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COMMENTARY

A proposal to introduce STEM and educational robotics in kindergarten through an educational scenario for the global food system with resources from Europeana

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Abstract: In recent years, increasing attention has been focused on developing Kindergarten children's acquisition of 21st-century digital skills and competencies. New educational technologies have been created to engage students in computational thinking activities. In addition, the use and teaching of robotics have been increasingly studied in recent years, as research data has shown recommendations and positive outcomes for students and teachers. As global demand for food and non-food products continues to grow, primarily driven by population and income growth, the challenge of addressing resource depletion and climate change is also expected to increase. This intervention aims to present the global food system and food waste phenomenon to toddlers through an educational scenario for kindergarten using educational robotics and STEM methodology.

Keywords: 17 Goals, STEM, educational robotics, Europeana, global food system

1 Introduction

In recent years, increasing attention has focused on developing kindergarten children's acquisition of 21st-century digital skills and competencies (Chaldi & Mantzanidou, 2021; Papadakis & Kalogiannakis, 2019). New educational technologies have engaged students in computational thinking activities (Kapaniaris & Zampetoglou, 2021; Papadakis, 2022). Proponents of creative thinking and problem-solving in education support the need to reform the system in primary and secondary schools to include modern technological educational tools so that students acquire the competencies and skills required in the twenty-first century (Tzagkaraki et al., 2021; Vlasopoulou et al., 2021). In addition, the use and teaching of robotics have been increasingly studied in recent years, as research data have shown practical recommendations and positive results for students and teachers (Tallou, 2022a; Kikilias et al., 2009).

Many researchers have argued that teaching technology – the "T" in STEM (Science, Technology, Engineering and Mathematics) – is vital for young children to meet 21st-century employment standards (Noh & Lee, 2020). When used purposefully and appropriately, technology and interactive media are practical tools to support learning and development (Donohue & Schomburg, 2017). In early childhood, new interactive and intelligent screen technologies create opportunities to enhance young children's development, learning and play (Bers, 2008). Technologies, such as those involving robotics or coding applications, come when the demand for computing jobs around the world is at an all-time high while its supply is at an all-time low (Glezou, 2020). At the same time, researchers and scholars have highlighted the enormous cognitive benefits of introducing Computational Thinking (CT) skills to young children (Bertel et al., 2019; Kalogiannakis & Papadakis, 2017). Children as young as four can learn fundamental computational thinking concepts to support their language, math, cognitive, and social-emotional development (Papadakis et al., 2021).

On the other hand, the environmental degradation of the last decades leads to the need to study how daily activities affect the quality of the environment. Reusing non-harmful waste is considered the best option (linear economies lead to resource depletion). At the same time, it is also a necessary and powerful tool to ensure a fully circular economy (Kasioumi & Stengos, 2022). Lately, environmental economists are also focusing on habit formation models since habits affect how we deal with the environment and the general quality of life (Kasioumi, 2021), which is the essential role of education.

2 Theoretical framework

2.1 STEM in kindergarten

The term "STEM education" refers to teaching and learning in the fields of Science, Technology, Engineering and Mathematics (Martín-Páez et al., 2019). Creative engagement in solution discovery is the best way to discover knowledge. STEM education is essentially an interdisciplinary approach to learning where students combine scientific concepts with authentic everyday life problems, develop STEM science literacy skills and, with it, the ability to be competitive in the new economy (Tsupros et al., 2009).

There is an undeniable connection between early childhood and STEM. Early exposure to STEM, in whatever way it takes place, be it at school, in a museum, in a library, or through play, results in children's overall academic development. Furthermore, it positively affects children's critical thinking and reasoning skills, enhancing later interest in STEM studies and an ideal career (Chesloff, 2013; Tallou, 2022b). Children are born scientists and engineers. STEM education is a good investment in preschool (Figure 1). Research has shown that high-quality early childhood education helps to increase good educational performance in the future, increases participation in Secondary Education by 1/3, admission to higher education by 80% and employment by 23%. Preschool children's natural tendency to explore and build a high-quality learning environment enhances the question in Kindergarten (Chesloff, 2013). Recent neuroscientific research shows that early life experiences are critical in shaping young children's brains (Sripada, 2012). Children's attitudes toward scientific concepts and learning science are substantially shaped in their early years of education, while it becomes difficult to change once children reach adolescence (Archer et al., 2010).

