and B, as well as the 3 general Pins, the 3V output and the Ground-Pin are cleary visible.

The Micro:bit addresses this problem in its construction. It has most of the elements that are needed in class already included in the system. Thus, to make an LED light up, one does not have to attach the LED and the resistor correctly to the MC, as it is the case with the Arduino. On the Micro:bit, there is already an LED-pannel of 5x5 LEDs that can be easily addressed in the program. No electronics skills are needed for that. However, there is more to the Micro:bit than just the LEDs. The Microbit further has two switch-buttons already included. Therefore, programs including the pressing of a button can be included easily, too. Further, the Micro:bit is able to measure temperature and light intensity. Besides that, a magnetic field sensor can be used as a compass or to detect electromagnetic fields – for more advanced projects. In addition, a 3-axis-gyrosensor measures how the MC is changing its position long x-, y-, and z-axis. Last but not least, a Bluetooth module can be used to communicate between two Micro:bits or even one Micro:bit and an Android mobile device. All of those elements can be used and included into the programs without any knowledge about electronics or physics. The learning curve for students, as well as for teachers is very steep and progress can be made quickly. Yet, the Micro:bit is not limited to the parts that are already included on the board. For advanced users the Micro:bit can also do everything that the Arduino can regarding external electronics. The Micro:bit has three pins that are very easy to access and can be used with all kinds of conducting material found in classrooms, such as paperclips, screws, or aluminum foil. Two more such pins allow for 3.3 V power and a ground connection. Additionally, another 12 pins can be accessed with a special connector for very advanced projects. One can easily see that the Micro:bit not only is very well suited for even the youngest beginners, but also very well suited for highly advanced users, too.

Another aspect that the developers of the Micro:bit have kept in mind for the development is the problems that arise while attempting to pair the Arduino with a computer for programming. While this process is very difficult with the Arduino and might even be impossible due to the Administrator settings on school computers, the Micro:bit behaves just like a USB-Stick. If it is attached to the computer, uploading a program is identical to moving a file to a regular USB-stick. Again, even teachers without any programming experience can easily do this in a class setting without fearing any problems that might extend their skills.

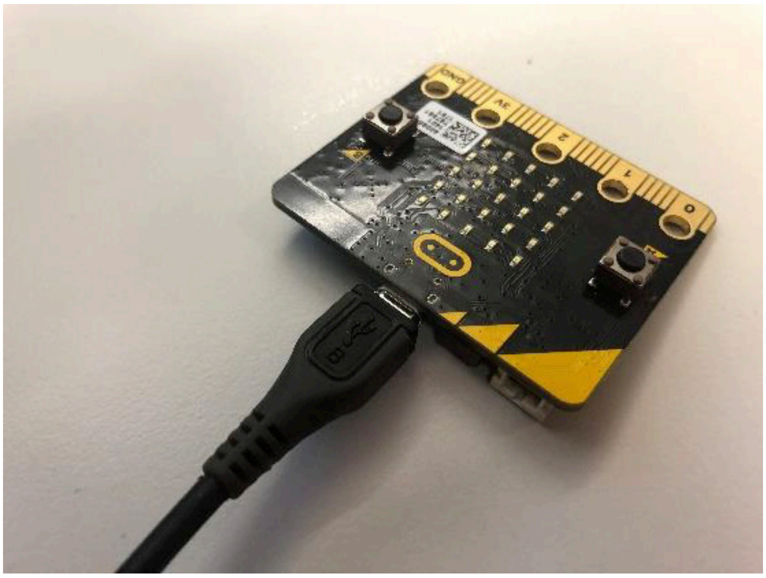

Image 2: The Micro:bit is connected to the computer with a Mini-USB cable. While it is connected to the computer, the Micro:bit also gets power from the USB connection

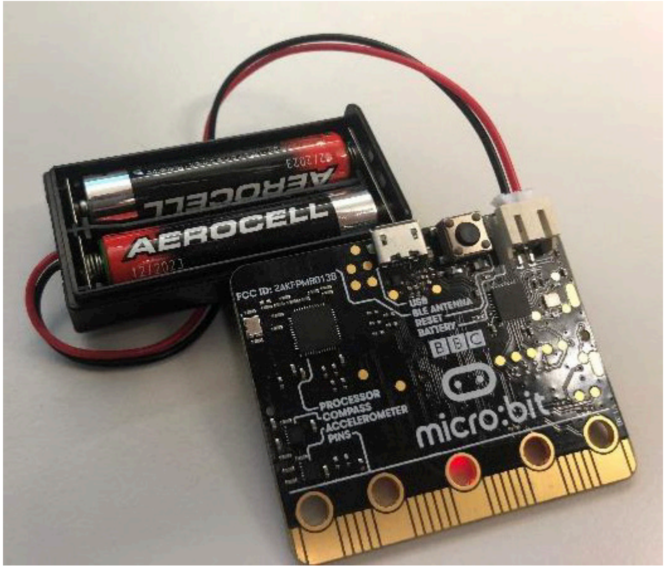

Image 3: With a small battery-pack, the Micro:bit can be used everywhere and is very mobile

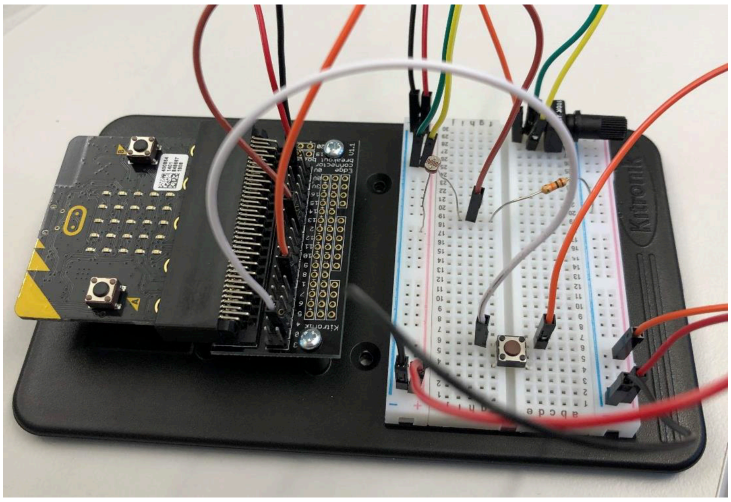

Image 4: With an additional connector, the Micro:bit can be used for very complex problems.

And another aspect that should be mentioned here, is the programming environment of the Micro:bit. It is designed in a way that can be used throughout all classes, starting when children can read. On www.makecode.microbit.org Micro:bit and Microsoft have set up a website that enables different ways of programming. A big advantage: the language can be set to Turkish. Besides a graphic block-based programming language which will be discussed later, it is also possible to program the Micro:bit in Java, a text-based programming language. The setup of the webpage is such that no program has to be installed on the computer. Again, that makes the use in school much easier. Further, the page is set up in a way that allows for the users to use a basic menu or and advanced menu. This has shown to be good for motivation, as it does not appear as threatening for new users, as having a menu with a majority of commands that one does not comprehend. The page is colorful and appears attractive without looking childish. Overall, one can assume that the developers did not want to create a stereotypical nerd-look but something that is appealing for everyone.

Besides the smart menu setup and the colorful environment, the programming page features a very useful element for class. The whole programming can be simulated within the page. A virtual Micro:bit can be used identical to the real one. Therefore, not only can programs be tested before uploading them to the MC, but not every student actually needs his or her own MC. That is very cost efficient. Theoretically, it would not be necessary to have even as much as one MC at school. However, for the sake of motivation, students should have to option to share an MC to try the programs in real life. Still, homework can be assigned, as long as the student has the chance to access any computer with internet. Programs can be saved, emailed, or brought to school on a USB-stick without any technical requirements besides the aforementioned computer. However, public computers can also be used, as all of the programming happens on the Micro:bit homepage. For more detailed instructions in Turkish language, on how to use the website, the authors refer to the book by O. Celep (2020).

Overall, the authors of this paper are not aware of a system that is better suited for the use in schools than the Micro:bit. This assumption includes the setup of the MC itself, the setup of the programming environment, and last but not least the extraordinary price-value relation. With $16 the Micro:bit is certainly not cheap in Turkey. At the time of this article the price at the Turkish distributor https://market.samm.com/bbc-microbit-v2 was 383 TL + KDV = 452 TL. In comparison with other MC that would need to include all of the elements that the Micro:bit already has onboard, this price is still very reasonable.

Input, Processing, Output

All information technology and coding revolve around the concept of Input – Processing – Output (IPO) (Heinrich et al., 2002). In short, a MC measures the inputs from the environment (Input) with sensors and reacts to it (Output) according to specific rules that are written in its code (Processing). This fundamental principle is the key to understanding the whole world of coding and the use of information technology. While it is a question of physics, how the sensors actually work and how they detect the changes in the environment, the correct use of the sensors in coding makes it necessary to understand how the sensors communicate with the Micro:bit. The following unit will illustrate how students can acquire the knowledge about how the Micro:bit displays changes in its surroundings which can later be used in easy programming exercises.

