ROBOTICS FOR CHILDREN: NATIONAL POLICIES AND INITIATIVES IN THREE EUROPEAN COUNTRIES

Christine W. Trueltzsch-Wijnen :: Anca Velicu :: Vilmante Liubiniene

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ABSTRACT *This article explores the issue of introducing children between six and ten years of age to robotics and investigates the use of robots in schools and in extracurricular activities. The central questions are 1) whether and how the introduction of robotics is addressed in political strategies and educational policies (RQ1), and 2) what the main actors in the introduction of robots in educational settings are (RQ2). Therefore, a pilot study in three European countries (Austria, Lithuania, Romania) was conducted, which included an analysis of national policy strategies, as well as interviews with three stakeholders per country. The article illustrates the specificities of the investigated countries presented as case studies and discusses them in a comparative way. The findings show that the investigated countries' educational policies aim at mirroring the Digital Agenda for Europe and that two opposite approaches to implementation of robotics (bottom-up vs. top-down) can be identified.*

KEYWORDS

ROBOTS IN EDUCATION, CODING & CHILDREN, COMPUTATIONAL THINKING, DIGITAL SKILLS, MEDIA EDUCATION

Authors' note

Christine W. Trueltzsch-Wijnen :: Salzburg University of Education Stefan Zweig :: christine.trueltzsch@gmail.com

Anca Velicu :: Romanian Academy, Institute of Sociology :: anca.velicu@gmail.com

Vilmante Liubiniene :: Kaunas University of Technology :: vilmante.liubiniene@ktu.lt

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INTRODUCTION

Children start using the Internet at a young age (Chaudron et al., 2018; Lauricella et al., 2015; Marsh 2016) and engage in (playing) practices that move seamlessly between the online and the offline (Marsh et al., 2017). The Internet of Things (IoT), which stands for a shift from keyboards and touch screens to more embodied technologies, becomes more and more relevant for children of different ages (Mascheroni & Halloway, 2019). The Internet of Toys, as a special part of the IoT, comprises a set of software-enabled toys that Holloway and Green (2016) describe as: a) connected to online platforms (Wi-Fi, Bluetooth) and potentially connected to other toys/devices; b) equipped with sensors; and c) relating one-on-one to children. The characteristic of such toys (Mascheroni & Holloway, 2017) is that they blur the boundaries between digital and non-digital; online and offline; material and immaterial; local and global; private and public kinds of play (Marsh, 2017); becoming the settings of formal and informal learning (Montgomery, 2015, p.268). They have a potential in the individualization of learning, which might bring about educational benefits when they enable children to choose the pace, place and mode of their learning activities (Gordon, 2014, p.3). Playful robots, a specific kind of such toys, are in the focus of this article. We will give a short insight into the state of the art of research on educational robots and proceed with outlining the design and research questions of our study. The results will be presented as case studies and in a comparative perspective. The discussion will end with recommendations and prospects for future research.

STATE OF THE ART

Several overviews can be found on different aspects of using robots in education (e.g., Belpaeme et al., 2018). Mubin et al. (2013) analyzed learning activities and concluded that a robot can take the role of a tutor, tool or peer in educational settings, but that it must have animated features (Janka, 2008; Sullivan & Bers, 2013) to attract young children (Highfield et al., 2008; Stoeckelmayr et al., 2011). Karim et al. (2015) see robots as tools for encompassing new didactic fields.

Playful robots as part of the Internet of Toys are discussed for their educational potential to enhance motivation to learn (Ihamäki & Heljakka, 2018; Sugimoto, 2011). Robots that are specially designed for educational settings are praised for developing children's algorithmic reasoning and computational thinking (Catlin & Woollard, 2014; Ioannou & Makridou, 2018; Toh et al., 2016). They are discussed for offering new kinds of learning, creativity and problem solving (Davison et al., 2019), and are promoted for positively affecting children's cognitive development (Cook et al., 2010; Kahn et al., 2012; Shimada et al., 2012). They enable children to interact with real-world environments. Moreover, it has been shown that STEM (science, technology, engineering, mathematics) education can be transformed into a playful learning experience through the use of robots (Eteokleous, 2019; Tuomi et al., 2018).

