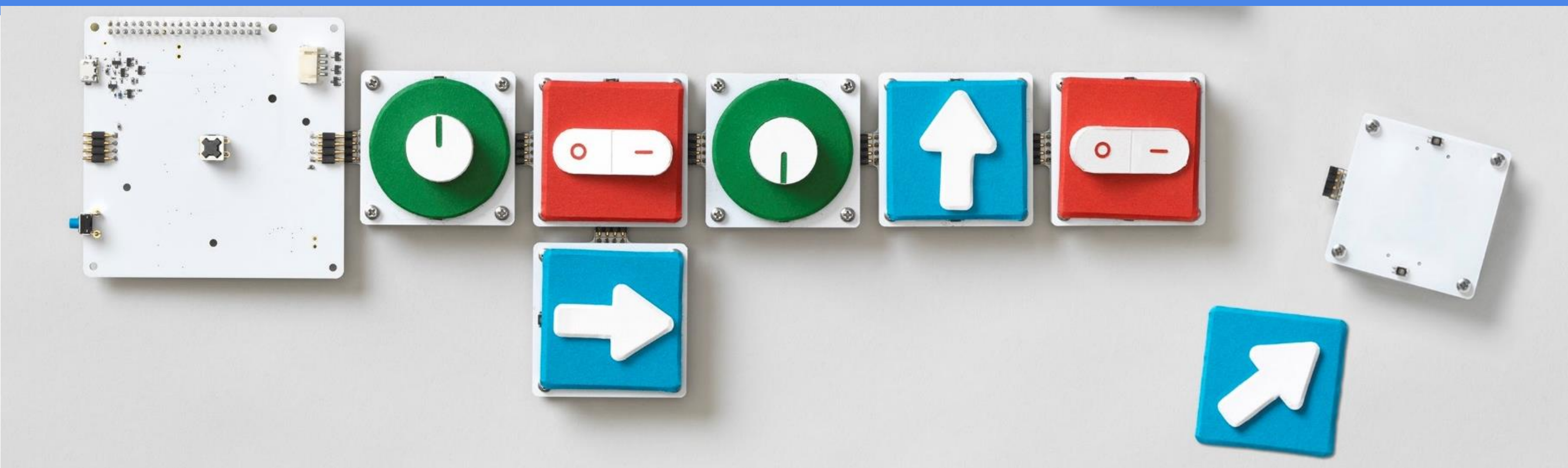
TangIn

Tangible Programming & Inclusion

Teachers' Training Handbook

Tangible Programming and Inclusion in Educational Context



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Colegio Santa Elena Villarejo de Salvanés

Сдружение "Знам и мога" — "Know and Can" Association

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1 Introduction

At an early stage, computer science was mainly focused on **programming** - understood as the process of obtaining a solution through a logical and explicit sequence of steps, inseparable from algorithmic thinking (Amorim, 2005; Futschek, 2006; Knuth, 1985; Schwank, 1993). Today, it is argued that **computational thinking** (Wing, 2012) involves the mobilization of citizens' competences at two levels:

⇒ Mental level - the formulation, resolution of problems (e.g. the decomposition of a problem into simple steps that lead to its resolution); the organization and analysis of data; the use of algorithmics; the abstraction, as a synthesis of information; the evaluation of solutions in a recursive looping process; the generalization and transferability to other problems (Csizmadia, Curzon, Dorling, Humphreys, Ng, Selb & Woollard, 2015; ISTE/CSTA, 2011);

⇒ Attitudinal level - the confidence to deal with complexity; the persistence to overcome obstacles; the tolerance to uncertainty; the motivation towards demanding tasks; the willingness to work and respond to the opinions of others (ISTE/CSTA, 2011).