Factors for good exercises

In order to make use of students' full potential, one should choose problems that refer to everyday problems from the students' life (Löffler, 1991; Möller et al., 2014; Schönknecht & Maier, 2012; Schwelle et al., 2013). Thus, students are able to use domain specific prior knowledge. Domain specific prior knowledge is known to be a key-factor for being able to comprehend problems and find solutions for them.

Choosing every day problems also helps to show to the students that digital technology is part of our everyday life and something that is easy to understand and replicate.

Further, problems should be chosen that can be solved with the Micro:bit and as little additional technology as possible. Thus, exercises can be simulated within the website or can be used in real life without any additional costs or the need for electronics-skills. For this, the inputs should be corresponding to the Micro:bit-sensors: temperature, light, magnetic field, tilt or button-press. This has the advantage that students will also learn to see their everyday life from a programmers perspective, as they have to think which sensors will fit a problem best.

As output, again the Micro:bit should be enough. However, the only output that can be used without any additional electronic parts, is the 5x5 LED-panel. However, this can be used to write text, display numbers, show simple icons, display bars, or to turn light on and off.

The problem for an introduction-problem

Usually, students are familiar with automatic lights that turn themselves on when it is dark and turn themselves off, once it is light again. This can easily be replicated on a Micro:bit. This problem fulfills all requirements for a good exercise, as it refers to an everyday problem, it uses only sensors that are already on the Micro:bit and uses only the LED-panel as output. The unit is divided into several phases that will be explained in detail in the following:

First phase: Getting to know the sensor

In order to solve the problem with the automatic light, the students need to know how the relevant sensor functions. Students should acquire this knowledge by an activity. Fort hat activity the main aim ist he comprehension of how the Micro:bit displays the values of the light sensor. This understanding is important, as the lightvalues will later be needed to create the code for the lamp that turns on and off according to the degree of darkness and light.

For this activity the students should work in groups. If possible, every group should receive one Micro:bit. Group sizes between 2 and 6 students have proven to be very effective. If not Micro:bit is available, the exercise can be done on the webpage as well, as the light sensor values can be simulated there as well.

As a preparation, the following code must be put on the Micro:bit. This needs to be prepared by the teacher. At this point, the students are not yet skilled enough to do this task. The main goal of this task for the students is the understanding of the light sensor values.

Several options are available to get the code onto the Micro:bit.

Option 1:

The code can be downloaded from the following link:

https://makecode.microbit.org/_K6DHXHMK6aAv

Image 5: QR-Code to download the program to use the lightsensor

Option 2:

For option two, the following text needs to be copied and entered into the Makecode editor. To do that, "JavaScript" has to be clicked on the top of the Editor first.

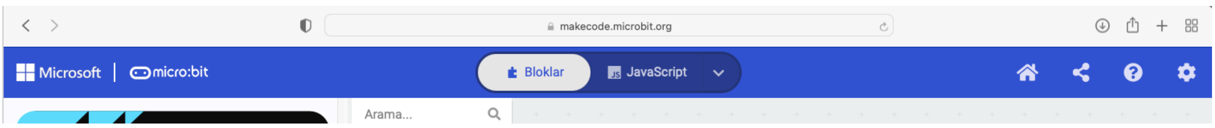

Image 6: How to change the Makecode editor to JavaScript

One can change between blocks and text easily. While we recommend strongly that students should only use Blocks in the beginning, it can be easier for teachers to use the JavaScript to enter code with copy and paste.

```
let Lightsensor = 0
basic.forever(function () {
if (input.buttonIsPressed(Button.A)) {
Lightsensor = input.lightLevel()
for (let index = 0; index < 3; index++) {
basic.showString("" + (Lightsensor))
}
Lightsensor = 0
}
basic.showString("" + (Lightsensor))
})
```

Option 3:

If one decides to code the program with blocks, the following picture shows, how the blocks need to be arranged.

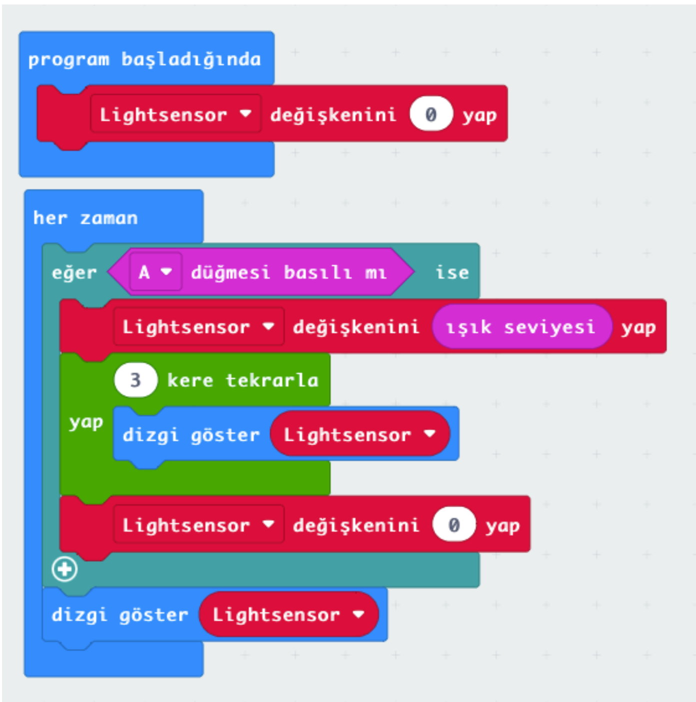

Image 7: Code for the lightsensor as blocks in the Makecode editor

To replicate the code in the picture, it is necessary to add another step. The block Lightsensor has to be created in the menu "Değişkenler" first. Then the blocks can be used as shown in the Picture. The program reads the lightsensor when the button A is pressed. This reading will be shown for three times. Afterwards, the value will be reset to "0".

Now the students have to go through the room with their Micro:bit and try to find places that are very bright, very dark, and everything between light and dark. The students will write down in their report card where they measured the lightvalue and the lightvalue that they measured.

They should find out that very dark places have very low numbers – as low as 0 for total darkness. Very light places have values going towards 254, if places are very bright. The students should use a table such as Image 4. The results should be discussed after the students found enough light values.

nerede						
kaç						

Image 8: With a table like this, or similar, the students should walk through the classrooum and should try to find places very dark, very bright and values inbetween.

The Lightsensible Light

In order to write a program on the Micro:bit that will simulate a lamp that reacts to light and dark, the students are first asked to describe how such a lamp works. For this, the teacher shows the students the Micro:bit with the program on it. The students are asked to describe what they see. The program to be used can be transferred on the Micro:bit as described earlier.

1 Option:

The following link and QR-code link to the download of the program.

https://makecode.microbit.org/_cjC7HrAyqRTE

Image 9: QR-code to download the program for the lightsensitive lamp

2 Option:

The following code has to be copied into the JavaScript Editor of the Makecode-editor.

```
basic.forever(function () {
if (input.lightLevel() < 80) {
basic.showLeds(`
# # # # #
# # # # #
# # # # #
```

```
# # # # #
# # # # #
`)
}
if (input.lightLevel() > 80) {
basic.showLeds(`
. . . . .
. . . . .
. . . . .
. . . . .
. . . . .
`)
}
})
```

3 Option:

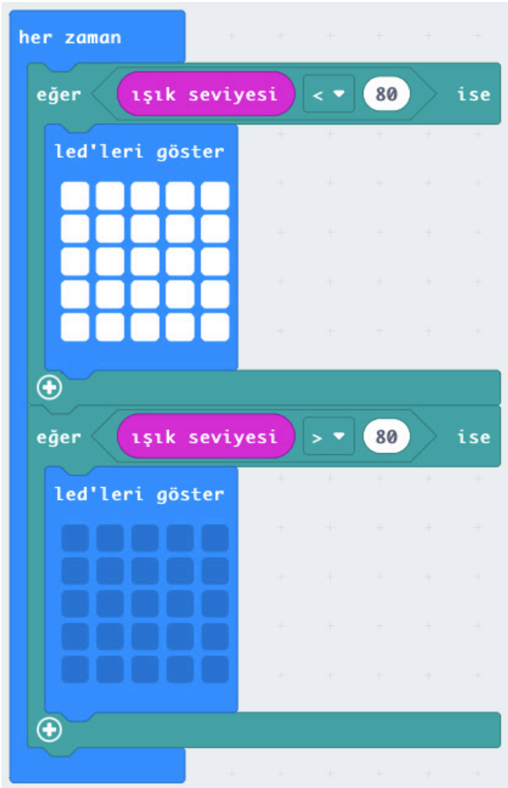

Image 10: Code for the automatic light as blocks in the Makecode editor

The description has to be made in everyday language. This part is very important. Usually students come up with at least half of the function and describe something like" When it is getting dark, the light will turn on". Often, it has been observed by one of the authors that students forget the second part of the function: "When it is getting light, the lamp turns itself of".