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Evripidou et al. (2021) state that educational robots help to promote education in general and should be used as a constituent part of an educational paradigm. Hence, different pedagogical projects involving robots are organized in various countries (Blum-Ross et al., 2019; Marsh et al., 2017; Riedo et al., 2012). To ensure that such attempts gain sustainability and persistence, educational policies are needed. However, little research exists on such specific educational policies. Therefore, we conducted an explanatory qualitative pilot study to get a first insight into this field. Its results are intended to serve as a basis for a broader study including more countries and going more in-depth by using a mixed methods design.

THE PROJECT

Our pilot study includes three European countries (Austria, Lithuania, Romania), which were chosen because they differ in their educational systems, in the level of integration of ICTs in society (EC, 2019a, 2019b), and in their location in Europe. For this article, we focus on two research questions: 1) Whether and how is the introduction of robotics addressed in political strategies and educational policies of the researched countries (RQ1), and 2) What are the main actors in the introduction of robots in educational settings in these countries (RQ2)? We analyzed current policy strategies of each country and their references to EU regulations and strategies, and conducted interviews with experts (three per country, between December 2019 and March 2020)[1] that are either concerned with the implementation of robotics projects or are part of such. Further, we investigated how the use of robots is implemented in pedagogical practice (in formal and informal learning settings).

For each country, all national documents and statements of NGOs etc. that could be accessed were included in a literature review following the principle of thematic analysis (Corbin & Strauss, 2015). For the analysis, a list of codes (deductive/inductive) was developed together by all researchers. To ensure intercoder-reliability, the coding was discussed and adapted several times during the coding process in regular project meetings. The results of the literature review served as a basis for the development of the interview guide for semi-structured expert interviews. This interview guide was developed together by researchers of the three countries and translated into national languages.

We conducted three expert interviews (van Audenhove, 2017) in each country. This method differs from other kinds of qualitative interviews because our focus was more on supra-individual and universal information given by different experts than on the individual situation (Harvey, 2011). Specific experts were strategically chosen for answering the research questions. Important for this methodology is a clear definition of 'the expert' (Dexter, 1970, p. 18). For our project, we defined an expert as a person

[1] We completed our research when the Covid-19 pandemic started to cover Europe. Our interviews are not influenced by the changes that this pandemic had caused in the educational sector of the countries under scrutiny. Most of the initiatives described here stopped due to the Covid-19 lockdown. The presented study gives an overview of the situation in the field of education just before the sudden shift to remote schooling as a result of the pandemic. Hence, the results obtained are even more valuable for future research and comparison of the effects of the lockdown.

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who is a) concerned with the implementation of robots in educational settings (e.g., representatives of governmental institutions, private initiatives, the public sphere etc.), or b) directly involved in projects that use robots in educational settings (e.g., organizers of robotics workshops, teachers etc.). As the study has a pilot character, three persons per country were chosen (nine in total) based on the principle of including for each country: a) persons from the educational sector as well as from the private sector (outside school), and b) persons who presumably were able to present a good variety concerning different perspectives on the topic (persons from different fields/with different responsibilities). In Austria, we interviewed a person who is responsible for the regional implementation of a national project on the integration of robots in primary education (AT1); a primary school teacher who uses robots in class (AT2); and a researcher and teacher who has set up a private initiative for coding workshops (AT3). In Lithuania, we interviewed a primary school teacher who leads classes of robotics integrated into the formal education curriculum (LT1); a person who is responsible for the organization and implementation of a robotics centre that offers workshops for schools (LT2); and a person from a public enterprise focused on robotics that also offers workshops and educational activities (LT3). In Romania, we interviewed a school inspector who is responsible for ICT education (RO1); a founder of a private organization that provides robotics courses mainly for primary school children (RO2); and two partners and founders of a private organization that used to provide robotics courses in face-to-face settings but moved their classes online (YouTube channel) (RO3). The interviews were transcribed and analyzed using thematic analysis (Corbin & Strass, 2015). The interviews and the literature review were the basis for a case study of each country; the cross-country comparison is based thereon.

Hence, we will first describe the situation of each of the selected countries by giving an insight into their educational policies and illustrating some specific projects that are designed for children at the age of six to ten years. We will then compare our three cases and discuss similarities and differences.