Tangible programming constitutes a fundamental element for **digital thinking** development (Bers & Horn, 2010). Tangible programming uses physical objects to make programming an activity that is appealing and accessible to young children, by making it more direct and less abstract. Using physical objects to represent programmatic elements, commands and movements of control structures is within the reach of any individual, from the earliest age, even if they don't master any technology (Sapounidis & Demetriadis, 2013).

It is also important to explain what is understood by **tangible programming** in opposition to **graphic programming**. By definition, tangible programming is the one which is directly done on the robot or the blocks that command it. It is done by touching the robot, like other objects. The graphic one involves a programming language, done on the computer, and that will control the pathway of the robot.

When it comes to the education of young children, **tangible programming** is considered more adequate as young pupils can easily see the programming they are doing in a very direct and proximal way, promoting physical involvement, since pupils learn by increasing the senses used (touch, sight, hearing) (Zuckerman et al., 2005). In fact, in these age groups, the discovery of the world through touch is of supreme importance in the construction of learning, in the construction of the knowledge of the world and in the appropriation that they make of the reality (Loureiro, Moreira and Senos, 2018).

However, it is important to clarify that there are different definitions of **digital and computational thinking:** frequently, there is the tendency to associate and describe it as "solving a puzzle", in the

sense that there is the need to divide problems in smaller and simpler parts and to organize them in a logical, sequential way (table 1).

⇒ **Table 1 – Digital and computational thinking skills**

Digital and computational thinking skills	
Skills	Definition
Abstraction	Representing/converting a subject/object (tangible or not) in a more understandable form by eliminating unnecessary detail. Prioritizing and choosing the most relevant descriptors by sorting them according to the degree of information (100% meaning that one characteristic is enough to describe the subject)
Decomposition	Coherently separating the logical parts of a subject/object and deconstructing them in simpler units/axioms until they can be understood, solved and evaluated separately but without losing crucial information on the original object/subject
Sequencing	Arranging the different parts of a problem in a certain order so as to create steps towards a solution
Automation	Recognizing patterns to find shortcuts and creating repetitive tasks and loops to save work and time and to improve the flow of information
Debugging	Predicting and verifying outcomes using a systematic approach
Generalization	The strategy of exploring and exploiting previous solutions to similar problems by finding connections and similarities

The **school needs** to contribute to the development of the **pupils' digital and computational thinking** (Barr & Stephenson, 2011; Caspersen & Nowack, 2013; Grover & Pea, 2013; Qualls & Sherrell, 2010; Sengupta, Kinnebrew, Basu, Biswas & Clark, 2013; Voogt, Fisser, Good, Mishra & Yadav, 2015: Weintrop, Beheshti, Horn, Orton, Jona, Trouille & Wilensky, 2016). This educational challenge is related to the importance of the development of e-skills for future workers and all citizens, in order to promote inclusion and developing skills to promote more participation in a democratic society.

Tangible programming contributes to main **'Sustainable Development Objectives' related to 'Quality Education'**, **'Gender Equality'**, **'Decent Work and Economic Growth'**, **'Reducing Inequalities'** and **'Peace, Justice and Effective Institutions'** (UNRIC,2019). In fact, in order to educate citizens to contribute to a sustainable world, it is important to teach them to interpret world phenomena in a more holistic and non-segmented way. Consequently, it is important to promote the integration of **STEM areas** in a transversal way in the educational curriculum (Corlu, Capraro & Capraro, 2014; Honey, Pearson & Schweingruber, 2014; Sanders, 2009; Zeidler, 2016).

Also, **tangible programming** can facilitate the **inclusion of children and young people** regardless of gender, physical-psychological conditions or socio-cultural-economic conditions (Gordon, Ackermann & Breazeal, 2015; Gordon, Rivera, Ackermann & Breazeal, 2015; Koster, Nakken, Pijl & van

Houten, 2009; Sapounidis & Demetriadis, 2012; Tabel, Jensen, Dybdal & Bjørn, 2017; Unnikrishnan, Amrita, Muir & Rao, 2016).

