Erasmus+

INTELLECTUAL OUTPUT O1.A1

botSTEM

"roBOTics and STEM education for children and primary schools"
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Intellectual Output: O1.A1 Compilation of Best Practices at European level to encourage STEM Vocations and Best Practices at International Level on Robotics and Early Childhood Education.

Lead Partner: HKR, UBU

Overview of O1.A1

This document contains a description and list of good practices that have been found. It is a Document of Work (DoW) that is jointly developed and shared, and it will be continuously revised by the Project Coordinator and the consortium.

Partners have analysed and continue to follow the development of curricula in partner countries and this together with a common framework for collaborative inquiry-based learning, gender perspectives for children, is the basis of the search and comparative analysis of good practices.

All partners have looked for successful practices at European-scale in fostering scientific and technological vocations, paying special attentions to Science, Technology, Engineering, Mathematics (STEM) and gender perspectives. Robotics in childhood education is not extensive in Europe, especially robotics connected to several or all subjects in STEM.

Partners have interviewed three experts or expert teachers per partner-country to help the assessment process and selection of the best practices assessment.

Preliminary teaching sequences for childhood education will be developed and this DoW defines the topics and structure of the interactive Toolkit that responds to cross-curricular activities.

Estimated Dates: 9/2017 - 2/2018

Activity leading organisation: HKR (UBU)
Participating organisations: All

Introduction

The Intellectual Output (IO1) is addressed to build a downloadable interactive Toolkit, freely available on the project website addressed to teachers in Europe. The toolkit will include good practices for collaborative inquiry teaching and learning concerning robotics and STEM, methodological guidelines, as well as additional resources and OER (Open Educational Resources).

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Theoretical Framework

Collaborative groups benefit from establishing common ground, i.e. formation of norms as to what can be taken as shared and what should be the target of communication, debate and negotiation. This is an ongoing process that needs to be maintained throughout the collaboration. The goal of this framework is to help the partners reach common ground on key theoretical issues.

The framework is intended to facilitate communication and decision making among partners during the project. In the case of the botSTEM project, it serves three main purposes:

- Identification of key constructs pertinent to our project goals
- Making tacit assumptions of individual groups explicit
- Reaching common ground between the different groups.

In what follows we present a synthesis of our positions concerning the following key theoretical issues:

- Science Learning
- Inquiry
- STEM
- Reflection
- Collaboration
- Programming and Computational thinking …
- Gender learning

- Robots and robotics
- Good and best practices

Additional key issues may be added during the project.

Science Learning

Two main themes figure prominently in the botSTEM partners' stance on the goals of science education: science as an institution of liberal democracy, and science as a discipline composed of principles and processes that need to be mastered. There is often a tension between science education aimed at producing the next generation of professional scientists (vision I), and science education aimed at equipping citizens with the knowledge and understanding of science that they need to participate in democratic decision making (vision II), cf. Roberts (2007). Countries, school districts, schools and even individual teachers differ in the relative weight that they give to each aspect, though it seems that many standards-based movements and organizations, such as EU, OECD and NRC support a combination of the two, which will be our goal.

Inquiry

Generally, the botSTEM partners view inquiry as an approach and a process that enables the understanding of a natural phenomenon and the generation of new knowledge. More specifically, it is the process through which scientists study, understand, and explain the natural world. Inquiry in this sense may not be unique to science, though it may take on a particular form in the sciences. Seen as a teaching methodology, it requires activities that include the analysis of scientific questions through the use and the development of many process-related skills (how to identify variables, proposing and planning experiments, controlling them, interpreting, summarizing and evaluating data, etc.); the development of explanations and models using evidence; the extraction of conclusions from the results; public presentations and discussion of the results; and group work (NRC, 2012; EC, 2015).

The botSTEM partners adhere to the idea of a coupled inquiry (Martin Hansen, 2002), in which different aspects of science, mathematics, technology and engineering are addressed. The couple inquiry combines a guided and open inquiry investigation, and begins with an invitation to inquiry in which teacher select the first problem to investigate, that is connected to a specific science standard or content. Next, an open-inquiry is implemented where students generate questions related to the first problem and "specific concepts can be explored in a more didactic fashion allowing students to connect their concrete experiences to abstract concepts" (Martin Hansen, 2002, p.35, Toma & Greca, 2017). The type of combination, length and depth of these investigations will be varied taking into account ages and themes.

STEM

botSTEM is focusing on an integrative STEM (Science – Technology – Engineering – Mathematics), which is a comprehensive approach which merges the different fields through active and participative methodology focused on projects, Problem-Based Learning, collaborative projects. The objective of this approach is to achieve a STEM literacy that can be summarized as

> "the ability to adapt to and accept changes driven by new technology work, to anticipate the multilevel impacts of their actions, to communicate complex ideas effectively to a variety of audiences, and perhaps most importantly, to find measured, yet creative, solutions to problems that are today unimaginable" (Lederman, 1998).

The botSTEM STEM model consists of four phases that seeks to encompass different STEM disciplines. Thus, in the first phase (inquiry invitation), teacher propose an engineering-based real-world problem, that serves as a context to teach science-related content matter. During the second phase students perform a guided inquiry in which the students conduct different experiments using scientific practices using technology, and interpret data using mathematics. The third phase consists of an open inquiry during which students should discuss the results obtained in the guided inquiry and propose new research questions necessary to solve the initial problem. The fourth and final phase (inquiry resolution) requires the design or implementation of a technological solution. In this way, students begin to explore engineering design, linking engineering and science, as proposed in NRC (2012).