CASE STUDIES

In the case studies, we first address the policy strategies that are relevant for the introduction of robots in primary school education (RQ1) and then focus on the main actors responsible for introducing children between six and ten years in formal and non-formal educational settings to robotics (RQ2). We describe some of the projects that can currently be found in each country and illustrate their organizational and pedagogical background. The case studies are based on the literature review and on the results of the comparative analysis of the interviews. When we directly refer to a specific interview, it is indicated by the country code and number (e.g., AT1 stands for interview 1 in Austria).

Case I: Austria

In 2001, a decree requiring the integration of media education in all school subjects, across all kinds of schools and in all classes was issued (Brousek, 2008, p. 120; Süss et al., 2018, pp. 63-70). It is being adapted continuously to new media and technologies (actual

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version: BMBF, 2014). Although such a transdisciplinary approach seems very promising, its daily practice in schools is disappointing: over the last nearly twenty years, only some engaged teachers integrated media education in their classes and developed hands-on media projects (Trültzsch-Wijnen et al., 2019). In 2001, and as a result of the EC's Lisbon 2000 strategy (Rodriguez et al., 2010), Austria invested in infrastructure, in teacher training and in the establishment of a national network of teachers that is responsible for the integration of digital media in their schools (Buchegger, 2010). In 2010 and again with reference to the EC (2004), a digital competence directive that focused on the promotion of technical, creative, critical and social skills in handling digital media was issued (Schrack et al., 2010). As these initiatives were extremely narrowed down to computer literacy, they only reached a small community of teachers of Informatics and were therefore not more successful than the media education decree (Trültzsch-Wijnen, 2014). In 2017, the Ministry of Education took a new approach aiming to foster computational thinking, programming and digital competencies from primary education to upper secondary education. This policy strategy draws on the DigComp model of the EC (Carretero et al., 2017; Ferrari, 2013). It refers to general guidelines and recommendations of the European Commission (EC) (EC, 2018; EC/EACEA/Eurydice, 2012) regarding the support of key competencies and digital literacy. In line with this initiative, a compulsory subject called Digital Education was introduced in lower secondary schools. In addition, a pilot project with over 100 participating primary schools was launched (Himpsl-Gutermann et al., 2017).

It is the fourth year that this school project has been running. It is designed with reference to Papert's (1980) work on constructionism and computational thinking (BBC Bitsice, 2017; Barefoot Project, 2014). Its aim is to foster competencies in problem solving and to introduce coding in primary education, by working with BeeBots (small robots that look like a bee and are codable by the user) and LEGO WeDo®.[2] These tools are used in different subjects with the idea to familiarize pupils with them and to let them become a regular part of the lesson. In this nationwide project, children start to work with Bee-Bots (possible commands: *forward*, *backward*, *left*, *right*, *rest*). They learn to control them in a playful manner by solving quests and different tasks (e.g., the Bee-Bot has to move along a specific path to find the right answer). After pupils gain a first understanding of commands and algorithms by using Bee-Bots, they start to work with LEGO WeDo®. Therewith children can build small robots or machines with sensors (motion/distance, tilt) and a motor which can be connected with tablets by Bluetooth. With a special app, pupils are able to code their robots with a visual and child-friendly coding language (using pre-programmed sequences that are arranged by drag-and-drop). The app offers a variety of different commands that enable pupils to control their robots. As coding with this app enables to define conditions for different actions (e.g., stop if there is an input from one of the sensors), LEGO WeDo® can be used for experiments (e.g., friction/traction), for solving various problems from the field of natural sciences and beyond (e.g., storytelling, working with sounds etc.). As the project is set up by the Federal Ministry of Education,

[2] LEGO® Education provides various robotic tools mainly for STEAM education (science, technology, engineering, arts and mathematics) for different age groups with standards-aligned lessons that are adaptable by teachers. For primary education, LEGO WeDo® enables children to build their own robots and code them using a visual coding language. Regarding our case studies, LEGO WeDo® is used in Romania (non-formal education), in Lithuania (formal education) and in Austria (formal education). LEGO Mindstorm EV3® is used for children from 10 years onwards in all researched countries in special projects (formal and non-formal education).

it is closely connected to national educational strategies, while European strategies are not relevant for teachers and organizers involved in this project. Our interviews (AT1, AT2) show that teachers value robots because they enable collaboration among pupils and foster their social competencies. They report an increase of pupils' motivation and self-confidence. They also mention that the project enables some pupils to better display their competencies than in regular classes. Furthermore, a teacher (AT2) also mentions that children with learning disabilities can be integrated very well.