The interactive and physical nature of tangible programming, where children must collaborate to solve problems, is a great opportunity to shorten differences concerning children' backgrounds. Teamwork, discussions, and the fact that more than one pupil can control the robot can foster their social negotiation and collaborative behaviours.

In summary, **tangible programming** offers several advantages: i) it facilitates collaborative peer-to-peer programming; ii) it simplifies debugging processes; iii) it helps to narrow gender differences regarding the interest in computing and iv) it promotes physical involvement and empathy; v) it helps to elaborate a mental picture (abstraction) more easily due to the sensory input; vi) it promotes more efficient ways of learning. With more sensory input it is easier to elaborate a mental picture (abstraction) and to connect to experiences that can lead to even more efficient ways of learning.

Studies about educational challenges highlight the potentialities of **tangible robotics in Science, Technology, Engineering and Mathematics (STEM) education**. Specifically, it can develop pupils' transversal competences (e.g. digital skills, problem-solving, collaboration, critical thinking and creativity), as well as inclusion and gender equality, two of the main concerns of the European Commission (Redecker, 2017).

The following sessions were designed within the scope of this project and aim to support the training of primary teachers.

2 TangIn teachers' handbook

The project "TangIn: Promoting inclusion and a STEM curriculum in schools through the use of tangible programming concepts and activities" aimed to develop teacher's competences when it comes to the promotion of pupils' inclusion and the development of computational thinking in the areas of Science, Technology, Engineering, and Mathematics (STEM).

Its specific contributions are:

i) the promotion of inclusion and the **STEM curriculum integration** in an inter and multidisciplinary approach, through the use of tangible programming concepts and physical objects;
ii) the development of a toolbox with teaching materials both for teachers and pupils, focused on the STEM areas, aiming at the development of computational thinking, inclusion and other important transversal skills presented above;
iii) the promotion of a transnational collaboration culture between education professionals through the establishment of training guidelines that will contribute to the innovation of formal, informal and non-formal teaching.

The **teachers' training handbook** was built with the knowledge constructed within the activities implemented during the pre-pilot of the TangIn project. An in-service primary teacher education course was developed in the University of Aveiro (January 2019), that was accredited according to the European Credit Transfer System (ECTS) with 2 ECTS (54 hours of training). This course is integrated within the level of the 2nd cycle of higher education courses (Bologna agreement) orientated to train teachers from the 1st and 2nd cycles of Basic Education, belonging to the consortium partners.

The trainees, partners of the TangIn project, had to implement educational resources (included in the TangIn-TOOLBOX) in order to promote learning activities related to tangible programming concepts within the STEM areas. The TangIn-TOOLBOX plans contain different pathways, under the format of didactic unit plans, aiming at the development of transversal competences in pupils (e.g. Algorithmic thinking, computational thinking, problem-solving, communication, collaboration, respect and other social and relational competences, valuing behaviours that foster inclusion). The plans were designed according to the curricular matrix created in the scope of TangIn Project identifying specific STEM areas, in an articulated way and under the principles of curricular flexibility.

Following this course, the trainees were 'ambassadors' for the use of these educational resources in their own school contexts. Trainees shared their training experience with other colleagues in a pilot study. The purpose was to implement and evaluate the TangIn-TOOLBOX resources in different schools. For more information please access the project's website: www.tangin.eu.

TangIn's **teachers' training handbook** appears in this **context** and has the purpose of enriching teachers' professional development (from initial to continuous training) in the fields of tangible programming, STEM and inclusion.

The underlying training philosophy of the **teacher training handbook** has the following **principles** and **guidelines** used for initial and/or continuous teacher training (with the necessary adjustments) and the UA teacher's training course just explained above.

Specifying, the **principles** consist of a theoretical approach to the most relevant themes, topics and concepts related to programming and mostly tangible programming in STEM areas and Inclusion. Additionally, it is also important to create practical experiences to make the trainees familiar with problem-solving activities within a more inclusive learning environment (e.g. gender equalities; ethnical issues), as well as to develop activities to explore, integrate and/or evaluate educational resources, such as the robots.