STEM in early childhood education is preferably holistic, child centred, project and problem based. It is the integration of science, technology, engineering and mathematics fields that creates valuable STEM experiences for children (Kermani & Aldemir, 2015). Inquiry helps intertwine the different fields in STEM through real world problems. Working with inquiry-based STEM lessons provides children with opportunities to practice skills such as reasoning, reflection, questioning, modelling, justifying decisions and communicating.

Reflection

The botSTEM partners consider reflection to be an implicit process that occurs whenever we re-use ideas. It includes both retrospective and prospective self-assessment processes where one analyses progress relative to goals or plans next steps. This can refer to abstract goals such as comparing one's current understanding to a target understanding, to concrete goals such as analysing whether one has collected evidence that can be used to support an argument. Both of these retrospective and prospective assessment processes can occur during the execution of a task or the task or a phase of the task have been completed. Learners vary in the degree to which they engage in reflection spontaneously. Thus, it is important to encourage and support reflection, but there is more knowledge of the importance of reflection in learning than of how to foster reflection. This should be taken into account when designing learning activities.

Collaboration

The botSTEM partners consider collaboration to be a key part of the educational experiences we aim to cultivate, due to its potential efficacy for learning and productivity. We distinguish between collaboration and cooperation. Collaboration emphasizes joint full participation in the task, intellectual interdependence, and the co-construction of knowledge, whereas cooperation emphasizes task distribution and often involves isolated individual contributions that are later synthesized to a single product or outcome. In collaborative work it is difficult, and at times impossible, to identify the individual contributions to the final products or outcomes. It is worth stressing that botSTEM will promote collaboration not only with children but also with and between teachers.

Programming and Computational thinking

In botSTEM, the development of computational thinking will be encouraged through the use of robots, physical programming, virtual reality, animations, games, etc. Computational Thinking is understood as shorthand for "thinking like a computer scientist", i.e. using concepts of computer science to formulate and solve problems. In the past decade Computational Thinking has increasingly gained attention in the educational field for its potential to teach logical thinking, problem-solving and digital competence, see also https://ec.europa.eu/jrc/en/computational-thinking. However, an important point here is that, in our vision, programming and/or computational thinking have to be linked to the others subjects in STEM proposals, in order to go beyond computational thinking and help students achieve computational literacy in the sense proposed by DiSessa (2018).

Gender and Learning

botSTEM is aiming to establish gender inclusive teaching and learning activities. Girls came out as much more negative towards technology and its development in the ROSE project, e.g response to the question "Science and Technology can solve nearly all problems" (Sjøberg & Schreiner, 2010). Reasons for encouraging girls and the importance of role models to accomplish this are discussed in Henriksen et a. (2016), from perspective of Beauvoir's description of women as "the second sex" and an expectancy-value model of educational choice. Four reasons were formulated as to why we need to seek gender balance in STEM occupations,

- girls are an underused source of recruitment
- girls can bring new perspectives
- girls can profit from STEM occupations and the empowerment it can give
- everybody should be able to consider all educational and occupational options equally.

A basis for botSTEM is that no single factor defines who is suitable for STEM, and that skills needed in order to make valuable contributions to STEM can be acquired by greater variety of individuals than those dominating STEM enterprises today.
Equal learning opportunities for girls and boys are in botSTEM generated through consideration of

- girls' attitudes and interests of the objects of learning
- the importance of role models, i.e. girls and women engaged in STEM education and occupations.
- professional roles and knowledge society for women in STEM

Theoretical models in science

The relation between theoretical models and reality is central for the scientific processes. Observations and experiments are embedded in theory and therefore "Theory laden" (Hanson 1958). Empirical and theoretical work is connected leading to construction and refinement of theories and theoretical models in an interactive process of discussions, experiments and observations in the science community (Adúriz-Bravo 2012, Giere 1988, Koponen 2007). Communicating this in science class is part of making the nature of science (Erduran and Dagher 2014, Lederman 2007) explicit, which has been found central for the teaching of science.

botSTEM activities will focus on versatile theoretical models for talking about, predicting and explaining science phenomena pertinent to the selected age group (4-8 years old). Therefore, focus in project is on theoretical models connected to Big Ideas (Harlen, 2015), see appendix A for a complete list, and to the everyday lives of the selected age groups.

Robots and robotics

botSTEM concurs with the definition found in Wikipedia for robots and robotics.
A robot is a machine, especially one programmable by a computer, capable of carrying out a complex series of actions automatically. Robotics is an interdisciplinary branch of engineering and science that includes mechanical engineering, electrical engineering, computer science, and others. Robotics deals with the design, construction, operation, and use of robots as well as computer systems for their control, sensory feedback, and information processing. (Wikipedia)

Hence, best practices for STEM education can be formulated in terms of robotics activities focusing on several, if not all, of the four "letters" in STEM, and pertinent theoretical models of science. Robot is also an innovative pedagogical tool enhancing the level of students cooperation, problem solving attitude, the proximal learning areas and the promotion of Pro-social values such as empathy, solidarity, cohesion, generosity, cooperation level.

Good practices

Best practices will be jointly chosen within the consortium among good practices of robotics for STEM learning collected by the partners – based on the criteria below and in cooperation with experts and practicing teachers. Partners will detect good practices and assess them to prepare for the selection of the best practices that will be the basis of the guidelines for teachers. For the assessment, partners will interview experts or expert teachers and together with teachers implement the good practices in preschools and schools. Recommended best practices will be established after that.