It was amazing to see how a boy with autism suddenly started to integrate himself in the class more than he was able to do ever before. He helped other teams as a 'coding expert'. (AT2)

In Austria, there are also a few smaller initiatives or companies that promote coding and robotics outside school. They are all private and not publicly funded. One example is the so-called Coding Club that was founded by a teacher and post-doctoral researcher (AT3). This initiative is interesting because it was founded with the mission to make coding accessible for everyone and especially for people who do not have easy access to education (e.g., in rural areas). Unlike similar initiatives, they organize free workshops and open spaces for collaborative coding where everybody who is interested, is welcome. The youngest people that take part are nine- to ten-year-olds. Younger children have not attended these workshops yet, although they are open to them. The pedagogical approach is different than in the school project described above. The Coding Club focuses on learning and understanding coding languages and not primarily on robots but on problems or ideas that can be realized by coding (e.g., creating their own apps). Moreover, starting with this approach, young people also create their own robots (e.g., drones with the help of micro:bits). As this creative approach is very successful, companies and organizations have become interested in it and finance such workshops and coding spaces in order to recruit future staff from various fields of informatics and technology. Although the Coding Club also organizes workshops at schools, there is no connection with the national strategy on digital education or EU strategies. Other private initiatives have similar aims. They are often small but successful. However, they are hardly addressed to children under ten.

Case II: Lithuania

The Lithuanian Primary Education Programme (Švietimo, mokslo ir sporto ministerija, 2016) fosters the integration of ICT skills in primary education in a cross-sectional way and issues guidelines for integrating ICT use in teaching languages, mathematics, social/life sciences, arts, and sports. According to that, children should learn basic computer skills in the first two years of primary school and proceed with text editing in grades 3 and 4. However, this is optional and based on the teacher's preference. As a result, some schools are highly equipped and have trained teachers, whereas others have neither the equipment nor trained staff for integrating ICTs as described above. Kubilinskiene et al. (2017) point out a lack of specific teaching methods adequate for using educational robots in Lithuanian schools.

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In the region of Kaunas, a teacher training program in robotics was provided five years ago with the result that some schools (approx. 10-12) started to integrate robotics into their classes. This was also the case in Kaunas primary school Šviesa. A teacher of this school (LT1) explained the use of LEGO® Education kits as follows:

The entire class is split into two groups and each group has robotics lessons twice a month (LT1).

Computational thinking (Papert, 1980) is mentioned as a didactic reference with clear similarities to the educational philosophy promoted by LEGO® Education (LT1). However, despite such examples, primary schools that integrate robotics in regular classes are rare in Lithuania.

As formal education does not provide opportunities for all children to develop digital skills and coding in particular, several initiatives appeared in the field of non-formal education. One example is a crowdfunding initiative that aims to donate a microcomputer to each child in Lithuania, and to train teachers for using microcomputers in class. While this initiative is more focused on children at the secondary school level, the Academy of Robotics, a non-formal public company established in 2013, focuses on younger children as well. They founded local education centres, robotics labs and mobile classes all over Lithuania. There, they organize robotics classes in non-formal education settings, provide teacher training programmes, and develop curricula in the field of STEM (science, technology, engineering, mathematics) and HUSO (humanities, social sciences). As the largest non-formal education institution, they reach over 6,000 children from three to 14 years in over 20 places across Lithuania. They offer after-school workshops and summer camps by drawing on LEGO® Education kits (Robotikos akademija, 2019). The workshops are paid by parents (LT3).

Another robotic centre (Robolabas) was founded in the region of Panevėžys Municipality in September 2019. According to its director,

the centre is dedicated to the development of children's technological and engineering skills, and wants to engage as many people as possible in technology education. We bring together young people and retired engineers to share their expertise (LT2).