Figure 1 Kindergarten cooking class (STEM)

The social inequality of students swells during the first years of kindergarten and school, and differences are shown between children, especially in the STEM fields, where usually children from low economic strata are in a difficult position compared to other children (Pasnik & Hupert, 2016). The importance of engaging young children with technology and engineering education, educational robotics, and programming is highlighted by the publication of new learning goals and practices for early childhood technology integration (Sullivan et al., 2015). Preschool children must take an active role in learning by participating in research projects, asking questions, gathering, presenting, and presenting data with the help of a skilled teacher who guides the learning experience (Katz, 2010). The literature gradually supports the importance of STEM education at young ages (Torres-Crespo et al., 2014). Research proves the importance of engineering and STEM education in the early years; therefore, it becomes mandatory for future teachers to integrate STEM into educational practice (Bagiati & Evangelou, 2009; Bagiati et al., 2010).

Effective STEM education should capitalize on students' initial experiences and interests, build new knowledge on top of what is already known, and provide rich and exciting experiences for science practices knowing how STEM should help students acquire all-round development (NRC, 2012).

An integrated STEM approach fits easily into preschool teaching, given that teachers should be content knowledge bearers and have acquired supportive learning skills for toddlers (Tallou, 2022a; Thulin & Redfors, 2016).

2.2 Educational robotics in kindergarten

Educational robotics (Figure 2) has many real-world applications in science, mathematics, and engineering, helping to remove the abstract nature of scientific fields. At the same time, it improves skills and effective learning strategies such as spatial ability, selective attention, risk-taking, decision-making skills, *etc.* (Papadakis, 2018; Papadakis & Orfanakis, 2018). Robotic technologies offer children and young people opportunities for a practical understanding of things they encounter daily but do not fully understand. These include proximity sensors, motion detectors and light sensors, software errors and connection problems (Wi-Fi, Bluetooth disconnection) (Vidakis et al., 2019).

Figure 2 Educational robotics in our kindergarten

Educational robotics combines learning through play, so education quickly turns into a fun process (Kalogiannakis & Papadakis, 2020). It is widely known that learning is easier, faster, and more effective when combined with play. Robotics can be an educational tool that arouses the interest and curiosity of young children by using enjoyable activities in an engaging learning environment, free expression, and experimentation (Eguchi, 2010).

2.3 Robotic devices for kindergarten – BeeBot, Edison

In the Greek market, the robotic devices that can be used in the preschool classroom for developing skills in toddlers are many and are constantly increasing at a rapid rate. Robots are used more and more every day as teaching tools and are becoming popular in the educational field (Barianos et al., 2022). Working with robots is a constructive process, especially for young children, as it helps them acquire special skills (problem-solving, cooperation, creativity, team spirit (Figure 3). On the other hand, the assimilation of devices by society, the continuous drop in their prices and the increasing supply of applications (apps) make these devices more accessible in the educational process (Kastriti et al., 2022). There are multiple advantages to using these devices in the learning process, including stimulation, motivation, ease of use, availability, and connectivity (Kim et al., 2021).

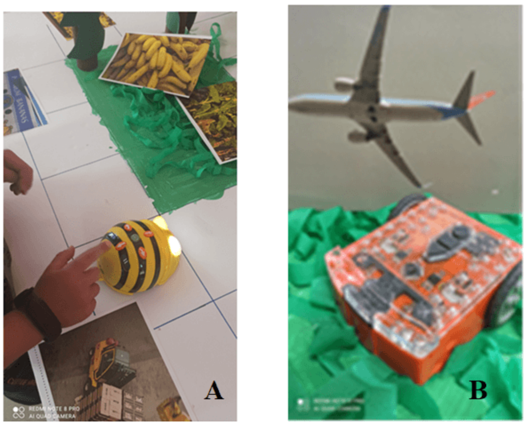

Figure 3 Working with robots BeeBot (A) and Edison (B)