Main criteria for good practices addressing 4 and 8 years-old children:

- Pedagogical innovative strategies in education with robotics
- Generic and versatile in relation to robotics and robots
- Specific learning goals for several of the four fields S, T, E, M
- Learning goals related to big ideas in science (Appendix A)

- Gender inclusive
- Including collaborative work
- Involvement of a wide educational community (parents, stakeholders)
- Extended in time

Search – division of countries

Each partner looks for Good Practices in certain countries. Specifically:

- Spain (UBU, ADELE, KVC): Spain, Portugal, France, UK, the Netherlands
- Cyprus (IDEO): Greece, Turkey
- Sweden (HKR): Nordic Countries, Germany, Australia
- Italy (POLO): Macedonia, Lithuania, Bulgaria, USA, India

Spain

The search has been conducted through Google (using general keywords in Spanish and Portuguese), indexed Spanish and Portuguese journals in education and science education and personal contacts. No formal activities, including more than one STEM subject and robotics were found. Nevertheless, it was found that in Spain several companies begin to offer STEM activities for kids (from 4 y.o) and also for teachers, but you have to pay to get access. The companies offer extracurricular activities for children, especially for younger children.

Related from UK & France, the search has been conducted in Scientix database, ESERA proceedings, the classical journals in science education (IJSE, SE, JRST), in Science in School, and in STEM Learning database (the largest provider of education in STEM in the UK). Several examples were found, but a detailed review showed most of them addressed only one STEM subject or were designed for children older than 8 years old. This was particularly true for Scientix database and science education journals. Also, it has been quite difficult to find activities that include more than one of the areas in STEM coupled to robotics and programming for our target ages. In fact, we found neither in England nor France any STEM practices including programming for 4-8 year-olds.

In table 1 there are examples from UK & France. Although we still have to ask the experts, most of the practices listed from UK and France will probably be all best practices, because, in the case of UK, most of them have been selected to conform *CREST Awards*[1] and, in the case of France, to appear in the website of *La main a la Pate*[2] foundation.

Although the images that accompany the STEM activities selected are inclusive in terms of gender, and there are several campaigns (as WISE https://www.wisecampaign.org.uk/), Stem

[1] The CREST Awards scheme is the only nationally recognised accreditation scheme for STEM project work for 5-19 year olds. Around 40'000 students in the UK gain CREST Awards every year through investigations and enquiry-based learning, supporting them to solve real-life STEM challenges.

[2] La main à la pâte aims to develop inquiry-based science education in primary and lower-secondary schools. Launched in 1996 at the initiative of Georges Charpak (Nobel Prize in Physics), Pierre Léna and Yves Quéré, with the support of the Académie des sciences, La main à la pate became in 2012 a foundation for scientific cooperation founded by the Académie des sciences, the Ecole normale supérieure (Paris) and the Ecole normale supérieure of Lyon. The La main à la pâte foundation pursues and develops the activities carried out in France and the rest of the world.

activities focusing specifically in gender inclusion and described from a gender perspective weren´t found for young children. Nevertheless, Stemettes http://stemettes.org/, a social enterprise working across the UK & Ireland and beyond to inspire and support young women into STEM careers, develop some activities, as a "hackathon" (where girls make a website, game, app) for girls as young as 5.

Several searches were performed to find good practices in the Netherlands. The first search was performed on the *EU STEM Coalition* that promotes sharing good practices between national STEM platforms http://www.stemcoalition.eu/programmes. Several initiatives can be found for secondary education, but no results are found for primary education.

Searches were also performed in the Netherland Ministery of education. In general only general reports about the state of education in the Netherlands could be found https://www.government.nl/ministries/ministry-of-education-culture-and-science/documents/reports/2012/10/02/the-state-of-education-in-the-netherlands

The only initiative found for promoting stem in primary school is a programme to incorporate secondary teachers in primary schools https://www.government.nl/latest/news/2015/12/04/greater-scope-for-specialist-secondary-school-teachers-to-teach-at-primary-schools. Another initiative was found for train primary teachers in STEM disciplines http://newtechkids.com/2018/01/gearing-up-for-primary-school-teacher-training-program/

In the Netherlands one of the main problems related to STEM education is the low number of girls choosing STEM careers. Their position is relatively low compared with other EU countries. While 70% of boys with a STEM profile in secondary pre-university (of applied sciences) education opts for an advanced STEM study programme in higher education, less than 50% of girls with a STEM profile proceed to a STEM study programme. For vocational education and training (VET), only 10% of the girls chooses for the technology sector (compared to 44% of boys).

A study about attitudes and confidence on STEM education and careers can be found in: https://www.educationandemployers.org/research/trend-analysis-gender-in-stem-education/, which proposes four steps to improve that results.

- Step 1: awaken interest in the last 4 years of primary education
- Step 2: retain the interest of girls through company visits
- Step 3: support girls in choosing a subject cluster, e.g. through speed dating and providing parents with information
- Step 4: support girls in choosing a study programme, e.g. through speed dating, work shadowing or mentoring.

The only case study found suitable to be presented as a good practice is the one described in this paper http://genderandset.open.ac.uk/index.php/genderandset/article/view/413/756.

There are some initiatives to promote STEM studies in children, for example, in the webs of regional networks of technology and science: https://www.pbt-netwerk.nl/program/regionale-wt-netwerken and http://www.wetenschapentechnologieindeklas.nl/wat-is-wt/

An example of a good practice is from Agnietenschool in Elburg, see https://vimeo.com/175189469. This example is difficult to evaluate, because of the language.

Cyprus

In Cyprus Educational Robotics is an emerging term for the last three or four years. As a term it does not exist in formal education, and that was a result of a thorough search in the official documents of the Ministry of Education. The same results we had for the concept of STEM in general. Nothing has been published or was registered as an official good practice, or guidance for educators.

