Robotics for School – Erasmus+

RESEARCH REPORT ON GOOD PRACTICES

Robotics as blended learning approach for training

A "good practice" can be defined as follows: A good practice is not only a practice that is good, but a practice that has been proven to work well and produce good results, and is therefore recommended as a model. It is a successful experience, which has been tested and validated, in the broad sense, which has been repeated and deserves to be shared so that a greater number of people can adopt it. In the following report we want to share good practices and successful pedagogies for robotic education from different European countries. Main focus is Estonia, Finland, Sweden and United Kingdom.

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Erasmus+

ROBOTICS FOR SCHOOLS

Sense • Process • Control

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Robotic education & Good practice

Robotic education is a new and rapidly growing field in Europe. Robotic curricula and courses has been already long time in universities and vocational education schools but not so much in primary and secondary level schools. Right now (2015-2016) there is big change going on where more and more countries are officially introducing the robotics already in general education school level. In this process Estonia has been one of the leading country in Europe and official robotic course for secondary schools or gymnasium is already introduced in 2011. The experience of applying the robotics for schools has shown that one of the success factor is a motivation and competences of teachers who are teaching robotics in schools. Based on this we have started countrywide program for teachers trainings and trained most of the teachers in two level of robotics. However there are many innovative initiatives every country in Europe and these good practices are important to study and apply into practice where possible. This document describes selected good practices in our partner consortium countries as well as cross- European activities. Good practices are re-formatted and described in same format to make them comparable and include relevant information to those who are interested to learn or apply them in the organization, network or national level.

Good practice criteria

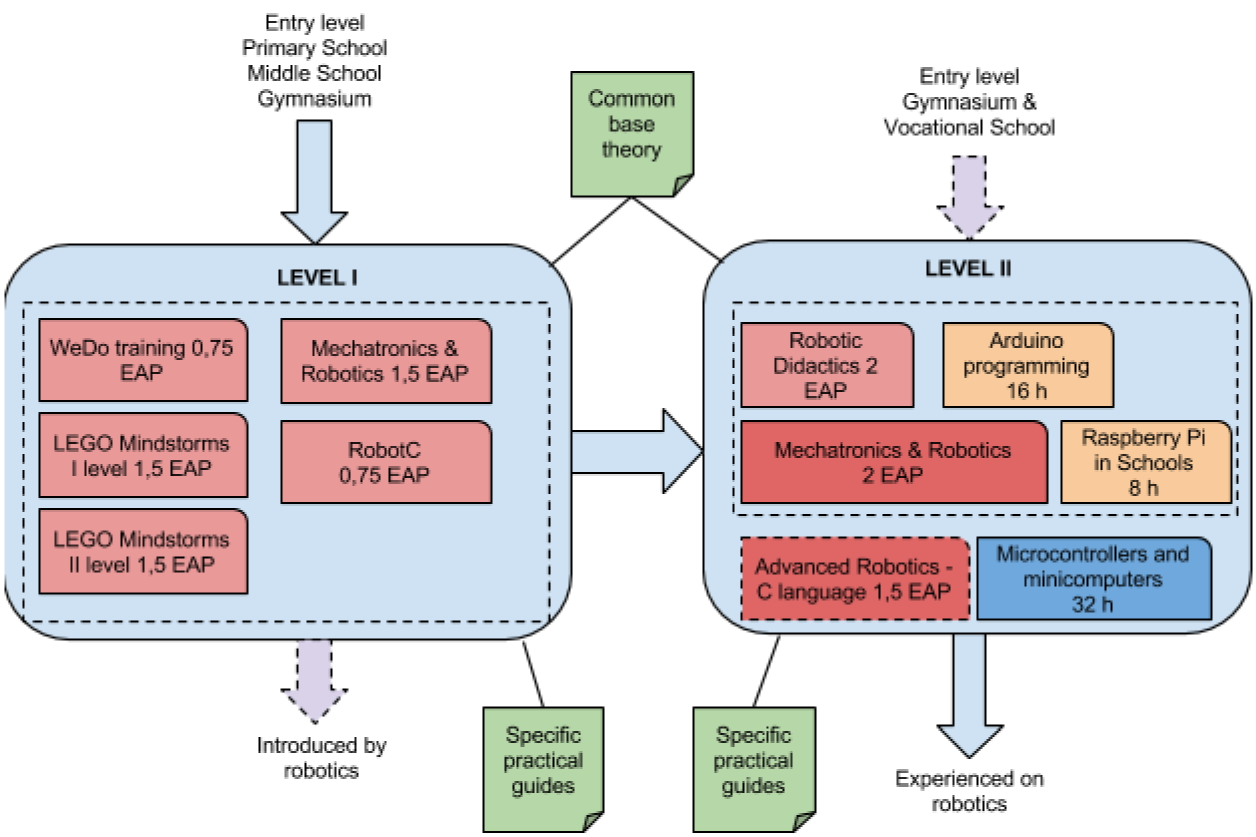
The following set of criteria will help you determine whether a practice is a "good practice":

- **Effective and successful**
  A "good practice" has proven its strategic relevance as the most effective way in achieving a specific objective; it has been successfully adopted and has had a positive impact on individuals and/or communities.
- **Environmentally, economically and socially sustainable:**
  A "good practice" meets current needs, in particular the essential needs of the world's poorest, without compromising the ability to address future needs.
- **Technically feasible:**
  Technical feasibility is the basis of a "good practice". It is easy to learn and to implement.

- **Inherently participatory:**
  Participatory approaches are essential as they support a joint sense of ownership of decisions and actions.
- **Replicable and adaptable:**
  A "good practice" should have the potential for replication and should therefore be adaptable to similar objectives in varying situations.

Good practices in Estonia

Teacher training in Estonia is divided into two levels based on hardware platform and target group experience. Both levels have inner structure where some of the material are common and some different. Following schematics is presenting an overview of teacher training concepts applied in Estonia and supported by governmental organizations or projects, meaning that all courses are free and even obligatory for some cases for robotic teachers in general schools and vocational schools.



Good practices in Estonia are hereafter described more detail and is divided according to the education levels and main organizers of robotic education in Estonia.