They have a broad focus, from teacher training to engaging families with young children in robotics. The centre is the only of its kind in Lithuania with modern and well-equipped working spaces. Besides LEGO® Education, other tools (e.g., 3D-printers) and robots are used in workshops. The centre is open to teachers who come there with their students. Furthermore, some primary school teachers bring their pupils (LT2). As the centre is funded by the municipality and industry, the fee for these classes is low (€ 5 per month for 2-hour classes once a week). The curriculum of these classes comprises theory and an introduction into practical tools, which leads to creative construction work. During the classes, children are encouraged to work in teams and take over various roles in the working process; the main philosophy is to help each other in teams as well as across teams. Attempts are made to pair weaker with stronger children in order to encourage them in learning from each other.

Case III: Romania

Various reports that evaluate the process of digitization of the Romanian educational system come to rather opposite conclusions, ranging from a critical view (Ducu, 2018) to a more positive perspective (Jugureanu & Jugureanu, 2018). There are a few policy papers, informing the framework - such as the National Strategy Digital Agenda for Romania 2020 (Ministerul pentru Societatea Informațională, 2015) which goes in line with the Digital Agenda for Europe 2020.

Previous to the National Digital Agenda, the National Education Bill (Parlamentul României, 2011) introduced Informatics and ICT as a compulsory subject from grade 5 (lower secondary) onwards. During primary education (grades 0-4), this subject is only optional, meaning that schools decide on adopting it depending on the availability of human resources and infrastructure, or (sometimes) on pupils' choices. The Informatics and ICT national curriculum contains elements of coding, computational thinking and computer literacy for each grade (above grade 5). However, robotics is mentioned in the National Curriculum only starting with grade 7. This is in fact the third year of studying informatics where students have already acquired advanced or at least basic knowledge in coding (Ministerul Educației Naționale, 2017). Robots are not seen as tools to introduce children to coding (Geist, 2016), but for applying already acquired knowledge. While in other countries, such as Austria and Germany (Trültzsch-Wijnen et al., 2019) or Finland (Kupiainen et al., 2008), digital education in school emulates former approaches of media education, this is not the case for Romania, where media education is hardly present in schools (European Audiovisual Observatory, 2016).

There are no available official data on how many primary schools are really offering optional Informatics and ICT classes in Romania. Velicu et al. (2019) show that digital technology is mostly absent in public schools. One of the interviewed experts, a school inspector for ICT classes (RO1), explains that from the point of view of public policies and the National Curriculum, the primary school level is considered as too early for introducing robotics. But in the majority of Romania's big cities, private initiatives offer robotics and coding classes in primary schools and even in kindergartens in response to parents' requests. These classes are paid by parents and turn out to be expensive for the Romanian average family (around 50-100 euros for 4 workshops a month).

In the following, we present two organizations that provide robotics workshops for primary school children. Each is representative for one of the two approaches we identified in the field. The first (Edubricks) is more business-oriented and is addressed to parents as its primary customers: parents who want to ensure (and are able to pay for) a playful learning experience for their children. The second initiative (Inventeaza.ro) considers children as their main customers (albeit also with costs): they should prove their passion to learn about robotics, coding and hands-on activities.

Edubricks was founded six years ago by a woman who, as a mother, identified a lack of enjoyable and educative activities offered to children in after-school settings (RO2).

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I wanted to find something new for children – and LEGO® is perfect (RO2).

She discovered LEGO® Education tools as a possibility to teach STEM and coding in a playful way. At the same time, she envisaged a new business opportunity. Drawing on these tools, the organization offers robotics workshops in after-school settings. They are structured in three levels, that correspond to three different age groups: at the introductory level (6-7 years), children learn basic elements of visual coding, while on the second level (8-9 years) they engage in more advanced coding activities. During the first two levels, children work with LEGO WeDo® – in a similar fashion as described in case I (Austria). On the third level, which is aimed at secondary school children (10-11 years), they work with LEGO Mindstorms EV3®. During the workshops, children are free to pair as they wish.

Being inspired by the philosophy of LEGO® Education, the organization's founder did neither draw on any national or European education policy nor on specific didactic theories. In retrospect, she explains that she learned about the principle of computational thinking (Papert, 1980) and STEM principles only after deciding on the tools.

The robot is pivotal to the course (RO2).