In higher education "Algorithmic thinking, programming and contemporary applications" is part of the curriculum and it is taught as a separate subject, while educational robotics is absent. http://archeia.moec.gov.cy/sm/110/ap_periechomeno.pdf

On the other side, in primary education Technology has not a position as a separate subject. It is only found in the curriculum of the fourteen (14) so called "Unified All Day Schools", that are operating in a pilot basis since 2006. According to the description for the content of the subject for this kind of schools, *"the subject of Computers remains as a separate lesson, taught at 2 teaching periods, in all classes (while the other schools do not teach the subject as a separate lesson). The aim is to integrate students into the ICT by acquiring satisfactory skills in using basic software programs and modern technology in general"*. The above statement, along with the content of the curriculum remains the same since 2006. http://www.moec.gov.cy/dde/programs/eniaio_oloimero/analytika_programmata.html

Any other kind of initiatives for implementing educational robotics come mostly from private schools and other private educational organizations but they mostly focus on children above 10 years of age. Unless a fund is covering a certain initiative, participants must pay. Usually, such kinds of programmes take place during afterschool activities and they have a "year-round" duration. Others have the form of educational visits during a formal school day, either from experts to schools, or from schools to specific centres, having the approval of the Ministry of Education. For the time being, the broadest (in terms of number of participants and duration) examples of this kind of initiatives, found in Cyprus, are the following two:

- Everyday educational visits from schools to the three hours "Learn programming – Be a superhero" programme, run by Mathisis educational team, where students aged 6 to 14 can attend two different workshops in programming and robotics. The programme is on its 2nd year and it is free since it is funded by Cyprus Computer Society.
- The everyday educational visits to pre-primary and primary schools from the team of the Frederic Robotics Academy, where students take part in various activities of educational robotics according to their age. Participation comes with a small fee per student.

Other kinds of initiatives are scarce workshops offered by private organizations to educators. Many of those workshops are carried out occasionally (e.g. during the European week of code), and the response to those calls is so big, showing us the need for educating and informing educators about STEM and robotics, especially in designing and implementing relevant subjects in their teachings.

Beyond the lack of material and good practices, there is lack of qualified trainers, which means that we need to obtain a system of good practices to train future trainers. One of the problem when it comes to finding good practices, is that most of them come only as general description, with no detailed structure, goals, methods etc., due to ownerships.

To find evidence for the same subject in Turkey, a search was done through the internet. We found nothing published concerning educational robotics or STEM implementation in schools.

We contacted a teacher that works in a private high school in Turkey to find out about their way of approaching the subject.

Sweden

The search process started from the basis of the theoretical framework described above and the national curricula. The national curriculum of Sweden for ages 1-5 years (Skolverket, 2016) is currently under revision for several reasons, one is a decision to strengthen the coverage of digital tools and programming. The current version holds learning goals for STEM, but it is not possible at this time to describe the articulating concerning digital tools (robots) and programming. The national curriculum for compulsory school (Skolverket, 2017) was revised 2017 to encompass specific goals concerning digital tools and programming. The changes foremost concerns the two subject Mathematics and Technology where several learning goals related to this have been included.

A search through Scandinavian and international research journals through uses of databases at ERIC, Springer, Routledge and Wiley, Google (Google scholar), NorDiNa, ForskUL, … has rendered a limited number of good practices involving robotics and programming and STEM subjects. Even though the US was not part of the targeted countries examples from there has been included in the list

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The initial search generated some 25 articles and one e-book (anthology) considered relevant in relation to the concepts of robotics and STEM. From content and reference lists some 10 additional articles and some websites were identified. A majority of the articles addressed social or logical issues e.g. collaboration, problem solving, communication, computational thinking etc. Few addressed the concept of educational robotics focusing on robotics as a mindtool for the construction of knowledge. In search for practices concerned with big ideas in Science only two cases were identified involving older children than our target ages.

Two of the articles generated some extra attention though. They constituted reviews of literature on robotics and STEM. *A Review on the Use of Robots in Education and Young Children* (Educational Technology & Society, 19(2), 148–163). 27 out of 369 articles published in English from 2003-2013 were selected. Articles were excluded due to: E1: Article reported the technical use of robots, designs or innovations. E2: Article reported robotics as a teaching subject. E3: Article reported studies conducted in higher or university education. E4: Article reported the use of robots as assistive technologies. E5: Article did not mention on the use of robots in education. 8 of the selected articles were addressing *Achievement scores, science concepts and sequencing skills*. These articles will be further analyzed.

Exploring the educational potential of robotics in schools: A systematic review (Computers & Education 58 (2012) 978–988). Out of 197 articles selected 107 were found relevant according to the criteria "approached teaching involving robotics for elementary, middle or high school" but only 10 was selected following exclusion due to: Four criteria for exclusion (EC) articles were also identified: EC1: Aimed at teaching of robotics, i.e. robotics is the subject of the learning and not a teaching tool. EC2: Article does not provide a quantitative assessment of learning. If an article presented only interviews, observation and motivating analysis, then it was excluded. EC3: It did not show the use of robots, involving automated equipment or simulation environments with robots. EC4: The article was considered out of context, addressing undergraduate education (the focus of study is elementary, middle and high school), or it reports the design of robots, among other aspects. These 10 articles will be exposed to further analysis.

Concerning the search for best practices in the other Scandinavian countries e-g Denmark, Norway, Finland and Iceland language issues are a hindrance. Although closely related (all but Finish) the peculiarities makes searches in native languages difficult.

