roBOTics and STEM education for children and primary schools

botSTEM

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Robotics and STEM education for 4-8 y.o children and primary schools

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Abstract

Recent research have demonstrated that early techno-scientific literacy in children as young as 4 years old could improve their long-term achievement in STEM fields and raise the scientific and technological vocations, especially for girls. It is the integration of science, technology, engineering and mathematics fields that creates valuable STEM experiences for children. In particular, inquiry teaching methodology and engineering design help intertwine the different fields in STEM through real world problems. With this approach, children have opportunities to practice skills such as reasoning, reflection, questioning, modelling, justifying decisions and communicating. In addition, computational thinking (by means of robotics and/or code learning) should be introduced at early childhood for its potential to teach logical thinking, problem solving and digital competence.

botSTEM is an ERASMUS+ KA201 project with partners in Spain (coordinators), Sweden, Italy and Cyprus, that aims to address this point, through the development of a new methodology for including gender inclusive STEM integrated programmes into the formal education curricula for childhood and primary schools (4-8 years old). One of it aims is to build a downloadable interactive Toolkit, freely available. The toolkit will include good practices for collaborative inquiry teaching and learning concerning robotics and STEM with methodological guidelines. Main criteria for good practices addressing 4 and 8 years-old children are:

- Pedagogical innovative strategies in education with robotics
- Specific learning goals for several of the four fields S, T, E, M
- Learning goals related to big ideas in science
- Gender inclusive
- Including collaborative work
- Extended in time

Theoretical Framework

Science Education

There is often a tension between science education aimed at producing the next generation of professional scientists , and science education aimed at equipping citizens with the knowledge and understanding of science that they need to participate in democratic decision making. 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.

Also, 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 and to the everyday lives of the selected age groups.

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.

Robots/robotics

Robotics is an interdisciplinary branch of engineering and science and deals with the design, construction, operation, and use of robots as well as computer systems for their control, sensory feedback, and information processing. 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.

Inquiry

Inquiry 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 STEM. **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 The couple inquiry combines a **guided and open inquiry investigation**.

Programming – 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

Gender Inclusion

botSTEM is aiming to establish gender inclusive teaching and learning activities. 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

Integrative 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 and collaborative projects.

> "(…) 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).

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

Methods

First results

Spanish partners

Spain and Portugal

Google, indexed Spanish and Portuguese journals in education and science education and personal contacts

UK & France

Scientix database, ESERA proceedings, the classical journals in science education (IJSE, SE, JRST), in Science in School, and in STEM Learning database

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)

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. Although the images that accompany the STEM activities selected are **inclusive in terms of gender**, Stem activities focusing specifically in gender inclusion and described from a gender perspective weren´t found for young children

Italian partners

Italy

National Operational Plan (PON), Ministerial initiatives that have promoted the implementation of activities in the field of coding and robotics, internet search and our permanent network of schools

Macedonia

Internet search, association of Macedonian (FYROM) teachers

Lithuania

Contact with the Panevezys District Education Center and internet search

The MIUR announced March 2017 as the month of STEM and gathered in a specific site the various initiatives proposed by some schools and launched for on 8 March of that same year the "Le ragazze contano" initiative . 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, and several courses for teachers are being develop on the use of educational robotics.

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.

Preschool sector has got a very useful website www.ikimokyklinis.lt-. 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

Swedish partners

Nordic countries, Germany,

National curricula, Scandinavian and international research journals through uses of databases at ERIC, Springer, Routledge and Wiley, Google (Google scholar), NorDiNa, ForskUL; contact with 17 Swedish experts (12 respond) on digital competencies selected from reputation, contact with 2 expert-teachers

The national curriculum of Sweden for ages 1-5 years is currently under revision. The current version holds learning goals for STEM, but is expected to be expanded concerning digital tools (robots) and programming. The literature search is based on this assumption. A majority of the located articles address social or logical issues e.g. collaboration, problem solving, communication, computational thinking etc. Few address the concept of educational robotics as a mindtool for the construction of knowledge related to STEM.

None of the selected teachers recognized themselves as particularly experienced concerning younger children. 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.

Language issues are a hindrance and particularities in national curricula make searches in native languages somewhat challenging.

Cypriot partners

Cyprus

Internet, personal contact analysis of syllabus and educational regulations

Educational Robotics is an emerging theme for the last three or four years. As a theme 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. Nothing has been published or was registered as an official good practice, or guidance for educators. In primary education Technology has not a position as a separate subject. It is only found in the curriculum of the fourteen. Any other kind of initiatives for implementing educational robotics come mostly from private schools and other private organizations

Turkey

Internet, personal contacts.

We found nothing published concerning educational robotics or STEM implementation in schools.

Examples of Best 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_PhyMa (Friction and mathematics)	7-9	S (physics), T, E, M, 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
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
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
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
Inseparables or not	5-7	S (physics), M	2 sessions 60 min each	classroom
Vibrating sound and music!	3-6	S (Physics), Music		
Geometry with MIND robot	6-7	M, T	90 min	classroom
Many flowers with ICT	5	S, M	3 classes	classroom
Scribbiling story	5-6	S, T, Art	2 hours	classroom
Robot DOC on the line of numbers	6-7	M, T	Adaptable to learners	classroom

Conclusions

Documented examples of teaching and learning practices for integrated STEM utilizing robotics are scarce, and has made the search difficult. Most of the practices found are extracurricular practices, being developed in non-formal environments and they are especially scarce for the focus age of this project. However, there seems to be integrated STEM activities beginning to appear for older students, in particular secondary school students. Other points that emerge from the interviews of experts is that teachers use what is available and easy to buy and use. Hence, activities are not necessarily guided by developed framework methodology and teaching approaches.

Preliminary teaching sequences for childhood education are currently being designed based on the outcomes of the initial search for good practices. These activities are designed from the guiding theoretical ideas of the project and will be implemented, refined and evaluated in preschools and schools in the partner countries.

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