The teacher then writes the two sentences on the board:

"When it gets dark, the Micro:bit turns on the light."

"When it gets light, the Micro:bit turns off the light."

For this, it is important that the grammatical structure with "eğer" is used, as this wil later be transformed into a part of the code.

These sentences are usually not a problem for students to explain. From there it is not hard to come up with the actual code.

First, the teacher should explain to the students that the Micro:bit does not understand human language and some of the words have to be translated into Micro:bit language. Here, the first exercise is used. With the table that the students have created about the readings of the lightsensor, the teacher can ask them: "How can we tell the Micro:bit that it should turn on the light?"

Students can check their findings from before and argue that a value somewhere between 40 and 80 is a good value for "when it gets dark".

Thus, the first sentence changes:

"When the lightvalue is smaller than 80, the Micro:bit turns on the light".

The teacher repeats the same with the second sentence. This time, the sentence changes to:

"When the lightvalue is bigger than 80, the Micro:bit turns off the light".

Thus, the students can see that a computer program is basically the same as what they said, just with other "words".

Next, the teacher asks the students, how the light can be turned on and off. The students should explain that all LEDs should be turned on and off.

The sentences will change to:

If the light is lower than 80, turn on all LEDs.

If the light is higher than 80, turn off all LEDs.

At this point, the students are ready to try that on the computer. Within the programming page, nothing can be broken. The blocks are intuitive and fit into each other. Thus, the students can explore where they can find the appropriate blocks for their program and simulate it. As help, the teacher can show the proper code and ask students to replicate it.

To get more familiar with the editor, the teacher can ask the students to

a) Change the values of light to higher or lower values.

b) Ask the students to change the LEDs to other forms or images.

c) If the Micro:bit is facing East (90°), turn on the LEDs. If it is facing West (270°), turn them off.

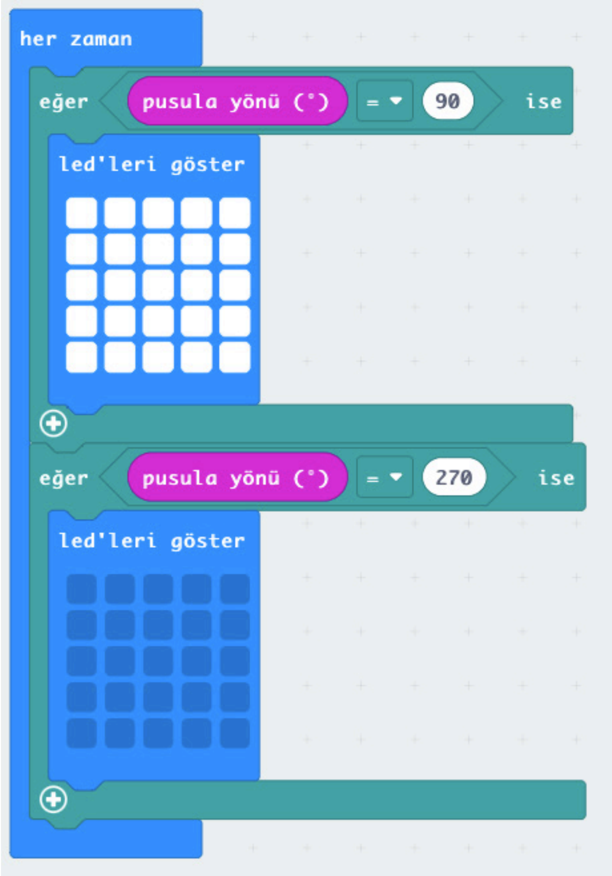

Image 11: Code for the compass sensor as blocks in the Makecode editor

At the end, the students should understand that coding is not a mystery. They should understand that the computer talks "with different expressions" than humans do. However, telling a computer what to do is not different from explaining something to a person. If one wants to continue to program, one needs to learn how the computer "talks" and then this knowledge can be used to solve problems. Without the experiment about the lightsensor, the lightsensitve lamp cannot be programmed.

For further exercises, similar lessons should be held for additional inputs and outputs of the Micro:bit, such as the gyro-sensor, the pins at the bottom of the Micro:bit or the temperature sensor.

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Case studies of innovative learning pathways to STEM

Panagiota Argyri[1]

Abstract

Teacher participation in European digital communities for the use of digital resources, tools, innovative teaching and learning practices is an important form of professional development. Scientix is the number one community for science education in Europe and it aims to promote and support a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other educational stakeholders to inspire students to pursue careers in the field of Science, Technology, Engineering and Mathematics (STEM). In this paper, analyzed case studies of creation and dissemination of educational learning scenarios, through the participation to the projects of the Scientix repository. The case studies include interdisciplinary teaching approaches for STEM lessons and based on the connection of the cognitive areas of the science courses and functions as a bridge for the connection of their knowledge (school) with the study of real problems (society). A key feature is the assumption of multiple roles by students with the aim of multifaceted development of their personality and skills required by modern social reality. The context of education for sustainable development is characterized by holistic pedagogy, which on the one hand incorporates critical issues, but also aims to cultivate the basic skills of cooperation, communication and critical thinking, the adoption of values and approaches to addressing global challenges. The main goal is on the one hand to increase students 'interest in science, for its role, on how it affects daily life and, on the other hand, to stimulate teachers' motivation in innovative teaching methods, in order to enrich and renew the curriculum.

Keywords: Scientix repository; educational learning scenarios; skills.

Introduction

Scientix (www.scientix.eu/) is the number one community for science education in Europe. It aims to promote and support a Europe-wide collaboration among STEM teachers, education researchers, policymakers and other educational stakeholders to inspire students to pursue careers in the field of Science, Technology, Engineering and Mathematics (STEM).

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The main stakeholders of Scientix are teachers, researchers and project managers in STEM education, and policymakers. Each of these groups can benefit from Scientix activities and events.

Teachers:

- Browse through the Scientix resources repository and find inspiration for your classes
- Get involved in European STEM education projects via our matching tool
- Participate in national and European workshops and professional development courses

Theoretical Framework

While the number of science and technology graduates continues to decline, recent reports estimate the need for a high number of scientists and researchers in Europe (European Union, 2015). A plethora of sources has provided evidence that European industries are having difficulty finding skilled workers, causing the so-called "STEM skills gap". Youth education should equip them with the capabilities and skills to adapt and respond to the changes of today's world, characterized by new levels of complexity and contradiction. This requirement is in line with UNESCO's publication on the re-examination of learning and education. Efforts to reduce the distance between science and society are also dictated by the European Union Program for Research and Innovation 2014-2020. The implementation of research topics to raise awareness and motivate students to explore aspects of society where science can play a crucial role can balance the challenges faced by students when they pursue their professional careers. The interdisciplinary linking and application of the cognitive subjects of the curriculum's positive curriculum to the real world is a challenge for the preparation of the new generation of scientific researchers.

Technology is an integral part of their teaching and learning, supporting the dynamic forms of representations for linking concepts to science lessons (diSessa, 2007; Heid & Blume, 2008; Kaput, Hegedus, & Lesh, 2007). In the case that the interdisciplinary approach to concepts is combined with discovery learning (Kelly, Lesh, & Baek, 2008; English et al., 2008), then there are all the prerequisites that help to deepen understanding, extend and implement new knowledge. Technology plays an important role in the development of the educational process (Gursul and Keser, 2009). The inclusion of Information and Communication Technologies (ICT) in science teaching can stimulate students' curiosity and encourage them to develop strategies to solve their problems. For teachers, the use of ICT can improve their effectiveness by giving them time to tackle students individually in order to mobilize them in new ways of approaching learning.

Inquiry Based Science Education (IBSE) is a pedagogical strategy based on the student's physical curiosity, which is the power that leads to the understanding of knowledge. Learning is organized around questions and problems in a highly learner-centered environment. Students gain knowledge through questions, assumptions, experiments, observations and analyzes, not through frontal teachings and exposure of knowledge by teachers and sterile memorization by students (Sotiriou et al., 2012).

The interdisciplinary linking and application of the cognitive subjects of the curriculum's positive curriculum to the real world is a challenge for the preparation of the new generation of scientific researchers. Students are invited to take up the role of scientist and study climate change based on the scientific knowledge they have been assigned to. Their research includes the collection of scientific data and elements that capture the changes in the environment, modeling the causes of the phenomenon, exploring through simulations, and analyzing the graphs of the phenomena associated with the variables. The cultivation of scientific skills and critical thinking is accompanied by cooperation among the members of the group, as they discuss the results, to come to conclusions and together as responsible citizens of society, take initiatives and propose solutions for the protection of the planet.