Title	Robotic Teacher training program on advanced level
Author(s)	Raivo Sell, Ph.D
Objective	To provide knowledge and practical skills on teaching advanced robotics for gymnasium and vocational education teachers. Ensure that pupils and VET students are introduced and have an experience of building intelligent systems. Pupils and students are attracted to continue their studies on engineering domain.
Location /geographical coverage	Estonia
Introduction	In Estonia, it is crucial to reflect technology changes and worldwide trends in education due the small population and need to compete with other well-established countries. In Estonia fundamental changes are sometimes easier to initiate due the small population and relatively openness for new technology. Robotics is one of the technology where well educated people are desperately needed in near future and therefore it is also included into official state curriculum of gymnasiums in Estonia. However there are not enough teacher who are able or educated to run robotic courses included into school programs and it is challenge to start robotic course from scratch. As initial situation described above the teacher training program with full educational material was developed by cooperation with different parties for supporting new generation teaching. As a result of this practice the robotics in schools are successfully

	started and now needs to brought into new level with new interactive material and methodologies. The good practice is carried out in a time period 2012-2015
Stakeholders and Partners	Main beneficiaries and target group was gymnasium and primary school teachers and through them also pupils. Secondary target group was vocational education teachers and students. Trainings and material development was performed by Estonian leading universities, private companies and non-profit organizations. Main partners: ● Tallinn University of Technology ● University of Tartu ● ITT Group ● NPO Robootika Support and finances were provided by governmental organizations and EU projects, namely: ● TigerLeap Foundation ● HITSA ● EU programs
Methodological Approach	Main methodology applied for this good practice is the “Robotic Teaching and Learning Concept - RTLC”. The methodology is designed and implemented by research team of ITT Group and Tallinn University of Technology. See more details of RTLC in reference [2]. In the trainings the hands-on approach is prevailing.

Validation	The results were always validated by teachers who finalized program and applied the knowledge into the practice in their own school. First initial feedback was gathered through the feedback forms and secondary, but more important validation was recorded by the number of schools, number of new robotic initiatives from schools and participation from different robotic events.
Impact	Main impact is that the robotic course in schools is started and teacher have full material as well as possibility to get free training course which includes also didactics of robotics and technology. The number of pupils showing interest to the engineering fields and applying to engineering curricula in universities has been increased. The participation of robotic events (Robotex competition, etc) by school pupils is also dramatically increased. No negative aspects are recorder.
Innovation and Success Factors	Training teachers with new technology and applying it to schools is still innovative although the robotics has been available for a long time. So far it has been more a field for technical colleges and universities. Now the robotics education has been implement in lower educational levels and schoolchildren can start learning robotics very early. Success factor of this good practices are as follows: ● Pupils are interested and keen to study technology ● Teachers are ready to learn new technology and apply it to primary education ● Government and governmental institutions support the activity and provide legal framework (like updating

	curriculum) as well as financial support (for buying robotic kits) ● Comprehensive local teaching and learning material and qualified teacher trainers (both, in didactics and technology)
Constraints	For applying this good practice into force in other country than Estonia needs to deal with following constraints and challenges: ● There must be support from different parties like government, school management and educators ● Good financial schemas are needed for robotic hardware and also teacher training support. Robotics is strongly hands-on and hardware related domain and finances are needed to acquire the robotic kits. ● Teacher training courses are crucial to establish successful robotic course in school and convince teachers to start the process
Lessons learned	Most important is the collaboration. Collaboration between governmental organizations, educators, schools, teachers and financial support bodies.
Sustainability	The field itself is developing very rapidly and continuous support, updating material and offering trainings is a key factor of sustainability. Continuous process of updating the material, training curricula and equipment is extremely important and the process cannot be only project based, although projects can be arranged to provide time based support for continuous process.
Replicability and/or up-scaling	What are the possibilities of extending the good practice more widely? What are the conditions that should be met/respected to

	ensure that the good practice is replicated, but adapted to the new context? The aim is to go further than the section "Innovations / critical success factors" in specifying the requirements for replication of the practice on a larger scale (national, regional, international).
Conclusion	The good practice described here has been successful in combination with teacher training Level I activities as well as many other initiatives either local or EU support. For example massive teaching and learning material development, Robotic HomeLab kit development and DistanceLab establishment have played crucial role of the success of this good practice. It have to be kept in mind when trying to reproduce this good practice that the success factor includes also ICT infrastructure, motivated teachers and financial support for acquiring the hardware and development cost.
Contact details	Raivo Sell, raivo@robolabor.ee, ITT Group OÜ / Tallinn University of Technology
Related Web site(s)	http://home.roboticlab.eu http://moodle.robolabor.ee
Related resources that have been developed	● Textbook for Gymnasium Robotic course ● Workbook for Gymnasium Robotic course (Level II) ● Teacher book Gymnasium Robotic course (Level II) ● Open courseware in Robotic Network of Excellence (home.roboticlab.eu)

Photo/Image

Conclusions from good practices in Estonia

Even the good practice described here can be considered as success story there is strong need for continuation of trainings in different level and branches of robotics in school. For example good platform independent teaching material for primary school level is still not available in local language. This issue is addressed also by this project and will produce new teaching and learning content called RoboQuest. This will hopefully increase implementation of problem based robotic teaching and learning approach on different hardware platforms.

Good practices in Finland

Robotics and coding are not new in Finnish schools. In the 1990's robotics (e.g. graphical programming with LEGO LOGO) was a part of the technology education provided by some of the K12-schools in Finland. Despite the efforts in these projects, robotics/coding never experienced a more nationwide uptake, neither in practice nor in policy. As a matter of fact, coding/robotics are not part of the current national curriculum (implemented in 2004) and it does not include references to or from these projects. In the absence of reference in the formal curriculum, the current general situation has been that robotics and coding have been taught by active teachers who are interested in robotics mostly in after school activities, resulting in a situation that currently there are great differences between schools and districts when it comes to teaching coding and robotics.

This is however about to change with the new Finnish national curriculum comes into effect in 2016. Though the new curriculum does not mention robotics explicitly, it has implicit references to robotics via coding that has been added to the new curriculum. In the new curriculum, coding is included as a part of the handicraft and mathematics teaching, and coding is also mentioned in the cross-curricular activities in the curriculum, which are referred under the heading: wide-ranging know-how.

Adoption of coding in the national curriculum is the first step, but in the Finnish situation this does not necessarily mean that it is implemented in the same way throughout the country as Finnish school policy gives wide autonomy for communes and schools in curriculum implementation. The national curriculum does not prescribe detailed models for schools or teachers on how to implement the coding (and robotics) to their teaching. The national curriculum is merely a framework for defining local curricula and school level syllabi. Schools and teachers may decide themselves on pedagogical practices and technological solutions to implement the curriculum.