2.4 EUROPEANA

It is Europe's digital platform for cultural heritage, providing free online access to more than 58 million digitized objects, such as books, photographs, paintings, TV shows and 3D objects, from its museums, archives, libraries, and galleries. Given the difficulty of navigating a website with 58 million exhibits, Europeana partnered to create exhibitions, galleries, blogs, and other specially curated datasets searchable by subject or functionality. (https://www.europeana.eu/el, http://iep.edu.gr/el/deltia-typou-geni-ka/europeana)

2.5 Global food system

The global food system feeds 7.9 billion people and employs 40% of the world's population, contributing to a third of the global GDP.

The world's food, agriculture and fisheries systems are incredibly diverse. While regions such as North and South America have much agricultural land and have emerged as major exporters of agricultural products, other regions such as the Middle East and North Africa have relatively little agricultural land and water. In addition, many agricultural products grow only in specific climates or soils. Developing countries such as China and Vietnam have displaced advanced economies as the world's leading source of fishery products.

As a result, trade in food, agricultural and fishery products has never been as crucial as today. Much of the food we eat daily ends up in grocery stores, restaurants, refrigerators, and plates, thanks to commerce. Consumers enjoy fresh fruit and vegetables out of season and access meat and fish from foreign fields and oceans.

However, a few countries account for a large share of exports of certain agricultural products, reflecting a strong comparative advantage in production. For example, five countries account for more than two-thirds of world wheat and beef exports, and the share exceeds 90% for soy. Even for commodities where the share of the five significant exporters is more modest, one country often dominates. This is in the case of sugar (Brazil accounts for 45% of global exports), oilseeds (Canada accounts for 54% of global exports), roots and tubers (Thailand accounts for 56% of world exports) and several dairy products.

Agricultural imports are usually less concentrated than exports, with trade flowing from a small number of exporters to a more significant number of importers.

Food, agriculture, and fisheries depend on the world's natural resources, so future food production will depend on how well these resources are conserved and used. The food, agriculture and fisheries system are not only affected by the environment but also by production techniques that can affect land, water, biodiversity, and greenhouse gases. OECD analysis shows that while progress has been made in improving agriculture's impact on the environment and natural resources, effective resource use and pollution challenges remain in many countries.

As global demand for food and non-food products continues to grow, primarily driven by population and income growth, the challenge of addressing resource depletion and climate change is also expected to increase. The world population is projected to reach 9.5 billion by 2050, with much of the increase occurring in Sub-Saharan Africa, India, the Middle East, and North Africa. Income growth in developing and emerging countries also stimulates demand for more and a greater variety of food and non-food products (https://tinyurl.com/5eynh2pw).

2.6 17 BA targets

In 2015, world leaders unanimously endorsed the 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals are the path that leads us to a fairer, more peaceful, and prosperous world and a healthy planet. It is also an invitation to solidarity between generations. Our students are 17 BA Ambassadors from 2020 (Figure 4).

Figure 4 Our students are 17 BA Ambassadors

2.6.1 Goal 2 out of 17 seeks among other things

2.1 By 2030, end hunger and ensure access for all people to safe, nutritious, and sufficient food throughout the year.

2.2 By 2030, end all forms of poor nutrition.

2.6.2 Goal 12: sustainable consumption and production

12.3 By 2030, halve the per capita food waste produced worldwide and reduce food losses throughout the production and supply chain.

12.5 By 2030, reduce waste generation through prevention, reduction, recycling, and reuse.

12.8 By 2030, ensure that everyone everywhere has the necessary information and awareness about sustainable development and a lifestyle in harmony with nature.

2.6.3 Goal 4: quality education

4.7 By 2030, ensure that all learners acquire the knowledge and skills needed to promote sustainable development, though, among other things, education for sustainable development and sustainable lifestyles (https://tinyurl.com/yu7579ve).