In an effort to expand the radius of search for best practices 17 Swedish experts on digital competence, active in contemporary debates on inclusion of the concept of programming in Swedish national curricula (implemented as compulsory in July 1 2018) and issues concerning digitalization of education were approached through e-mail. 12 responses were obtained. The experts are prominent on a national level in producing TV-shows and books on digital competence. Directors of national centers for technology, education in physics, education in chemistry and a national Science Centre. Renowned scholars and experienced teaching champions. Active voices in the public debate both in traditional and social media. The experts were selected from reputation and asked to address the following question: Have you experience of your own on working with robotics, STEM and younger children? If not: with whom should I make contact in order to obtain expressions of best practices. None of the selected 12 recognized themselves as particularly experienced concerning younger children, STEM and robotics but another 8 persons were suggested for an interview. These person will be approached and if qualified interviewed for further input on best practices.

In following up the search process described above expert-teachers have been identified through networks of teachers and teacher educators at universities in Sweden. Views of two active expert teachers are presented here.

Expert teacher 1 (E1) is a teacher in preschool class and only a few months ago, she and her colleagues started working with programming. They started by downloading the Bluebot app to the iPads used in class and familiarizing the children with programming it. Next, they bought Beebots and E1's impression is that the children found it easier to program the physical robot compared to the app robot. She and her colleagues decided not to buy ready-made Beebot rugs, instead, they have made their own rugs that may be altered and created (e.g. by adding photos of science phenomena) the way the teachers and children wish. Bluebots have now been bought and E1 and her colleagues want to learn more about suitable ways to use them.

Expert teacher 2 (E2) is a primary school teacher that has been working with programming and Bluebots for six months. Her main concern when deciding activities is that they should be connected to the curricula and not 'aimless play'. An important aspect for her when children are programming is collaboration and social aspects of the activity. Another key aspect to programming according to E2 is the view that it should focus problem solving and 'a way to think'. E2 includes the robots and programming in many learning situations, for instance when teaching biology, physics, mathematics and language. She wants programming to be integrated in everyday teaching.

The search process has generated that companies rules and teachers use what is available and easy to buy. There have been some critical remarks on educational IT-fairs and conferences in Sweden. Gatherings like BETT in London and the Swedish equivalent SETT. The critique is formulated pointing out the hazard of mixing educational conferences with commercial exhibitions arranged by a commercial company itself. The solutions presented by the commercial companies are suggested to be too simple and not engaging educators in dialogue or development processes. The lectures given are suggested to be too superficial. There is a quest for the academy to step forward and actively show an alternative way of thinking. To offer a more scientifically based public debate on IT in education. (Selling tech to teachers: education trade shows as policy events). Before we have best practices there must be just practices developed. A relevant question is; where do the practices originate from?

Activities focusing gender inclusion and described from a gender perspective proved difficult to find for young children. However, so far discussions with teachers and expert-teachers has rendered a view tested activities with robotics have proven to be by nature gender inclusive, and it has so far not been seen as a major issues for the early-years age group (1-5 y.o.).

An overall take from the search process and the experts is that companies tend to rule the market and that teachers use what is available and easy to buy, which is why a conclusion is that it is time for academia to take its responsibility and produce lists of good practices – backed by a process like in botSTEM.

Criteria for good practices related to STEM based on the interviews of the experts were

- Programming activities including and relating subject specific content has proven more successful and usually make children more interested
- Should stimulate creativity and makes it possible for the children to be producers not consumers
- Activities should include social and democratic aspects such as collaboration and communication
- Activities should be gender inclusive and include boys and girls collaborating and communicating. Practices should encourage children to listen to, discuss and consider each other's thoughts and ideas, in a respectful environment.

Italy

Italian schools according to the legal system, have the decision-making autonomy in the type of educational activities to be offered to pupils. The good practices developed in the field of coding, of inquiry based learning and of robotics are therefore often local and linked to the sensitivity and preparation of the teacher or the permanent network of schools present in the national territory (such as Polo Europeo della Conoscenza).

At the national level, the launch of the National Plan for Digital School (Piano Nazionale per la Scuola Digitale) in 2015 promoted the adaptation of Italian schools to European standards both from the infrastructural (internet connections, technological equipment, etc.) and from the skills and programs (teachers' training, introduction of computational thinking and robotics already from primary schools, etc.) point of view.

Within this action plan we have focused our attention to the "Program the Future" initiative, that allows each primary school student to carry out a 10-hour corpus of logic and computational thinking, enriching the available educational paths. The Italian Ministry of Instruction University and Research (MIUR) started this initiative with the aim of providing schools with a series of simple, fun and easily accessible tools to train students in the basic concepts of computer science. A series of interactive and non-interactive lessons are made available to the schools, which each school institution can use according to their needs and their teaching organization (https://www.programmailfuturo.it/). The project was recognized as a European excellence initiative for digital education in the context of the 2016 European Digital Skills Awards. The initiative saw the participation in the 2016-17 school year of over 1 600 000 students, 25 000 teachers and 5 800 schools throughout Italy. According to data from the Digital School Observatory in 2017, in a sample of 3 500 schools, 74% of schools activated digital citizenship paths, 60% of school started computational thinking or robotics activities.