Moreover there is also the geographical challenge to reach all the teachers in Finland in relation to teacher training of robotics in Finland. As the Finnish economy has been in downturn past years and schools have been forced to cut their expenses, and in-service training has received less money year after year. This has led schools to cut down on for instance costs for travelling to in-service trainings provided by universities and projects. This situation is especially problematic for smaller periphery communes and schools that cannot cover the travel expenses for trainings, even though the training itself would be free of charge. The situation becomes even more problematic if one realizes that addition to the traveling expenses schools would often need to hire a substitute teacher for the duration of the teacher training, since some communes have had a substitute teacher ban as part of the austerity policy during the past years. This poses serious additional problems for teachers willing to educate themselves, especially in comprehensive schools where by law the students need to be supervised in every lesson.

As the teaching of robotics overlaps inevitably with computational thinking and coding, at the moment Finnish teachers train themselves mostly to basics of graphical programming environments, such as Scratch and Racket. Currently one of the most advanced practice in teacher training is a complimentary MOOC (Massive Open Online Course), which highlights ubiquitous learning.

Title	**Code Alphabet (Koodiaapinen), a MOOC for teaching basics of coding in graphical programming environment.**
Author(s)	M.Soc.Sci. Aleksi Lahti PhD in ed. Tomi Jaakkola PhD in ed. Koen Veermans
Objective	The objective of Code Alphabet –MOOC is to introduce basics of coding for Finnish teachers. MOOC provides examples, webinars and coding assignments for teachers in three tracks: Scratch Jr., Scratch and Racket. Aim of this MOOC is to give hands-on experiences for teachers about programming in graphical environments and establish understanding about coding teaching in primary and secondary schools.

Location /geographical coverage	MOOC is provided for all the teachers in Finland. As MOOC is generic and easy to disseminate, there are no geographical obstacles to take part to this course. Teachers need only internet connection and computer to run this course.
Introduction	The education of coding (or robotics) is not yet obligatory for graduating teachers, and at the moment in-service training for teachers willing to try robotics is rather scattered. In-service trainings for robotics are often provided by different projects (funded by e.g. the National Board of Education, Centre for Economic Development, Transport and the Environment, European Union) in often in collaboration with a University. As a result these projects often run in cities close to universities or large cities that can afford investment in know-how for robotics teaching in order to provide that to the community. Other projects operate often on a small scale, and lean mostly on active teachers who are willing to try robotics in their local school. As robotics and coding projects have been carried out in Finland since 1990's, there is tacit knowledge and know-how about teaching coding in Finnish schools. These resources and know-how are being disseminated with the MOOC, which was launched first time in autumn term 2015. For teachers the MOOC provided an ubiquitous way to explore basics of coding and computational thinking without geographical and economic constraints.
Stakeholders and Partners	Main beneficiaries and target group were teachers, mostly from primary schools. Through teachers competence increase also pupils will benefit from the MOOC. The MOOC was provided by five Finnish individuals, who are working as teachers and researchers. None of the administrators

were paid for providing Coding Alphabet -MOOC, so this entity was executed pro bono. Aalto University will carry out academic research of this MOOC, but it did not compensate costs directly. Some of the making of the materials for Code Alphabet –MOOC were endowed by the Finnish Federation of Technology Industries and Finnish IT trainers association. Still, none of the authors profited economically of this MOOC.

Cooperation organizations of Code Alphabet –MOOC:

- Finnish IT trainers association
- Aalto University
- Finnish Federation of Technology Industries
- Erasmus+ -project: “TACCLE3”

Methodological Approach

Coding Alphabet –MOOC consists of three basic entirety:
1. Theoretical sections on computational thinking
2. Pedagogical sections on how various concepts and tools can be used in classroom work
3. Hands-on exercises fitted to various age ranges with graphical programming tools

The course highlights teachers work life competences and takes into account the needs of implementation on national curriculum 2016 in Finnish primary school perspective. The course is based on an open library of content, which materials are distributed with CC-license (CC BY).

The methodological approach combines peer learning, collaborative working and learning by doing. All the materials have been designed to instruct the participants with clear learning paths. Participants collaborate in this MOOC with collaborative

	learning platforms e.g. by discussion parts and sharing their assignment outputs for other participants. Participants follow the designed learning path by watching learning videos and examples provided by the course administrators. After a theoretical part participants drill their coding skills with hands-on exercises. Participants share their exercise outputs to other participants with collaborative e-learning tools, so that the peer learning would bolster the learning curve.
Validation	The validation of Code Alphabet –MOOC was monitored with pre- and post-inquiries provided for all the attendees. The post-inquiries will be analyzed with academic research after the first MOOC in 2016. The good practice will be tough molded before the next MOOC, and the input from final users will be used to enhance the quality of the Code Alphabet –MOOC.
Impact	Impact of this MOOC can be seen in positive light. Over 2500 Finnish teachers enrolled to this course, and the course provided streamlined materials about coding in Finnish. These materials can be reused in forthcoming coding trainings. One of the key points of Coding Alphabet –MOOC was the ubiquitous feature that allowed participation on this course despite of your geographical location. Moreover MOOC utilized the possibilities of e-learning and gave practical experiences for participants how they could harness multimodal materials and e-learning approaches in their own teaching.
Innovation and Success Factors	Coding Alpahabet –MOOC possess major innovation prospects. As all materials are electronic and coding teaching is highly generic, this MOOC could be disseminated widely to other countries after language translations. The well designed course structure could

	also help other institutions to develop coding MOOCs for their needs. The downsides of this MOOC were the economic resources which were scanty. As five individuals designed and carried out MOOC for over 2500 participants on the side, inevitably the real-time feedback and instruction was minor. Even course harnessed peer learning and –support, such demanding subject as coding would need significant instruction in problematic situations especially on MOOC course, where the drop-out numbers are commonly high. Learning of coding and computational thinking are key elements in robotics, so Coding Alphabet -MOOC could play essential role in students or teachers introduction to robotics. As students could learn programming in graphical programming environments in this MOOC, could this course ease the threshold of starting robotics teaching. Coding Alphabet –MOOC could be also tailored for robotics teaching, as the learning materials could cover e.g. learning activities about Lego Robotics.
Constraints	As addressed above, constraints of this practice involve to MOOCs' high drop-out numbers as the instruction is minute and MOOCs demand high engagement from participants. Coding Alphabet –MOOC's final performance result was 36 %, which is higher than on average MOOC. This emphasizes the participants' engagement, but not least, because the national curriculum will be put in effect next school year. For those countries and teachers who are not forced to implement coding in their syllabi's MOOC is demanding way to learn coding. Moreover MOOC has to be well designed and structured, so that participants can progress with their learning activities. Designing a MOOC that both instructs participants enough and engages to complete the course needs proper recourses.