Inventeaza.ro (RO3) was founded ten years ago with the aim to create the first makerspace in Romania. This first attempt was unsuccessful because Romanian adults were not willing to pay a subscription for a joint makerspace. Hence, they (RO3) changed their focus towards offering robotics classes to children. The company also develops prototype hardware with automation ('robots') in different fields. While their robotics classes were originally intended to train their collaborators for developing such projects in the future, their initiative turned out to meet a strong demand of parents as robotics and coding are hardly taught at school. When we interviewed the two founders of this company (RO3), they were working on digitizing their lessons and making them freely available on YouTube with the financial support of a community grant they had won.[3] Their former face-to-face workshops were paid by parents and comprised 16 weekly two-hour sessions. The classes were not meant to suit a specific age group but were designed in several steps of progression in knowledge that should be followed by each student in his/her own pace. Some children managed to complete all steps, others only the first three during their time in primary school.

Based on the values of the maker movement, the founders initially wanted to build their own robot for the course, but as they got involved in providing feedback and helping with the development of the MakerBlock ecosystem, they were stuck with it, using two of their robots: mBot as the main robot (for modules 2 and 3) and Codey Rocky, a simple robot, for module 1. For module 4, they aim to develop the prototype of a product. Children attending these workshops buy their own robots instead of using the organizer's material and having to return it after every workshop (as it is the case with RO2). Moreover, children are not only taught coding but also electronics, soldering and

[3] This process started just before and independently from the COVID-19 lockdown.

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other maker-specific activities. The maker philosophy which stands for a community-oriented approach also gets visible in a platform where interested participants from the workshops share ideas, information and skills, and form teams for participating in hackathons and robotics competitions – some of these people are only eight years old. Besides the maker philosophy, the workshops rely on STEM principles and the founder of the company stresses that robots (without any loyalty for a specific robot) are seen as simply tools to work with and to understand STEM.

We can talk at length about theoretical issues, but if one can't touch them [robots] and make them physically, it's not STEM, but theory. [...] Our approach of robotics is not like 'look, this is a robot and it can do that', but we put the robot in a broader context of the labour market, [...] knowing what one would need to know as a programmer or as a future hardware developer (RO3).

CROSS-COUNTRY COMPARISON

In our study we compared two countries (Austria, Lithuania) that are about the EU average in the *Digital Economy and Society Index* (EC, 2019a) and one of the countries scoring less on this index (Romania). The countries differ in their economic development which influences the implementation of robotics in educational settings.

In answering our first research question (RQ1), we can say that all three countries' national educational policies aim at mirroring the Digital Agenda for Europe, but their actual implementations vary largely, reflecting the countries' strengths and weaknesses. When it comes to the implementation of robots in educational settings which is addressed by our second research question (RQ2), two opposite approaches appear that are also mirrored by the kind of actors engaged with the introduction of robotics to children. While Austria's Federal Ministry of Education has a strong top-down strategy with introducing an extra subject on digital education in secondary schools and launching a nationwide project for introducing robotics in primary schools (AT1, AT2), no similar strategies exist in Romania or Lithuania. Nonetheless, people in these countries regard digital skills, robotics and coding as important to be taught to (even) young children, helping them to learn and preparing them for future job markets. Therefore, many bottom-up initiatives have flourished in this field in recent years (LT2, LT3; RO2, RO3). Some of these initiatives have become influential actors in the education field, providing high quality education in after-school settings, and working together with schools and teachers. Some bottom-up initiatives are publicly funded (LT2), others have attracted the attention of business enterprises and get private funding (LT3), and some are organized as private companies that function on the basis of the fee that is paid by parents for the courses (RO2, RO3).

The type of institutions that are involved in such bottom-up initiatives shapes the pedagogical approach. In Lithuania, mostly public local initiatives (municipalities), private initiatives and NGOs are involved. Their pedagogical focus is on the tools (different kinds of robots) that are provided to the children. This strategy aims to foster computational thinking by teaching children to work with robots and to use them in various fields (LT2,

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LT3). In Romania, only private initiatives can be found, mostly functioning at the local level. One of the Romanian organizations that we focused on has a similar approach (RO2) to those from Lithuania. In addition, small enterprises that stem from the maker movement (RO3) are present in Romania. With a stronger goal on training future workforces, their focus is not on a specific robot, but on the whole process of developing automatic hardware, including coding, hardware constructing and creative problem solving.