3 Implementation of the intervention

More than two-thirds of the crops supporting national diets came from somewhere else. Moreover, this trend has accelerated over the past 50 years.

Students, in groups, will use Europeana resources to map crop ’primary areas of diversity (where crops were first domesticated and evolved over long periods). In this way, they can understand that national diets and agricultural systems depend on crops from other parts of the world and that specific geographical areas, often far away, are critical (Understanding the global food system – OECD).

This specific intervention is part of a more comprehensive project concerning the circular economy and food waste and took place in the 2021-22 school year in a Kindergarten in the city of Ioannina within the framework of the European SALL project.

4 Objectives-expected results

This intervention aims to present to kindergarten children the food systems (production, globalization, and sustainability), the phenomenon of food waste, the concept of the circular economy to toddlers, and the reference to the ways of dealing with it. A second aim is to develop 4 Cs skills (cooperation, communication, creativity, and critical thinking) and language literacy (visual sign language, listening and speaking). The intervention will be implemented through the involvement of toddlers with STEM education, educational robotics and two robotic systems (BeeBot and Edison) that will be the principal animators of the program. In addition, resources from Europeana’s European platform will be used, as students will come into first contact with it. Finally, the learning scenario develops and improves students’ communication and collaboration skills, global awareness, and environmental literacy, cultivating 21^{st}-centuryskills.

At the end of this specific intervention, students are expected to be able to recognize that those specific geographical areas around the world are of particular importance for the development of agricultural cultivation. Through this, they will recognize how important the consumption of food produced in each region is for the sustainability of our planet, as large amounts of fuel are consumed to transport them from one continent to another, which increases the greenhouse effect.

5 Methodological techniques

(1) Active learning strategy: Europeana gallery tour;

(2) Cooperative learning: a strong focus on teamwork;

(3) Student-centred learning: the work is led by students, and the teacher has the role of moderator and facilitator of the group;

(4) STEM Education – Educational Robotics;

(5) Continuous Assessment: the focus of assessments shifts from ’what students know’ to ’what students can do’.

Online materials used: Mentimeter, electronic form (Google Form, Survey Monkey or other), LS “Where did your food come from?” the Europeana Public Gallery provides almost all images used in this LS, Padlet or Wake let for teams to share and organize their findings.

Offline Learning Materials such as Printed Fruits, Legumes, Cereals and Legumes Pictures, Five Sheets of Different Color Paper, Printed Fruit, and Vegetable Symbols from CIAT “Origins and Primary Areas of Agricultural Crop Diversity” Infographic, large map for each continent: Africa, America, Asia, Europe, and Oceania.

Europeana materials: Europeana Public Gallery (76 items) curated by Anabela Estudante LS “*Where did your food come from?*”

5.1 1st activity: Raising awareness and providing students with internal motivation

The first activity aims to map the students’ eating habits regarding fruits and vegetables. Students do an online activity (*e.g.*, on Mentimeter) to find out which food they eat the most by answering questions such as:

What is your favorite fruit?

What is your favorite legume? (Figure 5)

What is your favorite vegetable? (Duration 15 minutes)

Figure 5 What is your favourite legume?

5.2 2nd activity: Find the name

We divide the students into five random, heterogeneous groups of 4-5 people via a digital name wheel (Random Name Picker) and give instructions for the task. We explain the Europeana gallery browsing process (LS Where did your food come from? Europeana), discuss the importance of working in groups and describe how to assess their work (duration 15 minutes).

A set of pictures from Europeana and colored paper are distributed to each group. We ask each group to process their pictures and decide which fruit or vegetable is shown in each. We explain that it will be easy to identify the fruit or vegetable in some images, while it will be more difficult in others. We also explain that students should work together to reach the desired result in unison. Each group marks with colored paper the objects of Europeana, stating the name of the fruit or vegetable as they can (drawing, writing, writing the initial letter only, orally *etc.*) (duration 25 minutes).