Lessons learned	Code Alphabet –MOOC provided significant know-how and experience about MOOCs in Finnish in-service teacher training context. Moreover MOOC gave perspectives about training teachers to code. The end-user analysis will bring more knowledge about the course, but the general feedback from participants was positive. The MOOC was unique on resource perspective. Open Source –philosophy made the MOOC free for over 2500 participants, but this sets constraints for sustainability. MOOCs' high drop-out percentage may increase, if course doesn't include any supervision for participants. Key elements in realizing such coding MOOC are cooperation and know-how about (Finnish) school system. Course administrators are teachers by themselves and aware of demands of the national curriculum implemented in 2016. This showed in the assignments and hands-on exercises, which were designed to fulfill the curriculum contents and to be used in the classroom. This may have had an impact on participants' engagement to the MOOC, as participants learned skills to be used in their teaching. When designing a coding MOOC or in-service training, the knowledge about teaching in one's school system is essential. Also the possible needs of curriculum and work life competences should be addressed on the course.
Sustainability	MOOC may be a sustainable way to introduce teacher to coding, if the course design good. As materials have been once made, in electronic environment they are easy to distribute and rewrite. Open Source –courses are sustainable as long as there are

enough interested individuals to maintain course pages, materials and peer-collaboration.

In sustainability's viewpoint a MOOC is a good way to introduce teachers to coding, but what comes to teaching robotics, also frontal training and robotics kits are essential. Robotics teaching needs hands-on experiences and at least a distance robolab, where teachers can see the outputs of their code. To exemplify the costs of starting robotics Figure 2 shows estimation, how much would it cost to start robotics and coding teaching with the most common technical solution (LEGO).

Case: costs of starting robotics teaching
Estonian experiences suggest that sufficient amount of robotic kits is one robotics kit per two students (e.g. one LEGO EV3 –kit).

- One LEGO EV3 –set costs about **265€** (VAT 0%)
    - *LEGOs seem to be the most common robotics solution in Finnish schools' robotics clubs*
- Rasperry Pi –central module costs about **43€** (VAT 0%)
    - *Rasperry Pi is one of the options in advanced programming*
- On average there are about 20 student in one class (in primary school the amount of students may be less)
- For one group 11 sets of LEGOS would be enough, the cost for this would be **2918€** (one extra kit is included for spare parts)
- For advanced programming the costs with Rasperry Pi –CPU would be **476,50€**

In total: 3394,50€
*The model is approximate, for example the cost of substitute teacher is dependent on teacher qualification and the travel costs are based on assumption that the training is arranged on neighboring area. Moreover schools may have joint teachers, and every school may not send two teachers.

Figure 1. Costs of starting robotics teaching

The set-up presented in Figure 1 is for one student group learning robotics. This poses challenges for schools, as LEGOS can't be disassembled after every class, especially if students are working in longer robotics project. One solution could be local cooperation with robotics facility. Schools could for example schedule the robotics teaching to four sections during the school year and circulate the robotics facility locally between few schools. As robotics isn't meant to be taught on every lesson, local cooperation with devices would probably be recommendable. As there are co-educational schools in Finland, these units could also pilot cross-grade level projects with robotics.

Replicability and/or up-scaling

As stated before, Code Alphabet –MOOC may be replicated easily and up-scaled to first on national level and second on international level. The MOOC needs more resources to provide stable course planning and instruction for participants, but the ground-level development has been done. As all course materials and exercises are electronic, the replication could be done easily after translation.

When replicating Code Alphabet –MOOC, it would be recommended to design the course and exercises on the basis of the target country's or school systems' requirements. Code Alphabet –MOOC was designed for implementation of new Finnish national curriculum, so all of the materials may not be applicable in other school policy systems.

Conclusion

In general a MOOC seem to be good way to bypass certain geographical and economic restriction that the Finnish coding teaching has faced during past few years. MOOC provides ubiquitous and cost-effective way to promote the introduction of coding and robotics teaching. MOOC seem to suit for those teachers who are motivated to learn coding and computational thinking, but there is still obvious need for frontal in-service teacher training for those teachers who are still doubtful about this national curriculum newcomer.

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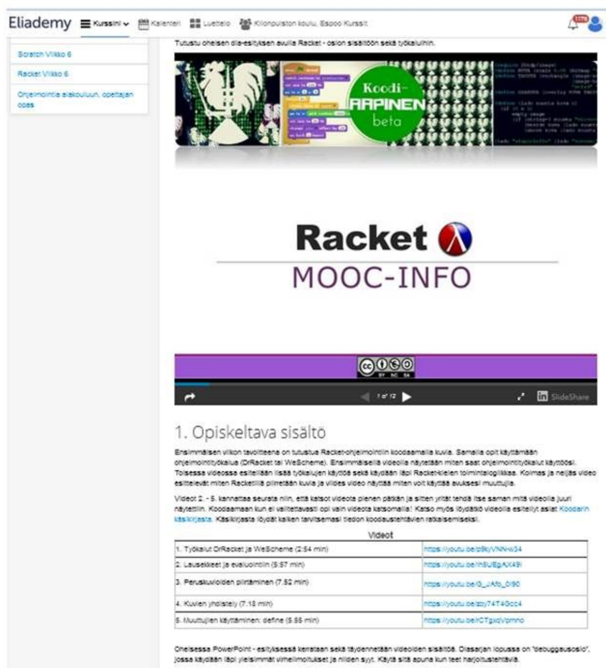
Related Web site(s)	http://koodiaapinen.fi/en/
Related resources that have been developed	Koodiaapinen – course in Eliademy
Photo/Image	

Conclusions from good practices in Finland

Finnish schools are funded by public funds and schools can finance their robotics teaching with their school budget. However budgets are usually rather tight what comes to technology acquisitions and as teaching of robotics is rather fragmented in the whole country, there is no clear view on the allocation of these resources either. One of the reasons for this situation is that resources for robotics projects are allocated through many different funding channels. The Finnish National Board of Education, Centre for Economic Development, Transport and the Environment, European Union and universities all fund robotics projects (quite often locally), but there is no coordination for robotics projects that would monitor coverage of all schools and teachers in Finland.

In general the amount of devices (e.g. computers) is good in Finland, but also here there are differences between schools when it comes to coding and robotics. While the most advanced schools may have 3D-printers funded by piloting projects for robotics activities, there are also schools that still struggle with their basic ICT-infrastructure like adequate wireless internet connection and a decent amount of devices for students. One of the key issues related to coding and robotics is that there is not yet established practice in teaching robotics and that in-service teacher training hasn't yet reached all the teachers, making the resource question not only one of available funding, but also of appropriate knowhow guiding purchasing decisions. That this does not only hold on a school level, but also on the national level is illustrated by the fact that, in the government platform 2015, the government has promised 300 million extra finance for digitalization of schools (e.g. for modernization of learning environments and to teacher training), without a clear demarcation of the allocation of these extra resources.