Moreover, the **guidelines** entail aspects such as practical activities that allow assuming peer-to-peer observation and collaborative learning tasks (working groups), to handle technical and functional aspects related to tangible robots.

To sum up, this **handbook** is a document designed for primary teachers' trainers (from initial and continuous training) that contains theoretical and practical guidelines to implement a course - Tangible programming and inclusion in an educational context - focused on the integration of tangible programming concepts and STEM subjects in primary teachers' professional contexts.

Furthermore, the **handbook** could become a pedagogical tool which constitutes a **guide** for initial and continuous teachers' training in order to contribute to an active, collaborative and meaningful primary teachers' personal and professional development. This could be a way to promote the sustainability of pupils' learning, regarding tangible programming and STEM concepts, using physical interfaces (e.g. tangible robots) in an active, attractive and challenging way that also encourages the inclusion of all children, regardless of gender, physical, linguistic, intellectual, racial and/or social conditions (among others).

3 Teachers' training course

This handbook, which constitutes the basis of the **course,** is organized in nine sections, namely: aims, skills and competences, contents, training plan, methodology, assessment, detailed sessions and resources, final considerations and bibliography.

3.1 Aims

The purpose of this course is to develop trainees' competences (including knowledge, abilities, skills, attitudes and values) by exploring the TangIn toolbox, as a mediator resource, to explore tangible programming concepts and the STEM areas, in order to enable the co-promotion of inclusion and computational thinking in primary education, in an enjoyable and effective way, considering the specificities of different educational contexts.

It is expected that this course will have repercussions on the active, collaborative and meaningful learning of the trainees, supporting the inclusion of (future) pupils and the development of specific competences in the STEM areas, as well as transversal competences, such as creativity and problem-solving.

The main aims of the course are:

i) to deepen concepts underlying computational thinking, tangible and non-tangible programming, STEM and inclusion;
ii) to reflect with peers (other teachers) on the real possibility of implementing activities in real educational contexts, regarding the above concepts;
iii) to evaluate and/or reformulate TangIn toolbox plans, taking into account the different educational contexts;
iv) to plan a flexible curricular integration of tangible programming in STEM-related areas; and
v) to reflect on the learning process that takes place in the course itself.

Those aims will be attained through a) the exploration of activities and resources included in the TangIn TOOLBOX and b) planning, implementation, reformulation and/or reflection about activities in a real school context, depending on the specificity of each context.

Through this course, undergraduate pupils and/or primary teachers in continuous training will be able to improve their competences regarding the development of innovative approaches to teaching STEM topics, using tangible programming concepts and tools, that will provide an opportunity to transform their (future) classes (and the schools) into more inclusive environments.

3.2 Skills and competences

⇒ **Professional skills and competences**

- To manage the curriculum within a flexible approach of the STEM areas;
- To observe, plan, implement and evaluate learning activities in STEM areas taking advantage of tangible programming;
- To promote inclusion while working in STEM education.

⇒ **ICT skills acquired**

- To develop computational thinking with and without technological resources;
- To reflect on the advantages of different programming typologies, namely graphical and tangible programming;
- To develop tangible programming skills.

⇒ **Organisational skills and competencies**

- To manage curricular and didactic STEM projects, based on tangible programming in order to promote inclusion.

⇒ **Social skills and competencies**

- To cooperate and collaborate in heterogenous group activities;
- To promote collegiality practices among teachers' communities.

⇒ **Other skills and competencies**

- To develop oral presentation competences.

3.3 Contents

The programmatic contents addressed in this course are focused on the theoretical, curricular, technological and didactic aspects of inclusion, computational thinking and, in particular, tangible programming. The content is divided into four main topics:

1. Importance, relevance and concept of computational thinking in education;
2. Computational thinking without computers (strategies and tools);
3. Tangible programming in education (typologies, advantages and disadvantages);
4. Inclusive learning within STEM areas related to tangible programming.