The objectives of the Curriculum for Mathematics in Compulsory Education are characterized by the fact that the student should (a) analyze, interpret and intervene in his / her social environment, using mathematics as a tool and (b) analyze and interpret the way in which mathematics for decision making in the social environment (Pedagogical Institute in the context of the implementation of the "New School, 21st Century School - New Curriculum). Education, learning and teaching is a collaboration inside and outside the school that prepares students to make conscious and substantiated choices about the future of society.

Additionally, we live in an era characterized by the rapid development of technology. Computer science has invaded the educational process and offers us many opportunities that we can take advantage of. On the other hand, an additional challenge faced by STEM teachers is the integration of IBSL in teaching. Whilst the use of ICT has penetrated the teaching process and research-based learning, we need to create and implement STEM courses that promote the cultivation of methodological skills and competences, experimental research, teamwork and communication between students through cooperative activities.

In recent years, IBSE has demonstrated its effectiveness in school education, extending its "traditional" frontal teaching and encouraging pupils to participate actively in the realization of science (Rocard, 2007). IBSL methods receive support through hardware and software technology. Digital technologies can support the necessary educational innovations and become the catalyst for changing the way the learning process (form, space, functions, services, tools, roles, processes) (Sampson, 2010). According to the requirements, virtual laboratory environments are a basic digital tool, which many European schools have computer classes, tabs and high-speed Internet connections using a huge variety of web-based learning applications, simulations and visualizations (Dikke et al., 2015).

The mobilization of interest in the science of science and the professional orientation of young people (regardless of gender) towards the fields of science, technology, engineering and mathematics is in keeping with the current needs of the European area.

The incentive and motivation to design the educational practice linking the STEM professions to climate change was to participate in the pan-European campaign through European educational projects aimed at enhancing industry-education co-operation at national level in all Member States of the European Union, with the aim of promoting the attractiveness and importance of STEM studies and professions, as well as the introduction of innovation in the teaching of positive studies. Considering the lack of STEM professionals at all levels but also gender equality in STEM scientific careers, studying the phenomenon of climate change is characterized by interdisciplinarity, connecting knowledge to the real world, scientific exploration, innovation, flexibility and adaptability to all science courses and the promotion of the basic principles of "Citizenship". Students "take science into their hands", and recognize their role and importance. They communicate their results locally (in the school environment they encourage their classmates in a creative way in the STEM professional orientation, through posted announcements) at national and international level.

Case Studies of Inquiry Learning Scenarios (ILS)

Title: Can Scientists collaborate for climate change? (https://www.golabz.eu/ils/can-scientists-colloborate-for-climate-change). This ILS refer on the environmental problem of global climate change. Students study and learn for causes, consequences and ways to address the problem. They could also take a role of scientist and investigate climate change by different aspects.

Orienting & Asking Questions phase: The main objective of this phase is to mobilize interest, orientation and awareness of students of the subject of climate change. Students are called to discuss about disturbing effects on the environment as listed on images and presented in a video, recall information on the phenomena captured by the media and the internet and exchange their views.

Research questions to students: Can you present evidences that the Earth signs signal of danger?

Hypothesis Generation & Design phase students: The main object of this phase is to support students make hypotheses of effects on the temperature during the increase of pollution gases and the change of temperature reduction of the heat emitted from the Earth.

Based on global maps of GISS Surface Temperature Analysis (https://data.giss.nasa.gov/gistemp/ ; https://data.giss.nasa.gov/gistemp/maps/index_v4.html), (GISTEMP Team, 2020; Lenssen et.al, 2019) create a table with the differences in the average global temperature from 1800 until today.

Based on simulation of the greenhouse effect

(http://phet.colorado.edu/en/simulation/legacy/greenhouse) experiment, observe and inquire:

- How the concentration of pollution gases from the ice age until today has changed.
- How the concentration of greenhouse gases has changed.
- How the temperature varies in relation to the increase of polluting gases.
- In the experiment, students add clouds and repeat the investigations of what differences are recorded in the direction of the photons and in the temperature.
- In the second part, they record an investigation in relation to the temperature and the visible and infrared radiation as they will add successive layers of glass.

In the planning and investigation phase: Students use the digital tool of the climate model https://scied.ucar.edu/simple-climate-model and develop and test their hypotheses. They change the value of the model variables, read and interpret graphs of data, understand how the rate of carbon dioxide emissions relates to the climate change.

In the analysis & interpretation phase: students analyse how the greenhouse effect is linked to the production of electricity. The electric energy is often produced from coal. When chemicals are burned, the greenhouse gases emitted contribute to air pollution and global warming.

Using the simulation game http://www.kineticcity.com/mindgames/enervia/ students learn about sources and energy management as a solution for the reduction of pollution gases and protect the planet from the climate change effects.

In the conclusion & evaluation phase: Students discuss with their classmates how we can contribute to protect the environment and especially to reduce the environmental impacts of climate change using the digital tool of the ecological house http://www.wwf.gr/footprint/

Additionally, students create a presentation that describes to their classmates of their school the causes and consequences of the phenomenon of climate change and an article for the school newspaper, in which they call the others to participate in the campaign to protect the planet from global warming and climate change.

Title: Creative colors of climate change Cool colors sign the dangers & Warm colors suggest solutions

http://portal.opendiscoveryspace.eu/en/community/creative-colors-climate-change-cool-colors-sign-dangers-warm-colors-suggest-solutions

With this demonstrator students are invited to take up the role of a scientist and study climate change based on the scientific knowledge they have been assigned to. Their research includes the collection of scientific data and elements that capture the changes in the environment, modeling the causes of the phenomenon, exploring through simulations, and analyzing the graphs of the phenomena associated with the variables. The cultivation of scientific skills and critical thinking is accompanied by cooperation among the members of the group, as they discuss the results, to come to conclusions and together as responsible citizens of society, take initiatives and propose solutions for the protection of the planet. Students are invited to take on the role of a scientist (http://bit.do/concept_map_lesson_plan) depending on their inclinations by thematic field of science) and to link their knowledge to study the causes, consequences and ways of tackling the phenomenon of climate change. The methodological scientific inquiry consists of the following stages:

- Search for sources (Greek and foreign literature) for the collection of scientific data and information (temperature maps, satellite images and pictures, data tables, temperature, sea, ice, etc.) recording changes to the planet as reflected by the climate change phenomenon (http://bit.do/worksheets_of_students).

- They use digital tools and simulations to process climate-related data / variables related to climate change (on-line interactive computer models). Through mathematical modeling, they cultivate and develop mathematical data processing and analysis skills, through mathematical graphs and algebraic calculations (http://bit.do/graphical_representations).

Each student has a crucial and important role as the geologist maps the climate change, the chemist studies the effect of carbon dioxide gases, the oceanographer effects the phenomenon at sea level, the natural energy changes in the atmosphere, the mathematical analyzer through modeling attempts to predict impacts in the coming years and the environmental analyst analyzes the consequences. Together they analyze the carbon dioxide emission link with electricity (http://electricitymap.tmrow.co/) and look for alternative energy-saving ways.

Title: Mathematical Approach Covid-19 Into Global Community

https://www.golabz.eu/ils/mathematical-aproach-covid-19-into-global-community

The purpose of this ILS is to develop mathematical knowledge to help students understand how a virus / infectious disease is spreading within a population.

Throughout this lesson it is justified on the basis of mathematics how important preventive measures are. Mathematics confirms the measures of individual and social responsibility that we all must adhere to. Mathematical modeling (algebraic and graphical) combined with the statistical processing of global data is an important mathematical tool of the world community for non-spread measures.

This lesson answers the questions:

- How does a virus spread through a population?
- What factors and how do they affect the speed and range of propagation?

The creation of mathematical models is a process with many limitations and can in no way replace the natural evolution of diseases, epidemics or the evolution of a population. This lesson is a starting point for understanding real situations with the help of mathematical tools (functions).

Results

The implementation of these case studies provides:

-The development of innovative ways of connecting the school to modern social reality.

-Participation of students and teachers in the promotion and implementation of research and innovation in the sustainable interaction between science and society.

-Building an effective collaboration between science and society to link student excellence to social consciousness and accountability.

-The development of issues related to research and innovation, where science and technology can play a key role

In the context of the ILS the general skill targets under consideration are:

-Active participation in the negotiation of scientific concepts

-Development of creative and critical skills

-Understanding scientific concepts and phenomena

-Developing a spirit of collaboration and teamwork

-Investigating their scientific knowledge on the phenomenon of climate change.