As robotics and coding are a new component in the national curriculum, it may be assumed that these resources are meant to also cover in-service teacher training of robotics and some acquisition costs of devices needed in teaching robotics and coding, but this has not been explicitly specified thus far. The need for such specifications and a supplementary budget for every school are however clear, as the cost of starting robotics teaching are considerable (Figure 1), and uninformed decisions in this respect may prove expensive in the longer run.

Though one might argue that there are free graphical programming environments available (eg. Scratch) these do not suffice to cover the whole curriculum, and would only provide a fairly limited view on coding and robotics. For a more broad coverage, equipment will be needed as well as in-service teacher training that at the bare minimum disseminates best practices gained from present robotics projects and knowledge for deciding on basic device acquisitions for starting robotics teaching. The MOOC presented in this paper is a cost effective solution to introduce teachers to coding, but the sustainability of Open Source or pro bono –course may be questioned. Also the hands-on experiences in robotics is challenging in MOOC environment, even though it seems to work properly in introductive way of teaching coding.

In summary, the Finnish situation could be best described as a grassroots approach, and there are elements to success with coding and robotics teaching. There is know-how and materials about these subject matters, but the policy-makers needs to address more resources for these kinds of MOOCs and initiatives that promote the implementation of school level coding and robotics.

Good practices in Sweden

The awareness of the need for Swedish schools to start teaching robotics and programming in all school levels is starting to increase. Programming and robotics is not yet a part of Swedish curriculum for school education, it can only be found as specialised courses at 18+ level. Digital literacy, information retrieval and source criticism is part of the essential content of the curriculum. This is general knowledge that students should develop across most subjects. It may also be a part of technology studies in lower or upper secondary level but then again, because of the structure of the Swedish National Curriculum, that would be up to each individual school or even individual teacher.

This document therefore tries to show some examples of good practices and initiatives for increasing the interest in programming and robotics among children in Sweden in both the public and private sector.

Title	**Robotics for Schools in Sweden - Private or Public sector?**
Author(s)	Kinda Teachers gathered the resources. David Powell CEO Elderberry AB Editor.
Objective	To show the several initiatives both public and private being introduced in Sweden to introduce robotics and associated areas of learning into the Swedish curriculum from kindergarten to 18+
Location /geographical coverage	This good practice is located in Sweden in several municipalities.
Introduction	The Swedish Government recently announced that digital competence and coding will be integrated in the Swedish school curriculum.

“Access to computers is not enough, it is the teaching and the teacher's knowledge that produce the pupils digital competence.” - the Minister of Education Gustav Fridolin, the Minister of Secondary Schools and Further Education Aida Hadzialic and the IT-Minister Mehmet Kaplan wrote.

Swedish school children have in an international comparison very good access to computers and the Internet, both at home and in school. But they are not equally successful in using the technology for learning. The Swedish National Agency for Education will from these prerequisites prepare two new National IT strategies. One strategy is directed on preschool and primary school and another for secondary school and adult learning.

This is for the near future. Therefore it is safe to say that at the present time robotics and programming in schools in not presented in a consequent way in Sweden. This document gives a sample of the many smaller local initiatives both private and public that hope to encourage this area of learning.

Stakeholders and Partners

1. The Swedish Association of Local Authorities and regions were commissioned by the government to assist in the efforts to digitize schools. This is partly about developing a framework that can be used to support the work and also about creating a national liaison group on the issue with the major stakeholders. The group - national forum for digitization of school - recently presented a progress report. The report identifies four issues:

- The use of ICT in education is slow and has not changed significantly in the past five years.
- Teachers receive too little training, especially when it comes to ICT education and skills development topic close to it.

- Many principals do not have the skills required to develop the school in a digital direction.
- There is a shortage of digital learning and development initiatives within the content area.

2. The newly founded association Kodcentrum, or “code center” aims to teach 100 000 children computer programming by the year 2020. Spotify will be the main sponsor of the initiative, which plans to achieve its goal by building a network of volunteers and “coding cabin” in 30 cities across the country. The classes, which are offered free of cost, will teach children between 9 and 13 years of age different types of computer programming. The association was founded in 2014 by the entrepreneur Johan Wendt, in response to a social need in the accelerating digital development.

3. The KomTek initiative, supported by the Swedish Educational Agency helps municipalities to establish “Komtek” schools specialising in technology, entrepreneurship and design. The Agency works to promote the development of new municipal engineering schools. Each municipality can customize KomTek for municipal needs and objectives. The initiative aims to increase children's and young people's interest in technology, entrepreneurship and design. KomTek offers exciting recreational courses and activities for children and young people as well as age-appropriate technology and design workshops for class visits. KomTeks experience of working with young people and technology can also enter the school to benefit from further education and inspiration courses for teachers from kindergarten to high school. Several KomTeks also collaborates with the University's teacher education programs. 24 municipalities now

	offer KomTek activities which includes programming, mainly using Lego Mindstorm. 4. CoderDojo is a global network of free, volunteer-led, independent, community based programming clubs for young people. These young people, between 7 and 17, learn how to code, develop websites, apps, programs, games and explore technology in an informal and creative environment. There are Coderdojos in 13 places in Sweden. They offer extracurricular programmes on regular basis after school and summer camps as well.
Methodological Approach	In general the debate on methodology in Sweden has focussed around the following questions, which at present lay unanswered ● Should all children be programmers, or is it sufficient that they can use computers? ● When should children learn to program and who is it that will teach them? ● Is it within the school's mission or should relevant knowledge be completely dependent on private initiatives? ● Should all children learn to program as part of the school curriculum?
Validation	1. Public - The Swedish Association of Local Authorities report was validated by the commissioning department of national Government 2. Private - The Kodcentrum is a private initiative sponsored by Spotify and the final validation will be coloured by its target of reaching 100 000 children by 2020 3. Public - Komtek validation comes under the Municipalities Education department and is linked to the national curriculum validation 4. Private - CoderDojo