5.3 3rd activity: Find theorigin of the food-Browse freely

The continents are placed on the classroom floor, in different “stations”. Each group also takes over a station. Each group is given a set from Europeana’s gallery of fruits and vegetables grown on each continent. They search in a safe search engine (Safer Junior Search) with the help of the teacher (or with the help of their parents at home, incorporating the flipped classroom method), information about the product crops in their corresponding continent.

Students can freely roam the gallery and come to a consensus on identifying the foods and their main continent of origin. If necessary, they will consult the Europeana Gallery to read the image’s identity through the teacher, to achieve or confirm the identification of the food. An online translation tool will probably be needed at this step unless the teacher knows the English language. They present the results of their research to the whole class.

In the second stage, we ask the teams to sort which vegetables and fruits from their set should be assigned to each continent. They have to look for the symbols on the graphs, work together and discuss with each other, deciding whether the fruit or vegetable from Europeana matches that symbol (Gallery Walk carleton.edu).

We rotate the groups at regular intervals so that all groups from all continents go through. At each station, the teams should check the previous teams’ choices and mark where they disagree (duration 45 minutes).

5.4 4th activity: BeeBot and Edison

They then drive the BeeBot to each continent on our floor model and explain which picture of fruit/vegetable they think is grown there (duration 15 minutes).

Finally, they created their school garden in the kindergarten yard (Figure 6). They become producers, grow organic vegetables, and consume their products by making healthy lunchtime salads (Figure 7). Whatever is left over, they donate to the fundraisers organized by the nearby church for our needy fellow citizens. On this trip, the young students learn about the product life cycle, draw it, and create an e-book. They work in all Analytical curriculum subjects and learn while having fun.

Figure 6 Students create their school garden

Figure 7 Students make a healthy lunchtime salad

Edison robot, via QR, gives them information about each fruit and vegetable, advice for proper production, and evaluates the knowledge they have gained by making the final evaluation of the action.

5.5 Discussion

The discussion with our students revolves around the results of the intervention and the knowledge they gained through it:

(1) Cassava, probably unknown to many, is the third largest source of carbohydrates in the tropics and is an important staple food in the developing world, providing a staple diet for over half a billion people.

(2) Food sales trends can have significant economic and environmental impacts.

(3) Many European products are not indigenous to our country: Italian and Portuguese tomatoes, Irish potatoes, Portuguese, Spanish oranges, *etc.* (Figure 8).

(4) The globalization of food production and its impact (duration 15 minutes).

Figure 8 Many European products are not indigenous to our country

6 Assessment-Assessment

The evaluation of the action is critical throughout the project (Initial, Formative, Final), as it determines its course and evolution. In addition, the self-evaluation by the students themselves plays an important role. They are given the CIAT Infographic, and the correct food locations are marked. At the same time, food names are mapped to Europeana objects and Infographic symbols. They discuss their findings and identify the primary continental origin of the food.

After the intervention and before the discussion, the students answer five questions in electronic format (Wordwall quiz). These questions concern their overall satisfaction with the course, cooperation, and self-evaluation. On an individual worksheet, they draw what they want from the intervention and capture it in any way (writing, painting, pantomime, theatre play, *etc.*). Furthermore, what they would like to learn more about, some possible comments and the feelings they felt during the intervention project. In addition, they choose from the Europeana resources their favorite fruit, draw it, and write its name in any way they can.

7 Conclusions

This scenario could be implemented without Europeana resources, but the result would not be the same. Europeana's digitized heritage collection provides a cultural, historical, and visual perspective on this globalization and sustainability activity, creating a more complete and authentic teaching scenario.

The project applied principles of the Living Workshop and found the enthusiasm of young and old for participation. The students devoted a lot of their time to the activities. They also had the help and support of their parents, even if there was no possibility of collective contact directly with the whole class, due to the health protocols for protection against covid- 19.

The project's final value is positive for the children, the teachers, and other participants. There is probably some need to improve the specific intervention to perfect the time required for its implementation. Nevertheless, it became clear that the results were quite positive as the students became aware of the issue of the global food system and were excited about the prospect of seeking information and co-creating solutions to issues affecting themselves and the local and global community.

Conflicts of interest

The author declares that they have no conflict of interest.

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