The State has created the National Operational Plan (PON) "For the School - skills and environments for learning": a program that contains the strategic priorities of the education sector to be implemented over a seven-year period, from 2014 to 2020. The PON provides the financial resources of the ESF for the training of teachers and for laboratories and digital facilities in accordance with the National Plan for the Digital School. Schools can present specific projects related to improving the quality of learning and the inclusiveness of training. (http://www.miur.gov.it/documents/20182/0/Programma+Operativo+Nazionale+%E2%80%9CPer+la+Scuola%E2%80%9D+2014+-2020/a1692813-09a4-4178-ba81-809c8e56cc49)

Also at national level, our research has identified some ministerial initiatives that have promoted the implementation of activities in the field of coding and robotics. The MIUR announced March 2017 as the month of STEM and gathered in a specific site the various initiatives proposed by some schools (http://www.noisiamopari.it/site/it/mese-delle-stem/) and launched for on 8 March of that same year the "Le ragazze contano" initiative (http://www.noisiamopari.it/_file/documenti/circolari/2017/circolare_STEM_2017.pdf.). On the other hand, the Ministry of Equal Opportunities has been funding STEM summer workshops for the last two years to foster collaboration between schools, associations and local organizations involved in scientific promotion. (http://www.pariopportunita.gov.it/notizie/31012018-al-via-la-seconda-edizione-di-in-estate-si-imparano-le-stem/)

In the second phase of the research, we turned to our permanent network of schools, to the initiatives and projects we brought forward. In 2016 we started a course of 40 for teachers from all over Italy providing specific training as a robotics tutor at their schools. In January 2018 was started a training course on the use of educational robotics to prevent bullying with over 100 participants.

Subsequently we have exploited the experience of previous European projects in the field of STEM, in particular the Teamwork Training and Technology Network project - TTTNet (www.tttnet.eu). Within the database of lessons collected by the project, those that were consistent with the age target of BOTSTEM were selected.

The third step was to address the teachers of our national network, collecting the activities they have experimented with at school. The robotics practices are in some cases with the Clementoni robots (other activities besides those described can be found at this site: http://www.clementoni.com/it/areadocenti/ricerca/).

Since the activities for the nursery school were reduced or not entirely suitable for the objectives of BOTSTEM we widened the search to the online portal http://www.scuolavalore.indire.it/ in which we found two practices for the use of the blackboard Interactive Multimedia in the area of STEM.

We have also broadened the request to an association of Macedonian (FYROM) teachers who collaborate with our network. One of the teacher discussed with an adviser from the bureau for Development of Education (Biology advisor). In FYROM students learn most of the STEM subjects 2 times a week in primary education. Seven years ago the Cambridge programme was adapted, the books translated into Macedonian so the teaching practice has become more practical, student centred, interactive and interesting. However, because of the lack of national strategy when it comes to making certain necessary resources available for the schools and teachers not every teacher could teach appropriately. There was a training for the teachers but only a small percentage of teachers have accepted this way of teaching.

There was a manual of good practices financed and supported by USAID (one copy or so for each school) but there is not an online version of it. There was a Facebook group where some teachers uploaded material but it is no longer active, anyway some of the practices were selected from there.

Some Macedonian schools with teachers who are agile and hard working participate in an event called 'coding week' that is taking place simultaneous with the international coding week (https://hourofcode.com/us). In Macedonia Microsoft supports this event.

The sites consulted for the collection of good practices were:

- http://sitezazemjata.ucoz.com/
- https://izvorcemk.wordpress.com/
- www.scientix.eu

Europole also contacted the Panevezys District Education Center in Lithuania, asking for their best practices in STEM education, but they don't have officially recognized practices in the age range of 4 to 8. Each institution chooses how to work with children. Innovative teachers choose the latest teaching methods.

Preschool sector has got a very useful website www.ikimokyklinis.lt, where you can find the newest information, STEAM examples, but everything is in Lithuanian.

The Ministry of Education has outlined the most important directions for the year 2018: to update preschool and basic development environment as well as contents with regard to special needs children and integrate sustainable development, creativity, business and STEAM competences. All this is going to result in: collections of methodological materials for teachers, aiming at implementing sustainable development, creativity competences and STEAM elements in preschool education; implementation of sustainable development, creativity, IT and STEAM development elements in preschool educational institutions.

Collection of good practices

The good practices found through the above described search processes are summarized in table 1, where they are described by name, age group, school subject, duration and locality.

Table 1. Summary of good practices.

Title of the activity	Age group	School subjects + other topics	Duration	Locality
KIBO_1	4-7	S, T, E, social aspects	Adaptable for learners	Classroom, lab, at home
Bluebot_in_person (Children programming each other)	7-9	S, T, E, M, social aspects	Adaptable for learners	Classroom, lab, outdoors, at home
Bluebot_PhyMa (Friction and mathematics)	7-9	S (physics), T, E, M, social aspects	Adaptable for learners	Classroom, lab, outdoors, at home
Bluebot_Ma (Math- and ABC-rugs)	4-8	T, M, Swedish, social aspects	Adaptable for learners	Classroom, lab, outdoors, at home
Bluebot_Sci (The robot as a link in e.g. biology)	4-8	S (biology), T, social aspects	Adaptable for learners	Classroom, lab, outdoors, at home
Bluebot_Phy (Gravitation and friction)	4-5	S (physics, mechanics)	2 hours	Preschool
From Poetry to Robotics	7	M, Italian, English	3 lessons a' 30 min, 1 lesson a´2 h	Classroom
Adaptable Learning Graph for Maths	6	M	Adaptable for learners	Computer lab, class, at home
High density cognitive paths	6-7	M	2 h	Classroom
Sound and light through cryptology and robotics	5-	S (physics), M, language	2 lessons a´90 min	Computer lab, class, at home
Useless machines	6-	T, drawing, Italian	90 min	Classroom, lab, outdoors, at home
Beebots in stimulated recall of science content	6	S (biology), T	Adaptable for learners	Classroom, lab, outdoors, at home
Beat the flood	7-8	S (physics), E, Art	2-3 sessions	Classroom, lab, outdoors, at home
Climate change activities for primary school	7-8	S (biology, chemistry), M, Art	6 sessions	Classroom, lab, outdoors, at home
The Hourglass race	3-4	S (physics), T	145 min in 9 sessions	Classroom, lab, outdoors, at home
Testing Timers	5-7	T, M, design	60 min	Classroom, lab, outdoors, at home
Microplastics: small but deadly	3-16	S (chemistry, biology)	10 sessions	Classroom
Talent viewer	9-12	Art, Gender, communication, creativity	8 sessions of 45 min	Classroom