The selection of the syllabus contents is designed in a transversal and integrating way, so that trainees can develop and mobilize their competences, considering the specific school context (pupils at primary and/or basic education level). The contents will be developed in a deeper way in the section of this handbook dedicated to methodology and assessment, course structure and detailed course sessions.

3.4 Methodology

This training course is based on an active learning perspective and follows a Project-Based Learning approach (PBL) (e.g., Bell, 2010), considering the learning aims and the selected program contents for the training course, promoting the trainee's academic success.

It is important to note that this course corresponds to a basic level of tangible robotics and neither trainers nor trainees need pre-requisites and skills related with programming and robotics. As a matter of fact, the handbook itself is organized in such a way that even beginners can successfully follow an entire course and/or manage to prepare, adapt and implement training on this topic, without any previous knowledge about this subject. In other words, it is expected that with the support of this document all teachers can become trainees and/or trainers in the field of tangible programming.

The main strategies to the course development are: **talks, peer-observation** in real school context**, workshops in group work** and **individual and autonomous work**. Notwithstanding the nature of these strategies, the work environment should be as dynamic and interactive as possible, so as to facilitate the development of the skills.

The **talks** are focused on the main theoretical aspects of the training course. They are intended to be dynamic, which means that brainstorming with the trainees should occur at the beginning of each session so as to verify the existence (or non-existence) of pre-conceptions. Following this strategy, trainers should facilitate trainees' discussion, debate, argumentation, refutation and so on, in order to consolidate main ideas and concepts.

When it comes to **peer-observation** in real school, trainees should also have the opportunity to observe didactic experiences centred on tangible programming, developed in real educational contexts, and to reflect on their potentialities and constraints, both from the pedagogical point of view and regarding the level of impact on pupils' learning.

During **workshops** the trainees should be organized in groups and actively explore concepts and resources and discuss some issues about the session to enhance the "*mise-en-commun*" and the debate. Course participants are expected to analyse, reflect and reformulate the lesson plans focused on tangible programming in STEM areas, that are available at the TANGIN Toolbox. Finally, trainees should create and present new lesson plans, considering their specific educational context and have the opportunity to reflect on the learning process that takes place in the training units and on the course itself.

This way, throughout the teachers training course, participants should be actively involved in discussions about the issues related with inclusion and computational thinking in specific educational contexts of STEM areas. On the other hand, they will observe, plan, evaluate and reformulate learning experiences using appropriate learning tools. This will contribute, in a dynamic way, to the development of the trainees' competences, namely to promote inclusion and computational thinking

and, in particular, to promote the integration of innovative educational resources aimed at approaching tangible programming concepts within the STEM areas.

Vis-à-vis the **autonomous work**, each trainee should be able to adapt and design (new) lesson plans for their professional practices and proficiency and, eventually, to sustain and enrich the TangIn Toolbox. Thus, in accordance with the trainees' level of digital proficiency, their needs and interests, they will be able, in future situations, to: conceptualize didactic proposals for educational intervention in the STEM areas, focused on tangible programming and adapted to their own school contexts; implement their didactic plan; to reflect with their peers (other teachers) on their learning process and to reformulate them as necessary. So, they can also be 'ambassadors' for the use of these educational resources in their own (future) schools' contexts and, thus, attract other colleagues to this goal, and to sustain the research results emerged from the TangIn project.

During the **individual reflection,** the trainees must come up with a document that states the gains about their self-professional development and evaluate the potentialities, constrains and suggestions for future editions of the course.