-The development of critical / analytical thinking skills.

-Participation in the analysis of scientific data.

-Combining different subject areas and supporting their results.

To achieve these goals, regional objectives are formulated to meet the needs of students:

-Develop the skills needed to carry out scientific research

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Theoretical and Practical Inquiry of the Practice of Philosophy for Children (P4C) structured around Questioning of Moral Education

Sümeyye Sel Odabaş[1], *Nihal Petek Boyacı*[2]

Abstract

Philosophy represents the opportunity to wonder and opportunity to question the ideas, knowledge and values affirmed in the state of things, and our relationship to those affirmations. And also, philosophy opens the spaces of education so that its subjects can ask and wonder about the world they inhabit in such a way that, through the experience of philosophy, these subjects can no longer think in the same way before philosophizing. Philosophizing does not aim at imposing a new point of view as of childhood, instead intends to stimulate students to think on an argument through their own reasoning and helps them redesign an opinion in cooperation. This work will focus on two intertwined sets of topics for approaching better to moral education: theoretical and practical inquiry

1. Theoretical inquiry includes argumentation, conceptualization and questioning. In a practice of philosophy for children workshop, arguments are produced, criticized and analyzed. What matters is to enhance our capacities of listening and understanding and to become eager to learn and research through using our minds. In this respect, practice of philosophy adopts the principle of pursuing the truth rather than being right by questioning and creating new concepts.
2. Practical Inquiry includes philosophizing with philosophical text of Thierry Dedieu's "Yakouba" comprising as a part of philosophizing tool for a moral dilemma and rethinking of virtue of courage. Also, a pedagogical sheet prepared in conformity with the methods of philosophizing which are conceptualization, questioning and argumentation is considered as a part of practical inquiry of moral education.

Keywords: Philosophy for children (P4C); moral education; theoretical inquiry; practical Inquiry

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Introduction

This work is divided into two parts: theoretical and practical inquiry structured around questioning of moral education. Theoretical Inquiry and Practical Inquiry of Moral Education is related to human development in which cognitive, emotional and moral skills are intertwined. Lipmanian moral approach about human development is not only related to cognitive side but also character-building and emotional liberation. That's why, listening and understanding the other are so important in philosophy workshop. In the workshop, encouraging students to think starting from their own questions represents moral education model of M. Lipman. In the theoretical context, our focus will be on the connection between Nussbaum's moral education system and M. Lipman's vision in the context of P4C practice and Mathew Lipman's Moral Education Model. In the practical context, our focus will be on an example of philosophy workshop with famous book of Thierry Dedieu that is Yakouba.

For approaching better moral education, we have to focus on the origins of actual crisis in education. For American Philosopher M. Nussbaum, a profound crisis in education that faces us today although we haven't yet faced it. In this context, I want to start with a quotation from Nussbaum:

"You can see clearly how a band of docile engineers can be turned into a murderous force to enact the most horrendously racist and anti-democratic policies and yet how can we avoid going his flaws in reasoning to parochialism, peer pressure, authority and great selfishness."

For solving these kind of problems, Nussbaum suggests a new education system based on encouraging man's moral balance and his human side. Her education model depends on human development by critical thinking and philosophy is a tool for human development in this education model. And also, Nussbaum's education model includes inter-subjectivity, listening the other and understanding the emotion of others.

M. Lipman's P4C pedagogy shows the influence of Nussbaum's education system based mainly on human development and based on critical thinking by listening and understanding the other. According to M. Lipman's P4C pedagogy, each child is an individual and each child is part of the class. As an individual the child is distinctive, and can develop his or her unique powers in terms of the roles to be played in the group. Every child in the classroom should make a difference. The teacher's role is to ensure that each child feels that he or she has the capacity to make a difference and each day acts on that presupposition. Lipman says in his book "Philosophy in the classroom": Teachers must ask themselves regarding each child in the classroom: "Would the absence of this child make a distinguishable difference in the classroom? If the answer is "no," then something is definitely wrong with the way that the teacher has conceived his teaching role in relation to that child.

Teacher has to encourage child to be an active seeker of his or her own uniqueness, an active harmonizer of his or her own powers, an active creator of his or her own contributions to the class group.

Theoretical Context of STEM Activity

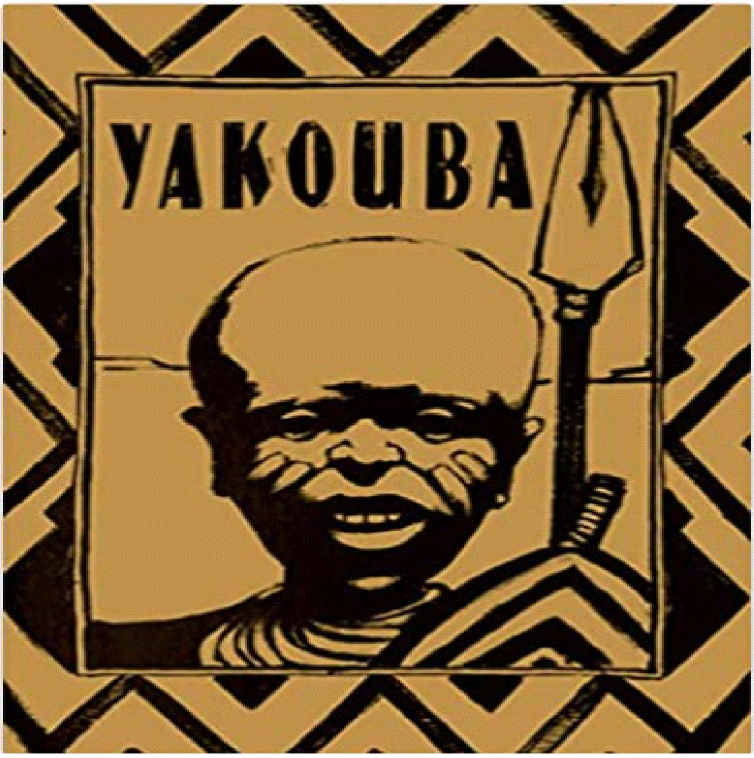
According to P4C pedagogy of M. Lipman, there are purely cognitive approaches and also there are purely character based approaches in moral education. Still others interpret the child as being naturally virtuous, so that good behavior will naturally ensue if only the emotions are unthawed and unrepressed and sensitivity to others heightened. Each of these approaches has a degree of validity. There is an element of reasoning in moral education, as there is an element of character-building, and as there is an element of emotional liberation and sensitivity training.

For Lipman, the problem is to consider that cognitive approaches, character based approaches and emotional approaches are independent from one another in moral education program. Lipman tries to unite all of them by thinking, by trying to understand the emotions of the others and by developing capacity of empathy and sympathy in the philosophy workshop of P4C pedagogy.

In the discussion of philosophy workshop with children we criticize, we argue, we conceptualize, we analyze the hypotheses, we listen to ourselves and we are open to criticism and to the arguments of others.

STEM Activity

Firstly audio book version of *Yakouba* (Audio Book Version: https://www.youtube.com/watch?v=2GKKE2N9pYE&ab_channel=Aport%C3%A9edevoix) is watched. This book is useful for showing an example of philosophy workshop related to moral education for high school level. And also, this book lets students to find their sensitive part starting from their own questions.



Book "Yakouba" tells:

In a small town in the heart of Africa, a big feast was being prepared. This was a feast day. Faces were painted and decorated. This was a holy day. The adult clan gathered together and will determine the children who are in the age of becoming warrior. It's a big day for Yakouba. He is eager to prove his courage by meeting the lion as alone. Go under the scorching sun, cross the valleys, the hills, feel the rocks, inevitably the grass, of course the wind, do all these things with very little water. Work day and night quietly; forget the fear that surrounds him. Wait for hours and then suddenly ...His weapon gives him the courage to fight in a hurry. Then Yakouba looked into the eyes of lion. This was deep look. He could read from the eyes of lion that: "As you saw, I am injured. I fought all night against a fierce rival. So you will have no problem to come the end. Either you kill me without force and become a man of warrior in the eyes of your tribe, or you save me alive, grow in your own eyes, but you are excluded from your tribu, you have a night to think about all these things. Early in the morning Yakouba looked at the eyes of lion one last time

Category	Book
Title	Yakouba: Thierry Dedieu
Level	High School
Age	15 years old +
Theme	Sagacity
Main Idea	Rethinking the virtue of courage is necessary.
Open-ended Questions	
1	What is necessary for becoming warrior in the eyes of Yakouba's tribe? What would Yakouba do to lion injured?
2	Why did not Yakouba kill the lion?
Targeted Behaviour	Conscience of A man of wisdom
Book Recommendation	Ethical Inquiry: Instructional Manual to Accompany, Mathew Lipman
	Activity If you were Yakouba, what would you do? Write down a paragraph.