Impact	The main impact at this early stage is that the profile of programming and robotics is being raised throughout the country
Innovation and Success Factors	There have long been voices in the education policy debate that want all students to learn programming in school, and the last few years they have become stronger. The ongoing digitization of society, which means that virtually all activities are becoming addicted to computer code and software, of course, is an important reason for this. The innovation and success factors are several depending upon who is measuring. For business and finance it is development, it requires many skilled programmers. The educational perspective is that success should be measured in terms of the main argument i.e.it is a democracy argument. Do we want people to be passive cyber-consumers of technology or to be able to shape the technology by themselves, find out how programs work, get a different perspective on digital development?
Constraints	The main constraint is of course financial. Although Sweden has a high ratio of computers and tablets in schools, it is still difficult to fund additional equipment for Robotics at all levels.
Lessons learned	The lessons learnt so far are difficult to decipher. The public sector represented by Education Authorities and Municipalities has been relatively slow to react to an obvious need in society. This void has been taken up by private sector actors. Who knows where this will lead?
Sustainability	The debate in public sector schooling involves, changes in the curriculum, which in itself would not be enough without extra funding for equipment and more especially a change in teacher

	training and/or in service training. The Swedish system at present allow a good deal of flexibility for individual schools and teachers to decide what they will teach. This means that change can be very slow. The private sector actors seem to have differing methods for sustainability with funding coming from several areas and a reliance on volunteers as trainers.
Replicability and/or up-scaling	The Komtek initiative is offered to all municipalities in Sweden , so far 29 out of 290 municipalities have joined. Here is the possibility to build upon the success of the initiative. Both Kodcentrum and Codedojo are expanding their centres exponentially at the present time.
Conclusion	The Robotics for schools should look more carefully at this comparison in other countries. Who are the actors implementing programming and robotics for young people and children in the private and public sector. What are their motives?
Contact details	info@skl.se anna.ekblom@orebro.se emelie@kodcentrum.se
Related Web site(s)	http://www.kodcentrum.se/ http://www.komtek.se/ http://skl.se/ http://coderdojostockholm.se/
Related resources that have been developed	See websites for examples and reports
Photo/Image	

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Conclusions from good practices in Sweden

The Conclusions for Sweden is that the country has been relatively slow to engage with programming and robotics in Schools via the traditional channels of school, even if the country has invested heavily and is in the forefront in digitalizing the schools themselves. The private sector is developing quickly in this area of education, mostly for children in their free-time. It will be interesting to watch future developments!

Good practices in United Kingdom

Current situation of School Robotics

The United Kingdom is made up of England, Scotland, Wales and Northern Ireland; with the schools education curriculum being different for each part of the UK.

In recent years there has been a gradual shift across all parts of the UK from 'ICT' to 'Computing'; which includes Digital Literacy, Computer Science and Information Technology.

England – The English curriculum has been the first to make this shift, with changes made to the National Curriculum introduced from September 2014. 'Computing' at Key Stage 1 and 2 (Primary). Includes a reference in the programme of study to *"Control or simulate physical systems"* . The national curriculum for computing (from September 2014) has been developed to equip young people in England with the foundational skills, knowledge and understanding of computing they will need for the rest of their lives. Through the new programme of study for computing, they will learn how computers and computer systems work, they will design and build programs, develop their ideas using technology and create a range of content.

The Computing curriculum is not vastly different to the previous curriculum. The previous curriculum had non-core units which included using presentation software (PowerPoint), creating spreadsheets (Excel), etc. These have been removed as it is felt that the skills learned are relatively basic. It is expected that pupils will now develop these skills in using computer applications across all subject areas.

Wales – A report in 2015 proposed changes to the curriculum involving cross-curricular digital competence. So rather than specific 'computer science' lessons teachers will be required to weave it, along with literacy and numeracy into every lesson.

Scotland – The education system in Scotland works differently than other parts of UK. Traditionally local councils have decided the areas of study. The Scottish Executive are currently implementing 'Curriculum for Excellence' (CfE), a major educational reform aimed at providing a wider, more flexible range of subjects and courses. CfE is an holistic approach focussing on developing key capabilities in pupils. One curriculum area is 'Technologies' which includes Computer Studies and Computing Science.

Northern Ireland – The curriculum here still includes 'ICT', "Pupils should use ICT to handle and communicate information, solve problems, pose questions and take risks."

It is arguable that secondary schools in the UK have focussed too much on 'Office' type applications and media over the last 20 years. Whereas there has always been an element of programming, sensors and control at Primary level, but more logic-based than deep coding. For example 'programming' a virtual or physical device to move Forward 2, Left 3, Forward 4, etc. Examples include software such as Crystal Rainforest and Mission Control; and 'Turtle-like' devices such as Roamer and Beebot (dee figure below).

"Computers are now part of everyday life. For most of us, technology is essential to our lives, at home and at work. 'Computational thinking' is a skill children must be taught if they are to be ready for the workplace and able to participate effectively in this digital world."

Following the changes to the National Curriculum in England many schools across the United Kingdom are incorporating robotics, coding and computational thinking into the curriculum. This has been driven by several factors including technical innovation and the 'maker' culture filtering through to schools, often with a single teacher leading the way.

Title	Raspberry Pi
Author(s)	Pete Stevens – Gryd Ltd
Objective	To provide an overview and introduction to the Raspberry Pi range of small computers which aim to inspire the next generation of coders and technologists.
Location /geographical coverage	It was developed in the UK but has been used by many people across Europe and the World
Introduction	In the early part of the new millennia Eben Upton, a Cambridge University professor, noticed a drop in the amount of students reading computer science of 50% over the preceding 10 years. Also, the new applicants for degree courses did not really know what a computer was or how it worked. He was frustrated by this. He realised that schools were not teaching pupils the basics of computing any more, they were just teaching them how to *use* software; which is a fairly basic skill. Pupils were not being properly equipped to think about how computers are programmed, about how they're built and how they work. Upton brought together a group of teachers, computer experts and academics to create a computer to inspire children. He said, "What was needed was a return to an exciting, programmable machine like the old BBC Micro; and it had to be affordable, say around £20 (25 EUR), so every child could potentially have one."

Stakeholders and Partners

The Raspberry Pi Foundation developed the Raspberry Pi. It is a charity formed 2006 with the aim of promoting the study of basic computer science in schools.

Whilst the foundation's original aim was towards school children there are many other people using a Raspberry. Due to their relatively cheap cost, size and flexibility they are used widely in the maker community as the controller in their projects. In the first year it was estimated that 75% of sales were for adults. The success of the Pi has also encouraged members of the public to get involved in coding.