The latter can also be discovered among the few bottom-up initiatives in Austria (AT3). While the ministry's top-down approach in formal education is tool-oriented, bottom-up initiatives that provide workshops and working spaces in a non-formal and after-school context, centre on coding and creation by using robots and other tools as working instruments. They focus on the process of creation and not on tools.

In our cross-country comparison we could identify LEGO® Education as a strong international player in the formal (AT1, AT2; LT1) as well as non-formal educational sector (LT2, LT3; RO2). LEGO® Education's pedagogical approach is on computational thinking and strongly refers to Papert's constructionist theory (1980). Because they provide a wide range of educational tools including robots for the primary and secondary school levels, and many suggestions of how to introduce and use them in different school subjects and for different age groups, LEGO Education is highly appreciated by teachers (AT1, AT2, LT2) who do not have a special training (or passion) for robotics. It could also easily be adopted by a lay person (without any previous training in pedagogy or in robotics) who started a business with it in Romania (RO2). When working with LEGO® Education tools, the teachers' pedagogical approach is very tool-centred; they also strongly refer to the educational philosophy that is promoted by LEGO® Education, including the pivotal value of playfulness.

When they are playing, children are much more willing and ready to learn (RO2).

DISCUSSION

Our study draws on qualitative data from three European countries. It is a pilot study whose aim is to get a first insight into the field on the basis of nine interviews following the concept of thematic analysis (Corbin & Strauss, 2015). Although its explanatory power is limited, it offers important insights that can serve as a starting point for further research. From our comparison, we can conclude that the countries investigated are going similar ways in implementing EU strategies in their national educational policies, however, progressing with different speed and drawing on different approaches. In these countries, ICT skills are valued as a prerequisite for being successful in future job markets independently from national educational policies. Where there is not a strong support from public institutions or a top-down approach, bottom-up initiatives are answering parental demand. Furthermore, other studies (Livingstone & Blum-Ross, 2020; Toh et al., 2016) show that parents believe in the importance of technology for their children's future and are willing to support them to gain ICT skills, robotics being a part of it.

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The educational value of robots is that they require a hands-on approach. This makes them useful in introducing young children to coding and computational thinking, because tactility is important for learning processes at primary school-ages. However, our study also shows that teachers and parents should be sensible when deciding on the tools that are used. In the researched countries, LEGO® Education turned out to be favourite among many educators and trainers in formal and non-formal education because it offers a comprehensive didactic kit and a pedagogical theory that can be easily adapted. However, drawing on a specific tool kit comes with the risk of limiting children's robotic education to a very specific programming language without grasping the idea of robotics. This narrow approach might be contradictory to the reality of future-oriented ICT skills and digital literacies.

Approaches that are more focused on creativity and the promotion of future-oriented solutions to everyday problems can be found among initiatives that are often connected to the maker movement. From a pedagogical perspective, they seem to be more promising than tool-oriented approaches. However, our study cannot give detailed answers on the pedagogical outcome of the described approaches and initiatives.

Our intention was not to look at how children benefit from the robotics classes and workshops that were investigated, yet, on the basis of the literature and the pedagogical approaches that were discussed above, we can propose some hypotheses which could be a starting point for future research. The introduction of robots in schools in a trans-disciplinary manner, like in the case of Austria, will probably not only enhance children's skills in coding, problem solving and collaboration (Hong et al., 2011; Kahn et al., 2012; Shimada et al., 2012; Wei et al., 2011), but it might also increase communicative skills, storytelling competences and children's knowledge in the subjects where robots were used. It might also increase a positive attitude towards learning (Chen et al., 2011; Wei et al., 2011; Young et al., 201) and help children to combine different subjects and increase their creativity in other school-related topics (Toh et al., 2016).

Robotics workshops in extracurricular contexts like in Romania and Lithuania might have similar effects, but there is a chance that children could not associate their experiences from workshops with formal schooling, but with play and hobbies instead (Mubin et al., 2013). At the same time, studies show that parents see robotics as an investment to their children's future and perceive it as having a positive effect on children's learning (Lin et al., 2012). This might be more the case for extracurricular contexts, where parents pay for robotics workshops.