For creating a discussion related to moral education and for giving some suggestions, we can read out the book till the sentence: *"Early in the morning Yakouba looked at the eyes of lion one last time"*. Each and every student is asked the questions below by taking some pauses while reading out. Each answer received from students might lay a suitable ground for making justifications, conceptualization, thus arousing new questions. It is so important to find their own questions.

1. What will Yakouba do? He will kill the injured lion or not? If Yes, Why? If No, Why?
2. What is the courage? Being warrior in the eyes of your tribe or being grown in your own eyes? Which one is the best for you?

    - Students can start to think and to criticize starting from these questions. After that, we can read out the following part of the book:

He saved the exhausted lion alive and turned back. The men in the village, his father, were all waiting for him. Yakouba was there with great silence. His friends became warriors. Yakouba took care of the herd of the village, it was at just about that time that the cattle were never attacked by lions again.

- Student start to ask their own questions like this: if Yakouba killed the injured lion not knowingly what it would be? (It is so important to find their own questions.)

For conceptual argumentation, the teacher (facilitator) can ask: what is action knowingly? And also teacher can ask student to give an example…

- Action knowingly (there is an association searching someone who helps the refugees for rebuilding their lives. There is a person who is searching a work for just earning money. Suddenly, this association and this person meet by accident. If this person is accepted as a member of this association, his action rebuilding lives of refugees will not be knowingly because the main intention of person searching a job is not to help the refugees for rebuilding their lives but earning money. That's why his action is not knowingly.

- Teacher can ask: Do you want to say for being brave one, Yakouba has to kill injured lion knowingly?
- According to the answer of student, the teacher can ask the other open ended question for encouraging the student to find their own questions.
- The students should not be forced to give this or that answer. The important thing here is to develop thinking and to try to find contradictions about what the students said, starting from themselves. In addition, the students can be deepened for the purpose of conceptual enrichment.
- After reading out the following part of book, another question can be: Yakouba did not kill the injured lion. Why?
- For being winner of the village where the cattle were never attacked by lions again or for just not killing? (their own questions)
- Teacher asks: can we say instead of for just not killing, for its own sake?
- Students says: Yes. Teacher can ask: What's the meaning of «for its own sake»? Also teacher asks to give an example about it…
- Action for its own sake (in Turkey, refugees are everywhere, when I asked someone, why are you helping the refugee? The response: I'm helping because I can face the same situation, this action is not for its own sake, and this action is for not facing the same situation. For being brave, person must be just for being brave not for another thing. No credit for brave one)
- Another question of students can be: If Yakouba regretted not having killed the injured lion, would he still be considered as brave one?
- Another student can say: brave one's action must be from firm and unchanging disposition, today I'm brave, but tomorrow not, no credit for brave one.
- Another student can say: If Yakouba stands firm against situations not considering him as warrior and does not find it painful, he is brave. But if he finds it painful he is cowardly. Teacher can ask in this case, is it always true? For opening mind of the student

All these reflections encourage the students to create their own questions including their arguments and their concepts for moral education related to human development in which cognitive, emotional and moral skills are intertwined. Listening and understanding the arguments and concept of reflections of each student is the crucial point of human development and moral education.

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How Ready are Teachers to Use Active Methods, Digital Tools and Gamification Techniques in Class – the ClimaTEPD Approach

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Abstract

Teaching about climate change in secondary school education is both complex and demanding for in-service teachers. The climate change education (CCE) should prepare the new generations to pro-actively deal with open-ended problems, employ digital technologies and investigate complicated cause-effect dependencies searching for interdisciplinary solutions. Moreover, the combination of STEM and social science approaches can improve the ways to research climate issues. Therefore, this paper aims at investigating the teachers' readiness and attitudes to use active methods and inquiry-based learning scenarios (IBL), game-based learning and digital tools in the field of climate change. The study is part of the ClimaTEPD Erasmus+ project for in-service teachers' professional development in the field of climate change education. The paper starts with a short overview of the concepts of learning experience design, covering active-learning methodologies, game-based learning and digital tools. Next, it presents the 25 IBL scenarios topics to take part in the ClimaTEPD teacher training. Further, the survey methodology is outlined, followed by analysis and discussion of the teachers' attitudes, experiences and preferences for adopting CCE scenarios in partner countries. At the end, the next step for the ClimaTEPD project implementation is presented.

Keywords: Active learning methods, learning experience design, inquiry-based learning, gamification, digital technologies, climate change educational scenarios

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Introduction

Teaching about climate change in schools still remains a challenging task. Climate change education (CCE) goes beyond the subject-oriented curriculum and often requires interdisciplinary approaches, combining methods from both STEM and social science disciplines. Furthermore, climate change issues cannot be "fixed" and immediately solved as new data and evidence emerge constantly, requiring dynamic adaptation and re-evaluation of real-life processes. This creates additional difficulties for teachers, as CCE is hard to be introduced in school curriculum with traditional teaching methods. Moreover, it has to be organized as an experience-based active learning, covering interdisciplinary, project-oriented, group activity and STEM-oriented scenarios. However, design and implementation of active learning scenarios for the interdisciplinary climate change problem can be a very time-demanding task, requiring teachers' preparation, topic adaptation and coordination with other teachers and stakeholders.

That is why, the present paper aims at investigating the teachers' readiness and attitudes in using active methods and inquiry-based learning scenarios (IBL), game-based learning and digital tools in the field of climate change education. The paper goal is to report the outcomes of the second stage of the ClimaTePD project (https://www.climatepd.eu) implementation, focusing on teachers' feedback and preferences about using active-learning scenarios, digital tools and gamification techniques in their classes. The structure of the current paper includes a short overview of the active-learning methodologies, based on the learning experience design of the ClimaTePD scenario approach, integrating inquiry-based learning, game-based learning and digital tools ; the topics of the 25 IBL scenarios, developed by the ClimaTEPD consortium; the methodology and the steps followed to implement the teachers' survey, followed by the analyses of the empirical results; the discussion part with a summary of the teachers' attitudes and experiences about adapting climate change scenarios in partner countries; as well as, the next steps of the ClimaTEPD project implementation.

Theoretical Framework

Research about CCE best practices across the EU, organized by the ClimaTePD consortium, demonstrated that Climate change education often integrates active-learning, networking, project-based, problem-based and other interdisciplinary learning approaches (Lymperopoulou et al., 2022-IO1). Active learning models proved to be appropriate for introducing CCE in school classes, as they can combine diverse learning techniques, such as inquiry, exploration, group work and collaboration, simulations, STEM research, outdoor learning, debates and brainstorming sessions, flipped classroom, supported by digital and gamification tools. Furthermore, active learning is based on the constructivist theories of learning (Piaget, 2013), which are student-oriented, and step on the student's direct experience while "learning-by-doing" (Dewey, 1933). Therefore, the key characteristics of active learning approaches are the role of student' experience and reflection, combined in the model of learning cycle of Kolb (Kolb, 1984).

Learning experience design (LXD) models gain popularity as an integrative approach for active learning (Wilson, 2005). The LXD shifts the focus from the instruction to attainment of specific learning goals, to construction of a human experience that is meaningful, engaging, and satisfying (Parish & Wilson, 2008). Thus, teachers have to design learning activities, aligned to students' personal motivations, goals, and values and guide them while constructing meaningful understanding (Chang & Kuwata, 2020). To achieve meaningful, engaging, and satisfying learner experience, teachers can use the scenario building model supported by appropriate learning approaches and activities, including learning materials, games and digital technologies (Chang & Kuwata, 2020). The main phases of the LXD process can be enumerated as follows: (1) identify the problem from the learners' perspective; (2) select experience design: select the most appropriate learning approach; (3) propose scenario: design/select scenario for specific learning experience; (4) increase motivation & engagement: select appropriate digital tools and introduce games and game-based learning elements; (5) plan sensory design: select appropriate digital tools, digital systems, print-outs and others to support scenario activities.

Inquiry-based learning (IBL) is among the most popular active-learning approaches, applying the scientific method of hypothesis testing, experimenting, results analysis and evaluation. After almost thirty years of empirical studies, a comprehensive body of both empirical research and meta-analysis studies, collected evidence on the effectiveness of inquiry pedagogies in the development of science learning and the improvement of students' inquiry skills (Chaimala & Kikis-Papadakis, 2019). Furthermore, IBL can be briefly described as a form of active learning where learners develop their own questions to examine, engage in self-directed inquiry (diagnosing problems - formulating hypotheses - identifying variables - collecting data - documenting their work - interpreting and communicating results), and working individually or in groups. The main goal of IBL is to stimulate learners to adopt a critical inquiring mind, critical thinking and problem-solving skills (Slim et al., 2017). The IBL approach can be suitable both to science-related school subjects such as STEM disciplines and to social science subjects (Khalaf et al., 2018), making it appropriate for climate change scenarios. Furthermore, the ClimaTePD approach aims to apply IBL scenarios as a tool to support teachers in developing competences related to: embedding the dimension of climate change into their teaching; using IBL and gamification principles when teaching about climate change and developing digital skills and teaching methods for delivering climate change instruction in face-to-face, online and blended environments.