Creating digital drawings with Python	8-10	T, Art	90 min	Classroom, ICT room
Transforming family props into a Scratch game	6-	T, Art, Portuguese language	90 min	Classroom, ICT room
Learn Coding – Be a superhero	6-15	T, E (coding and robotics)	3 hours each session	Computer lab
Joint through Technology	5-15	T, E (coding and robotics)	6 sessions a' 3 hours	Computer lab
Squashed tomatoes	7-10	S (Physics), T, E, M	1 session, 2h	classroom
The wind	3-5	S (Physics), T, D (design),	6 sessions, 1 hour each	Classroom &/ outdoor
Building with stones	5-8	S (Physics), E, D & T	15 sessions, 50 min each	Classroom &/ outdoor
The sons	6-8	S (Physics), M (music), & T	2 sessions, 60 min each	Classroom
The colours	4-6	S (Physics), T & D	2 sessions, 60 min each	Classroom
The vegetal biodiversity	6-8	S (Biology), T, D	3 sessions, 60 min each	Classroom &/ outdoor
Crystallography	4-11	S (Physics, Chemistry, Geology), M	4 sessions, 90 min each	Classroom
A mysterious grot	6-8	S (Physics), M ,E	3 sessions, 60 min each	Classroom
Inseparables or not	5-7	S (physics), M	2 sessions 60 min each	classroom
Vibrating sound and music!	3-6	S (Physics), Music		
The body and the movement	5	S (Anatomy)	6 phases	classroom
Geometry with MIND robot	6-7	M	90 min	classroom
Many flowers with ICT	5	S, M	3 classes	classroom
Snowman	3-7	Self developing	30 min	preschool
Scribbiling story	5-6	S, T, Art	2 hours	classroom
Robot DOC on the line of numbers	6-7	M	Adaptable to learners	classroom
Senses	5-7	S	40 min	classroom
Multiplication with the numbers 2, 3, 5 and 10	7	M	40 min	Classroom, hall, outside
Getting clean drinking water	6-7	S	40 min	classroom
Sources of light and shadow	5-7	S	40 min	Classroom, outside
Life cycles	5-7	S (biology)	Adaptable	Outside
Making an 'active' volcano	6-7	S	40 min	Classroom

Program directions with Next 1.0	3-5	Robotics, maths	50 min	Classroom
Program directions, colors, sounds, halts with Next 2..0	6-7	robotics, sciences	50 min	classroom

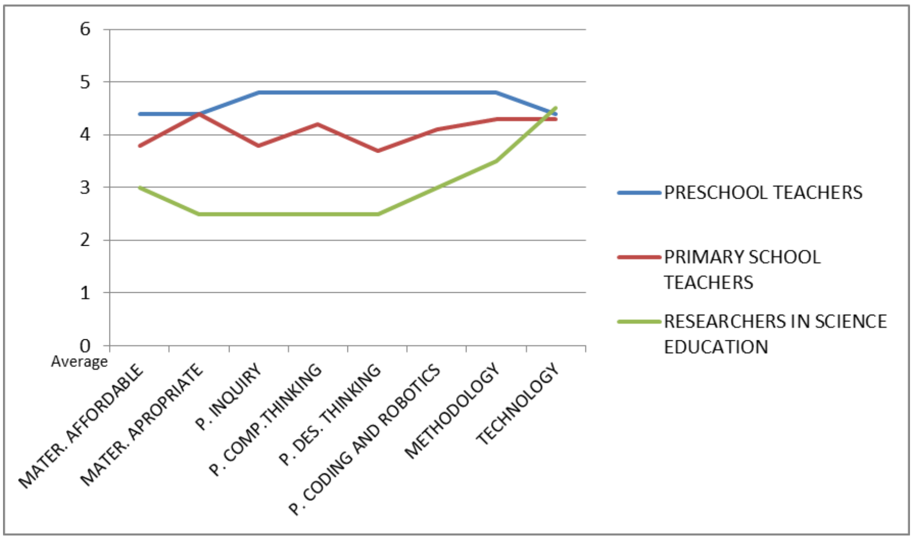
Descriptions of each the good practices in a form following a template agreed upon by the partners can be found at botSTEM.eu.

Evaluation of good practices

The good practices listed in table 1 has been evaluated by experts and expert teachers in the partner countries. The expert' evaluation was collected through a questionnaire filled out by paper and pencil or interactively via internet. The experts were asked about various aspects of the activities and in conclusion also requested to rate the activities, see appendix B for the questionnaire.

The expert sample consisted of 22 experts in education with an average of 16 years of expertise as Preschool Teachers (40.9%), as Primary School Teachers (50%) and as Educational Researchers (9.1%). The Good Practices' evaluation was mainly focused on the analysis of the materials, the pedagogy, the methodologies and the technology used, items were evaluated with an average score and the results are given in table 1.

Table 2. Punctuations given by the respondents.