RECOMMENDATION AND PROSPECTS FOR FUTURE RESEARCH

The aspects discussed above should be reflected more in educational policies. In what extent do children need to experience robotics in formal educational contexts and in what extent do they need free spaces for relating robotics to their hobbies and

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personal interests? Perhaps, a combination of both could be a suitable approach. Spaces for experiencing the multiple facets of robotics should be implemented and supported at schools as well as in after-school (e.g., workshops) or leisure contexts (e.g., summer camps, open maker spaces, youth clubs).

When supporting robotics, a critical consideration of the tools is also needed. Promoting a single pedagogical philosophy that is closely related to certain products bears the potential risk that children are offered a certain way of coding, thinking, and problem solving only. Instead, they should experience different robots and ways of coding, which might fire their creativity and imagination.

But still, our considerations draw on a small pilot study. To elaborate them more, further research is needed on various levels:

1) We could give a first answer on whether and how the introduction of robotics to children is addressed by national policies and strategies of the three countries and how they relate to EU policies. More information on educational policies and strategies of other countries as well as their connection to broader international developments and policies is needed, to get a thorough picture of how robotics is addressed and integrated in formal education.

2) We were also able to illustrate how actors in introducing robotics to children are confronted with different circumstances that lead to different approaches (top-down vs. bottom-up), and how they refer to different underlying aims (e.g., making vs. informatics). In this regard, a broader picture based on an expanded international dataset is needed to investigate the contexts and approaches that are most beneficial for introducing robotics to children.

3) Additionally, it seems promising to compare different pedagogical approaches to the use of robots (e.g., tool-oriented vs. problem-oriented).

4) Lastly, we have to take into consideration the fact that our study was conducted just before the Covid-19 pandemic that totally changed ways of teaching and learning, and which will have long-lasting effects on educational systems and policies. In the countries investigated, many projects and activities in robotics paused due to lockdowns, and for other reasons. Hence, it will be interesting to compare initiatives, projects and policies regarding the issue of introducing children to robotics before and after the pandemic.

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ROBOTIKA ZA DJECU: NACIONALNE POLITIKE I INICIJATIVE U TRI EUROPSKE ZEMLJE

Christine W. Trueltzsch-Wijnen :: Anca Velicu :: Vilmante Liubiniene

SAŽETAK *Ovaj članak istražuje upoznavanje djece u dobi od šest do deset godina s robotikom te ispituje upotrebu robota u školama i izvannastavnim aktivnostima. Središnja pitanja su 1) je li uvođenje robotike obuhvaćeno političkim strategijama i obrazovnim politikama i na koji način (RQ1) te 2) tko su glavni akteri uvođenja robota u obrazovno okruženje (RQ2). Kako bi se odgovorilo na ova pitanja, provedena je pilot studija u tri europske zemlje (Austriji, Litvi i Rumunjskoj) koja je uključivala analizu nacionalnih* policy *strategija, kao i intervjue s po tri dionika u svakoj zemlji. Članak ilustrira specifičnosti istraživanih zemalja prezentirane kao studije slučaja, raspravlja o njima i međusobno ih uspoređuje. Nalazi pokazuju kako obrazovne politike u analiziranim zemljama imaju za cilj preslikati Digitalnu agendu za Europu te da se mogu identificirati dva suprotna pristupa implementaciji robotike, odozdo prema gore i odozgo prema dolje.*

KLJUČNE RIJEČI

ROBOTI U OBRAZOVANJU, KODIRANJE I DJECA, RAČUNALNO RAZMIŠLJANJE, DIGITALNE VJEŠTINE, MEDIJSKO OBRAZOVANJE

Bilješka o autoricama

Christine W. Trueltzsch-Wijnen :: Pedagoški fakultet u Salzburgu Stefan Zweig **::** christine.trueltzsch@gmail.com

Anca Velicu :: Rumunjska akademija, Institut za sociologiju **::** anca.velicu@gmail.com

Vilmante Liubiniene :: Tehnološko sveučilište u Kaunasu **::** vilmante.liubiniene@ktu.lt