The IBL scenario approach makes a general framework of the inquiry process, selecting main activities, resources, guidance, questions, tools, reflection discussions and insights. The IBL can integrate up to six phases of the structured inquiry (Paniagua et al., 2018, Fei & Hung, 2016). At each phase, students, working individually or in groups, can develop their own questions to examine and engage in self-directed or instructor-led inquiry. The phases can include diagnosing problems, formulating hypotheses, identifying variables, collecting data, documenting their work, interpreting and communicating results (Chaimala & Kikis-Papadakis, 2019). Also, in the context of developing the ClimaTePD digital scenarios, other innovative teaching approaches can be used, such as storytelling, dilemma and debate in order to address socio-scientific issues (SSI) related to the dimension of climate change in teachers' teaching practices and didactics.

Constructing an active learning experience design (LXD) based on IBL can facilitate teachers to break the learning process into several sub-stages or phases. As presented on figure 1, the teacher can plan and align all relevant activities, materials and digital tools to every phase of the learning process. More specifically, figure 1 presents an IBL scenario in the LXD framework, covering all main six phases of the inquiry model. The model starts with selection of specific learning activities for each phase. Then, figuring out the learners' interests and preferences, teachers can identify the most difficult and challenging phases and describe specific pain points. For each phase, teachers can propose additional support with gamification and engagement techniques. Following the selected activities and gamification techniques, teacher can identify learning materials (hand-outs, presentations, reading notes, video), or digital tools (digital tools such as calculators, spreadsheets, search engines, data bases, interactive videos, digital games and others). Moreover, in this LXD model teachers can apply personalization and individualization strategies, exploring different learning activities, learning materials, gamification models and digital tools.

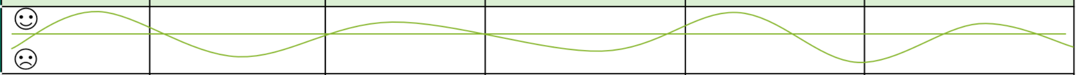
IBL PROCESS	Problem	Operationalization	Data Collection	Data Analysis	Interpretation	Communication
Learning Activities	WoW moment Define problem Discussion	How to… Group work Methods/Tools	Collecting data… Surveys/interviews /search	Data Analysis/ Statistics/ Scenarios/ Relationships	Hypothesis testing	How to present the result? Creativity/Design tasks
Learning Materials	Pptx Video/Game	Handout/Pptx/ Tutorial	Handouts/ Data bases	Handouts/ Presentation	Handouts/ Presentation	Handouts
Digital tools	**Video/PPTx Interactive videos/Games/ Mindmaps**	**Digital Metering Search engine**	**Data bases/ Digital Maps Internet sites Survey tools**	**Spreadsheets/ Statistic Calculators/ Graphics/Tools Mindmaps**	**Spreadsheets/ Statistic Calculators/ Graphics/Tools Mindmaps**	**Videos/ PPTx/Movies/ Web-Site/ Infographics/ Comics/Publisher/Digital books…**
Student Experience						
PAIN POINTS	How to gain interest	Loosing interest in tools/methods to investigate…	Feel lost in data available Critically assess data sources	Feel lost in data analysis/ Lack of skills/understanding how/ why…	Feel lost in data analysis/ Lack of skills/understanding how/ why…	Feel lost in data analysis/ Lack of skills/understanding how/ why…
Games and Gamification	Engaging students	First hand experiences on Draw/Map/Discover	Competition/ Exploration	Tools mastery	Gain context of the research	Competition/ Exploration

Figure 1. The LXD framework, combining IBL, gamification and digital tools.

Combining IBL and active learning approach with the model of learning experience design, the ClimaTePD project partners developed 25 scenarios about climate change teaching using inquiry-based learning (IBL), gamification and digital tools (figure 2).

Bulgarian Scenarios	Greek Scenarios	Spanish Scenarios
Bionic architecture of the future	Can I predict the future of the planet	Energy audit of the school
Vacation on a plastic island? Just bring some bacteria!	Do you have a climate-friendly carbon footprint?	Climate summit
Cataclysm in a bottle	Help climate following a diet low to food waste	Changes in the live cycle of plants
A treasure hunt in the recycle bin	Environmental migrants: Climate forcing people to leave their homes	Fighting the fires
Dress to impress	STEM careers in Climate Change	Intensive livestock farming

Turkish Scenarios	German Scenarios
Green energy is always by my side	Sinking islands
Alternative Energy Sources: Green science	Sustainable mobility
The use of data in Climate change and introducing argumentation.	Fair trade and climate protection
Depletion of the Ozone layer	Climate breakfasts- the impact of food on climate
Climate crises and biodiversity loss	Weather extremes

Figure 2. All 25 ClimaTePD topics scenarios, and 10 selected scenarios (2 for each country).

Study Methodology

An on-line survey was launched during February and March 2022, where project partners invited teachers and relevant stakeholders to choose the best two scenarios per country. With collaborative techniques were selected the 10 most popular IBL scenarios (out of the total 25, as presented on figure 2, in green), to be covered in the ClimaTePD teacher training. Thus, using an on-line survey approach, partners explored teachers' opinions and identified their attitudes regarding the climate change educational scenarios, active learning methods, digital tools and gamification techniques that they use in their classes. In total 90 participants took part in the surveys (33 from Bulgaria, 27 from Spain, 16 from Greece and 14 from Turkey). The survey questionnaires were translated in Bulgarian, Spanish and Greek . The partners used exactly the same survey template in order to directly compare the outcomes. The Turkish partners used a slightly different approach combining a part of the online survey with face-to-face feedback session, and that's why the Turkish outcomes are mostly qualitative. The German partners made selection of the best two scenarios based on direct discussions with their target group and therefore their results are not reported in this study. In sum, based on the teachers' and relevant stakeholders' preferences, the final 10 scenarios selected for the ClimaTePD training implementation are the following: Energy audit of the school & Climate Summit (Spain), Bionics for future architects & Vacation on a plastic island (Bulgaria), Alternative Energy Sources: Green Science & Green Energy is always by my side (Turkey); Can I predict the future of the planet & Do you have a climate-friendly carbon footprint? (Greece); Sustainable mobility & Sinking Islands (Germany) (Fig.2).

Analysis of the Main Outcomes and implications for STEM activities

The survey questionnaire covered three main issues: (1) the selection of the ClimaTePD scenarios for the on-line teacher training, (2) the teachers' and relevant stakeholders' attitudes regarding active learning and IBL, gamification and game-based learning and (3) the possibilities for using digital tools and digital technologies in their classes. The analysis of the collected results as discussed below provided valuable insights for the next steps of the ClimaTePD project implementation.

The first part of the survey introduced shortly the 5 climate change scenarios for each country, focusing on the scenario topics and the activities included. First, the respondents had to distribute every scenario from the first to fifth place based on their personal preferences. Then teachers had to evaluate each scenario based on three criteria: how the scenario fits into the school curriculum , how interesting it is for the students, and how feasible its implementation is in their classes. Using a Likert scale (1 not suitable and 5 very suitable), it is interesting to find that on average all scenarios fit in the school program. The highest average result of 4,3 is for the two Spanish scenarios "Energy Audit of the School" and "Climate Summit" and the lowest average result is 3,25 for the Greek Scenario "Helping climate by reducing the food waste". Next, as most interesting for the students are selected the two scenarios from Bulgaria – "Cataclysm in a bottle" (4,63) and "Treasury hunt in the Recycle bin" (4,60), using mainly practical activities and in-class experiments. The most feasible scenarios are selected: the "Treasury hunt in the Recycle bin" (4,33) and "Energy Audit of the School" (4,2). However, it was interesting to note that even evaluated as interesting and feasible, the scenario "Treasury hunt in the Recycle bin" was not selected among those to be implemented in practice, showing that some practical activities are connected with prejudices and personal preferences from teachers.

The second part of the survey focused on how teachers estimate their professional preparation, knowledge and skills for using active learning methods in class. The question explained that active learning methods can cover inquiry-based learning, experiments, discussions and debates. Then, teachers were asked to evaluate their real experience and practice of using active learning methods in class. Last in the section are put the teachers' attitude and experience of using games and gamification techniques in class. The table 1 makes a summary of the average outcomes from the teachers in Spain, Bulgaria and Greece.