The original founders of the foundation includes

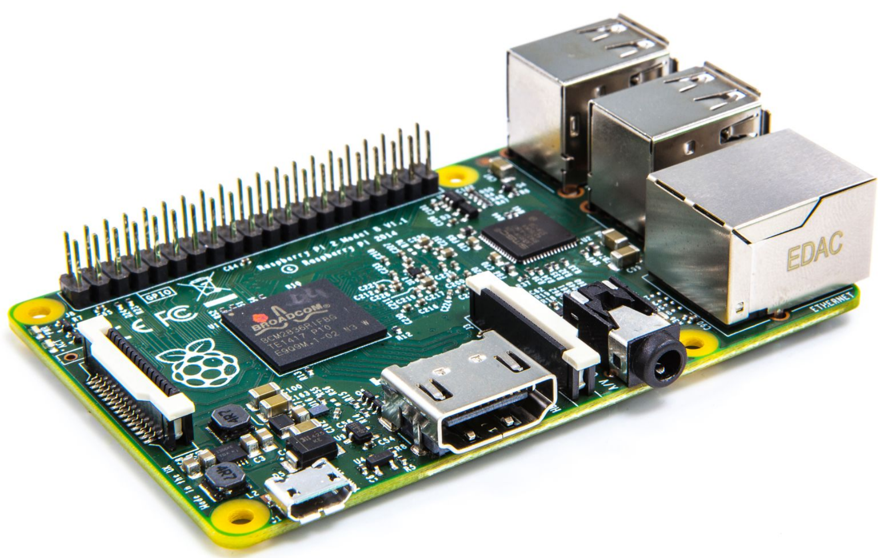
- Eben Upton and Rob Mullins from the University of Cambridge,
- Jack Lang the founder of Electronic Share Information Ltd,
- Alan Mycroft: professor of Computing in the Computer Laboratory,
- Pete Lomas: director of Engineering at Norcott Technologies,
- David Braben: CEO of Frontier Developments and co-writer of video game, Elite.

The organisation has two parts. The engineering and trading activities are overseen by Raspberry Pi (Trading) Ltd and its founder and CEO Eben Upton. Lance Howarth is CEO of the charitable and educational foundation part which was also ran by Upton until 2013.

Methodological Approach	Raspberry Pi founder and CEO Eben Upton focussed on making the device as cheap as possible so the most amount of children could use it. The device(s) should be affordable to both schools and pupils/parents directly. In 2012 the first Raspberry Pi was launched – a cheap, pocket-sized, programmable computer. Following early prototypes in 2006 the final devices were offered for sale at 25 EUR for Model A and 35 EUR for Model B. During the pre-production phase the Raspberry Pi went through many developments focussed on reducing the cost whilst adding more functionality and connectivity (and keeping the device small). In 2015 the Raspberry Pi Foundation launched the Raspberry Pi Zero, the smallest member of the Raspberry Pi family. It's also the cheapest, at only 5 EUR! The miniature computer is so cheap that several thousand were given away attached to the front of the official Raspberry Pi magazine.
Validation	Within two months of going on sale over 20,000 devices had been sold, with production increasing to 4000 units per day. By 2015 over 5 million Raspberry Pis had been sold, only 3 years since its launch!
Impact	The impact has been outstandingly positive. The devices have been used by children, schools, hobbyists and professionals to control all manner of projects. From schools using the Pi to sense and control a weather station, make robots, create a connected school garden; to professionals and hobbyists using them as a cheap controller for their projects. Many people who were new to coding had the opportunity to learn how to code through simple projects that they could see working instantly.

	Since the Raspberry Pis introduction several other small, cheap computers have been launched but the Pi continues to innovate and has a strong following. With the introduction of the 5 EUR Pi Zero the impact on the education and wider community will continue.
Innovation and Success Factors	The two main technical innovations and success factors are the Cost and Size of the devices. It was felt that children have access to technology at home but don't necessarily have it made small and cheaply enough to play with without fear of doing any harm. The opportunity to buy a fully working computer (with the user adding their own power supply, monitor, keyboard, mouse and storage memory) brought down the cost barriers to computer that many people face around the world. Alongside the technical successes the Foundation continually aimed to inspire and educate children and in turn teachers and hobbyists, to learn how a computer functions and explore the myriad possibilities of a relatively simple programmable computer.
Constraints	Whilst the Pi is aimed at those new to computer programming it does require some basic computer knowledge to use, or extra time allowed when getting started with the Linux operating system. The graphical user interface and regular updates of the operating system have helped to address some of the hurdles users faced.
Lessons learned	Throughout development, the Raspberry Pi Foundation remained focussed on the cost of the device so that it could be bought by anybody. They had to make some initial compromises on the

	first version of the device to achieve the low price, and then released updated versions as component prices reduced. This helped them to get the early versions in users' hands and then used their feedback to provide updates and improve future versions. The Foundation also released the software as open source so that people could make their own modifications.
Sustainability	At the time of writing the Raspberry Pi looks set to continue its success. With the recent release of the Pi Zero sales are expected to continue for many years to come. The largest threat is if large institutions, such as schools and universities, decide to use a different platform, such as Arduino, for their projects. In 2016 the Foundation will release their Flotilla kit which will include sensors, motors, and other peripherals to allow users to directly make robotics projects. In the past the Pi would have to be added to another system to achieve this. During 2016 all schools in England will be sent the new BBC microbit. A miniature computer, similar to the Pi, aimed at children and schools. A similar effort by the BBC to push desktop computing in the 1980s was a great success, with many people's first experience of a computer being the BBC Micro. If schools embrace the microbit over the Raspberry Pi this could the affect future sustainability of the Pi.
Replicability and/or up-scaling	Raspberry Pis are already available around the world. Sales are expected to continue
Conclusion	The release of the Raspberry Pi has been a resounding success and already had a large impact on computing education. It inspires young people and old to learn about the workings of a computer and to try using it for a project of their own.

	The Foundation's aim of a small and cheap computer to inspire children has been achieved yet there still remains many schools yet to use the Pi. One of the largest stumbling blocks is to upskill teachers so they can comfortably introduce more computing and robotics into their lessons.
Contact details	https://www.raspberrypi.org
Related Web site(s)	https://www.raspberrypi.org/magpi/ https://www.raspberrypi.org/resources/
Related resources that have been developed	http://www.theguardian.com/education/2012/jan/09/raspberry-pi-computer-revolutionise-computing-schools http://techcrunch.com/2012/10/21/getting-started-with-the-raspberry-pi-is-not-as-easy-as-pie/ https://www.raspberrypi.org/picademy/
Photo/Image	

Conclusions from good practices in UK

The recent and proposed changes to the curricula across the UK are a positive step towards incorporating more computer science and robotics into schools, but there is much work to still to do. The move in the 1980s towards teaching how to use applications, rather than how computers work, has limited the amount of teachers with the necessary skills and competences to teach these. Also, no extra funding has been given to schools in England to train teachers. Schools are dealing with this in a variety of ways – applying for specific project grants, using budgets from other subject areas, setting up 'robotics clubs' using volunteers.