Overall the experts were very satisfied with the good practices, especially the expert teachers. They considered that most of the practices can be used in their contexts and that the pedagogies by which they were implemented based on inquiry teaching, computational thinking, design thinking, coding and robotics are suitable. Also, teachers considered that the methodologies proposed in the practices may contribute to create inclusive environments. Nevertheless, about pedagogies and methodologies, the results show how the highest punctuations are given by Preschool Teachers, while the lowest are by Researchers. This may be due to the broader theoretical knowledge that researchers may have. It is important to highlight that all experts agree that the technology proposed (Robots; code-learning programs;

etc.) are appropriate for young children and their teachers. This result is important for the botSTEM project, because it indicates that teachers are open for introducing robotics and code learning in their classroom.

Table 3. Rating of the tested activities.

1º **(13) Children programming each other as bluebots in primary school**	7 (17,9%)
2º **(16) Bluebot – Gravitation and friction**	6 (15.4%)
2º **(5) Using the Bluebot as a link in natural science**	6 (15.4%)
3º (7) **Joint through technology**	3 (7.7%)
(21) KIBO	2 (5.1%)
(10) Learn Coding – Be a superhero	2 (5.1%)
(3) Microplastics: small but deadly	1 (2.6%)
(4) Bluebots on math and ABC-rugs	1 (2.6%)
(8) The sounds	1 (2.6%)
(12) Planting ideas: climate-change activities for primary school	1 (2.6%)
(14) The wind	1 (2.6%)
(15) Program directions with Next 1.0	1 (2.6%)
(26) High density cognitive paths doing geometry	1 (2.6%)
(29) Scribbling story	1 (2.6%)
(36) Bluebots, physics and mathematics in primary school	1 (2.6%)
(37) Squashed tomatoes	1 (2.6%)
(39) Talent Viewer	1 (2.6%)
(42) Multiplication with the numbers 2, 3, 5 and 10	1 (2.6%)
(45) Inseparable. Or not?	1 (2.6%)

The evaluation-questionnaire responses rates four of the activities in the top three positions, all of which related to robotics and STEM. These activities will be given special consideration in the implementation procedure during 2018-2019.

Conclusions

The overall process has been running smoothly, but the fact that documented examples of teaching and learning practices for integrated STEM utilizing robotics are scarce has made the search difficult. It has proven necessary for the consortium to extend the period of searches somewhat in order to collect and analyse a sufficient number of good practices.

The findings of good practice related to integrated STEM teaching and learning has been slim and the consortium will therefore increase efforts in designing and new activities. These activities will be implemented, evaluated, redesigned and made ready for final implementation at the local level. Thereafter they will be translated and tested at the European level by the different partners and made available through the interactive web-site of the project.

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Appendix A. Big Ideas in Science

In Harlen (2015) they concluded that big ideas should:

- have explanatory power in relation to a large number of objects, events and phenomena that are encountered by students in their lives during and after their school years
- provide a basis for understanding issues, such as the use of energy, involved in making decisions that affect learners' own and others' health and wellbeing and the environment
- lead to enjoyment and satisfaction in being able to answer or find answers to the kinds of questions that people ask about themselves and the natural world
- have cultural significance – for instance in affecting views of the human condition – reflecting achievements in the history of science, inspiration from the study of nature and the impacts of human activity on the environment. (Harlen, 2015, p. 14)

Ideas of science

1. All matter in the Universe is made of very small particles
2. Objects can affect other objects at a distance
3. Changing the movement of an object requires a net force to be acting on it
4. The total amount of energy in the Universe is always the same but can be transferred from one energy store to another during an event
5. The composition of the Earth and its atmosphere and the processes occurring within them shape the Earth's surface and its climate
6. Our solar system is a very small part of one of billions of galaxies in the Universe
7. Organisms are organised on a cellular basis and have a finite life span
8. Organisms require a supply of energy and materials for which they often depend on, or compete with, other organisms
9. Genetic information is passed down from one generation of organisms to another
10. The diversity of organisms, living and extinct, is the result of evolution

Ideas about science

11. Science is about finding the cause or causes of phenomena in the natural world
12. Scientific explanations, theories and models are those that best fit the evidence available at a particular time
13. The knowledge produced by science is used in engineering and technologies to create products to serve human ends
14. Applications of science often have ethical, social, economic and political implications. (Harlen, 2015, p. 15-17)

Appendix B. Questionnaire – Evaluation of good practices.

One of the main purposes of the botSTEM Project is to count on teachers' collaboration and support so that through your knowledge and experience you can help us to create an active and enriching learning community. Therefore, your contribution as an expert in education is essential.

Personal background information

Are you:

Preschool teacher □ Primary school teacher □ Researcher in Science Education □

Including this school year, how long have you been teaching? ___________

Indicate from 1 to 5 your degree of compliance with the following statements, being:

1: Totally disagree 2: In disagreement 3: Neutral 4: Agree 5: Totally agree

	1	2	3	4	5
The good practices proposed are useful for preschool and primary school teachers.					
Please, make any further remark in regard to this statement.					

	1	2	3	4	5
*The **material** included in the good practices is affordable.					
*The **material** included in the good practices is appropriate.					
Please, make any further remark in regard to material.					

*The **pedagogy** implemented is suitable:	1	2	3	4	5
- Inquiry teaching					
- Computational thinking					
- Design thinking					
- Coding and robotics					
Please, make any further remark in regard to pedagogy.					

	1	2	3	4	5
*The **methodologies** used contribute to create inclusive environments.					
Please, make any further remark in regard to methodology.					

	1	2	3	4	5
*The **technology** proposed (Robots; code-learning programs; etc.) is appropriate for children and teachers.					
Please, make any further remark in regard to technology.					

Among all the good practices selected, which three do you consider the best?	1.
	2.
	3.