Table 1. Teachers' results about skills and experience using active learning methods in class and gamification.

Teachers	Spain (n = 27)	Bulgaria (n = 33)	Greece (n = 16)
Likert scale 1-min. 5max	Average	Average	Average
How familiar you are in using active learning methods in class	3,8	4,13	3,625
How experienced you are in using active learning methods in class	3,2	3,63	3,563
How used are you to use games or gamification techniques in class?	2,9	3,33	2,563

As demonstrated in the data above, teachers are mostly familiar with active learning methods in class, but their self-assessment of their real experience and practice is much lower. Considering the next question, where teachers can mention which are the most popular games, game-based learning models and gamification techniques that they use in class. In Bulgaria, about 1/3 of all respondents mention some gamification methods, most popular of which are: role playing, simulations and drama techniques; pyramid game, quiz and fast-feedback game, computer games such as Kahoot! and ice-breakers, case studies; crosswords, brainstorming; mind-maps, different types of team and individual competitions. In Spain, the teachers specify role playing, Escape Room, discussions, problem-solving, goals and rules, adaptive challenges, control, feedback, uncertainty, sensorial activities, students designing their own games, adaptations of board games, breakouts, inquiry-based learning, digital games. Among the most popular gamification tools are FlipGrid, EdPuzzle, Kahoot, Quizizz, Blooket, EducaPlay, Classcraft and Minecraft. In Greece, teachers are used to flashcards , quizzes / reward quizzes, individual and group missions and leader-boards, digital games (e.g. ChoiCo), role-playing games, drama and narrative techniques, badges, simulations, group games and crosswords.

The analysis of this section demonstrates that teachers have in general a positive attitude for using active learning methods and games. However, their self-assessment is much lower, considering their practice and experience. Furthermore, teachers mostly prefer using face-to-face games and gamification methods and are still not used to mentioning digital games.

The third part of the questionnaire focused on digital tools. The teachers have to select the most appropriate digital infrastructure that can be used in their class. As shown in Figures 3, 4, and 5 below, teachers in most countries cannot easily use computer classrooms.

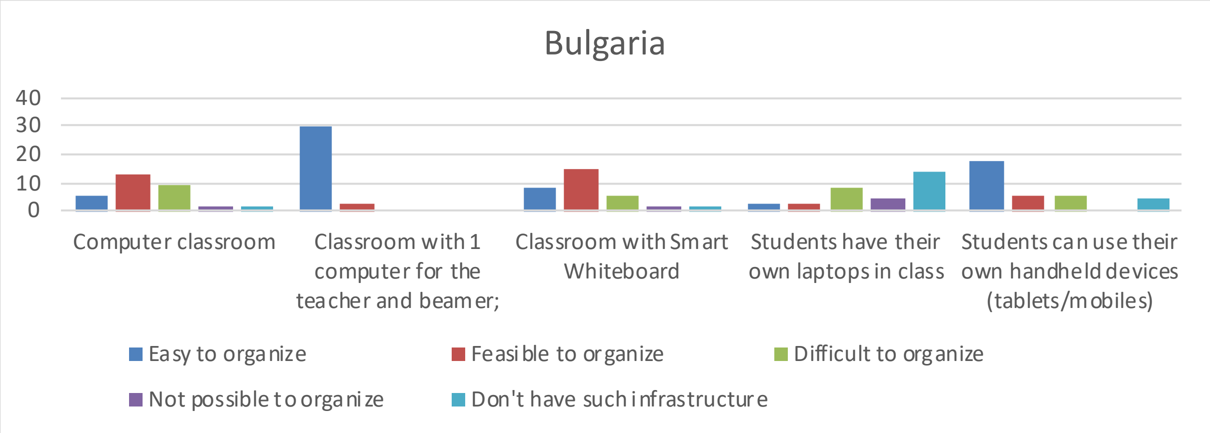


Figure 3. Digital infrastructure, available for organizing active learning in class, Bulgaria

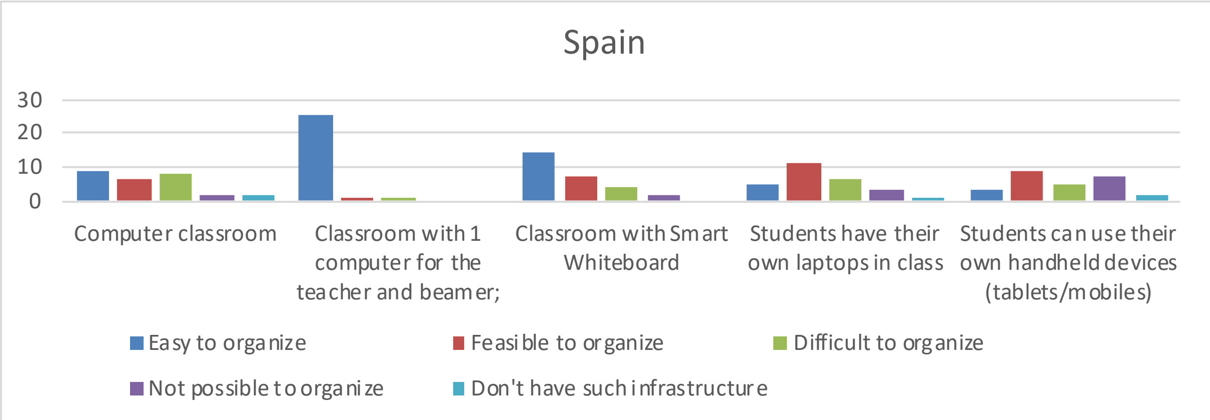


Figure 4. Digital infrastructure, available for organizing active learning in class, Spain

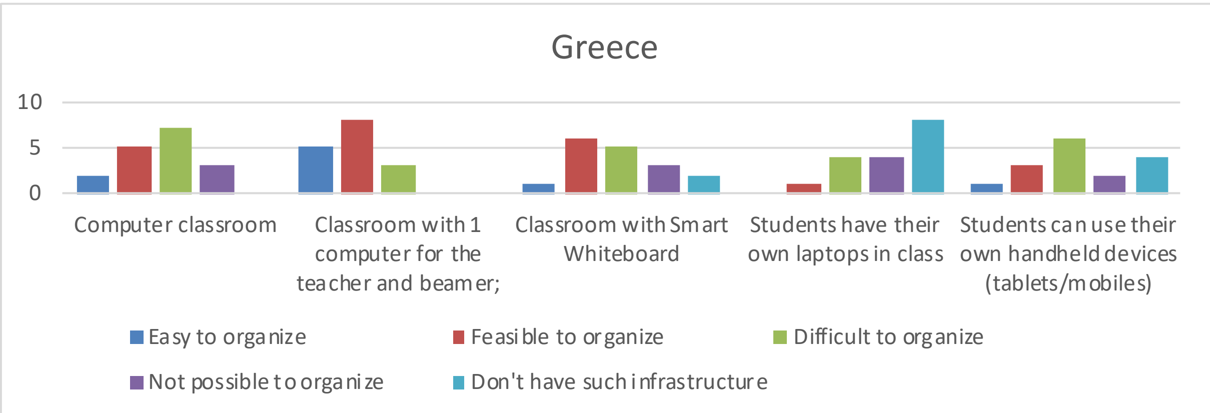


Figure 5. Digital infrastructure, available for organizing active learning in class, Greece

Most of the teachers report that they can use either a classroom with a computer and a projector for the teacher, or a classroom with a smart board. Only in Bulgaria, teachers feel that it is easy to ask students to use their mobile phones in class. In Spain, teachers consider it feasible to ask students to use their own devices (laptops or tablets) for school activities.

This section was very important as most of the teachers need to critically evaluate their digital infrastructure, before testing and implementing scenarios with digital tools. As teachers in most countries cannot easily use computer classrooms, where every student will have access to computers, active learning scenarios should support more flexible approaches considering not only tools, but also digital programs, computer-supported activities, games and others. Another implication is that teachers can easily introduce digital games such as Kahoot! and Mentimeter.com, relying on students to use their own mobiles.

Discussion and Suggestions

The presented research aims at investigating the teachers' readiness and attitudes for using active methods and inquiry-based learning scenarios (IBL), game-based learning and digital tools in the field of climate change education in class. Based on the survey presented above, 90 teachers in ClimaTePD partner countries can successfully integrate climate change education in their classes, considering several factors. First, most of the teachers do not have particular experience and may need additional training and support when organizing teaching with active learning methods and gamification. Second, more flexible approaches should be organized as teachers often do not have access to specific digital infrastructure, and thus alternative software tools and digital solutions should be provided in learning scenarios. Third, teachers have mostly experience in gamification techniques used in class, and thus more role-playing, quizzes and brainstorming group activities can be implemented in the climate change IBL scenarios.

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