Cheap and small computers, such as the Raspberry Pi, are beginning to have an impact in schools. Teachers are taking the opportunity to invest a small amount of money and their own time to learn how to use these devices. What is needed now are ideas for how they can be used in lessons, such as the RoboQuests developed through this project.

During 2016 the UK government is working with the BBC to distribute a new miniature computer called the BBC Microbit. All schools will receive these devices and it is hoped that additional support is also provided. We wait to see whether the Microbit will have as big an impact on UK schools as the BBC Microcomputer did in the 1980s.

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Good practices in Europe

Robotics is used in different ways in education, one of the most popular and motivating for students is competition based learning. Preparing for an upcoming event, wish for successful participation seems to affect youngsters to work more. On the other hand, there could be negative effect because everybody can't win. Nevertheless, the biggest program in education and robotics is called FIRST LEGO League. It is annual based program that is taking place all over the world, including Europe.

Title	**FIRST LEGO League**
Author(s)	Heilo Altin
Objective	To give a short overview how FIRST LEGO League is organized in European level.
Location /geographical coverage	Europe
Introduction	FIRST LEGO League is a science and robotics program developed for pupils in age 9-16. Season starts every year in September and finishes in May/June. Every season has new challenge/theme. It is based on real world problems. Pupils have to work in teams to build a robot and develop a research project related to annual challenge. Teams have minimum of eight weeks to prepare. After that they go to competition where they could advance to finals. Highest level of competing is international level. Every year, Open European Championship is taking place in Europe.

Stakeholders and Partners	FIRST LEGO League is organized globally by FIRST and LEGO Education. FIRST (For Inspiration and Recognition of Science and Technology) is USA based non profit foundation that inspires youth through robotics in same way as sport events. LEGO Education is a part of LEGO Foundation which enhances learning experience through constructionist approach. They work together by developing every year new challenge for robotics and organizing the program in global level. Program is run in all participating countries by local partners. They do not receive any funding from LEGO Education or FIRST, but they have a lot of help and support in form of materials and contact persons. Mostly their activities include finding sponsors, volunteers, organizing trainings and representing the program in their country.
Methodological Approach	FIRST LEGO League has a very certain way of coaching pupils. It is mostly based on Socrates method. Work is done in teams during school hours or after school with the help of coaches who are usually teachers. When they are asked questions, they cannot give direct answers, but instead asking questions that lead pupils to more information that would give them the answers. Example of this method would be when pupil is asking “Why this robot does not work?” and even if coach knows the reason, he could answer “Have you tried doing this mission any other way”. Purpose is to lead students to answers and solutions through work, not direct knowledge based talk. Even though this method might be frustrating sometimes for both parties, it depends on the experience of the coach and the results would we awarding. Teams have to follow core values of the program which is one of the criterias for participating in the competition. Core values are:

	● We are a team. ● We do the work to find solutions with guidance from our coaches and mentors. ● We know our coaches and mentors don't have all the answers; we learn together. ● We honor the spirit of friendly competition. ● What we discover is more important than what we win. ● We share our experiences with others. ● We display Gracious Professionalism® and Coopertition® in everything we do. ● We have FUN!
Validation	In season 2015/2016, there was over 233 000 participants worldwide with 29 000 teams. Partners organized together 1350 events in 80 countries.
Impact	From FIRST LEGO League official web page: The positive impact FIRST LEGO League has on participants is gratifying and well documented. Over 88% are more interested in doing well in school, and 87% have more interest in attending college. FIRST LEGO League teams get to: ● Research challenges facing today's scientists ● Design, build, test and program robots using LEGO MINDSTORMS technology ● Apply real-world math and science concepts ● Learn critical thinking, team-building, and presentation skills ● Participate in tournaments and celebrations ● Understand and practice Gracious Professionalism®

Innovation and Success Factors	Innovation is born through robot game challenge and project solutions. When project is based on annual theme, pupils are encouraged to think outside of the box and develop solutions that might not be technically possible yet. In more practical level, pupils have to also solve missions with robot on the robot game field. They can develop something more innovative that is not always working, but it gives them points in robot design judging. Success of the program relays in coaches and partners that run the program in countries.
Constraints	FIRST LEGO League is a program that requires work from coaches and pupils. Amount is sometimes frightening and keeping more teams participating because of being afraid. Besides, it is also program that costs for the team some money. General expenses are connected to a new field set every year, participating in competitions, having right tools (robots) etc.
Lessons learned	Program is a learning experience that has a good impact for pupils. It supports developing teamwork and problem solving skills. But it all comes through hard work and participants do not have that much time to invest. Program would see more teams if it would be included to curriculum or made compulsory at least for once for every pupil. The entrance skill level of the program is low, but there is high ceiling.
Sustainability	Sustainability is in partners that run the program and in FIRST and LEGO Education that support them. Partners gather every year to a partner conference where they change experience and discuss problems. It is an effective way of keeping them onboard, keeping the program sustainable.

Replicability and/or up-scaling	Program is run according to global standards. It is not difficult to start and run a pilot year. All the interested partners are welcome to contact to see if they could run this program in their countries.
Conclusion	FIRST LEGO League is science and robotics program for pupils 9-16 years old. They work in teams, trying to find solutions to global problems and build robots to solve missions. Program is managed by FIRST and LEGO Education and run by local partners in each country. Program is organized according to standards to assure the quality and correct experience.
Contact details	http://www.firstinspires.org/
Related Web site(s)	www.firstlegoleague.org
Photo/Image	

Conclusions

In this Good Practice document a situation of school robotics in consortium countries are briefly described and evaluated. Every partner have selected one good practice from their country and described it in detail. As it is seen the situation is quite different around Europe and some countries are moving faster than other. However despite of advancement, it is drawing out that all countries have also similar problems and shortages. First of all it is lack of funding and support for schools to establish or update their ICT and robotic equipment. Other main factor is the lack of motivated and skilled teachers who should implement the robotic courses. Nevertheless all consortium partner countries are showing promising steps to pay more attention to STEM and robotic education in schools. Curricula are updated or updating is in progress and several initiatives are taken to fund robotic equipment for schools. This project (Robotic for Schools) is also one of the initiative to support and push robotic education in schools into new level and offer simple and easy to use robotic stories for teachers and pupils, teaching and learning the robotics.

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