3.5 Structure

The course is structured in four axes to contribute to an active, collaborative and meaningful learning process, namely:

1. Theoretical approach - conceptual understanding about the importance of tangible programming, STEM education and inclusive education;
2. Showcases – demonstration, handling and experimentation of computational thinking resources (with and without computers) to promote children's education in STEM and inclusion contexts
3. Hands-on activities - analysis and production of (new) activities (to be) included in the TangIn-TOOLBOX to explore the potentialities of the MI-GO robot;
4. Evaluation – reflexion about self-professional development and analysis about the potentialities, constrains and suggestions for future editions of the course.

Although the four axes were presented in a segmented form, the sessions might cross and combine the theoretical and practical components of the course. The training flexibility and adaptability are keywords in education. The plan includes talks, workshops, peer-observation activities, group and individual work (Table 2).

Table 2 – Digital and computational thinking skills

Time	Day 1	Day 2	Day 3	Day 4	Day 5
10:00 am-	**Talk** From Tangible Programming to STEM and Inclusion	**Talk/Workshop** Tangible robotics in children's education in STEM and inclusion contexts	**Peer-observation in real school context** Tangible robotics in real-contexts - activities with children	**Group work** Analysis and adaptation of the TangIn plans	**Group work** Creation of contents/ activities to enrichen the TangIn Toolbox
11:00 am-	Break				
11:20 am-	**Talk** From Tangible Programming to STEM and Inclusion	**Talk/Workshop** Tangible robotics in children's education in STEM and inclusion contexts	**Peer-observation in a real school context** Tangible robotics in real-contexts - activities with children	**Group work** Analysis and adaptation of the TangIn plans	**Autonomous work** Analysis, adaptation and/or creation of contents/ activities to enrich the TangIn Toolbox
1:20 pm-	Lunch				
2:30 pm	**Talk/Workshop** Computational thinking without computers: an approach to the development of algorithmics and problem-solving competences	**Workshop** Hands-on activities with tangible robots. The example of Mi-Go	**Peer-observation in a real school context** Tangible robotics in real-contexts - activities with children	**Group work** Creation of contents/ activities to enrich the TangIn Toolbox	**Group work** Oral presentation of the contents/ activities created
4:30 pm	Break				
4:50 pm	**Talk/Workshop** Computational thinking without computers: an approach to the development of algorithmics and problem-solving competences	**Workshop** Hands-on activities with tangible robots. The example of Mi-Go	**Peer-observation in a real school context** Tangible robotics in real-contexts - activities with children	**Group work** Creation of contents/ activities to enrich the TangIn Toolbox)	**Individual reflection** about the course

3.6 Sessions

3.6.1 Talk and group discussion: From Tangible Programming to STEM and Inclusion

⇒ **Summary**

This talk addresses the emerging technologies in today's society and schools' key challenges to prepare students for the new technological revolution. Questions such as: What is happening in a European context as far as current educational polities are concerned? What are the common grounds and differences in educational polities in Europe? Are teachers prepared for these new demands? Is the training offered appropriate to these changes? Are the schools preparing students for new jobs? should be discussed by all participants in a reflexive collective process.

⇒ **Strategies**

This session should start by a group discussion with all the participants, without exception, about their pre-representations, pre-conceptions, and pre-requisites about programming and robotics.

Then, there should be a ***brainstorming*** with participants about the main programmatic contents of the course (presented above) and a reflection about the need to integrate a cross-curricular perspective on the use of technologies (robots) in different educational contexts (e.g. STEM), having in mind the inclusion of all children and gender equality, as a main principle of education. As a suggestion, the group can briefly answer three main questions: What is tangible programming?; Why is it important in STEM education?; and How can it be implemented in order to promote inclusive education?

Later, during the **talk,** the trainer should orient the session in order not only to discuss concepts but also to illustrate and discuss key topics, namely: tangible Programming; STEM and Inclusion. Furthermore, cross-curricular perspective on the use of technologies in different educational contexts (e.g. STEM) must be discussed, also having in mind gender equality and the inclusion of all children.

Considering the strategies, the work environment should be as dynamic and interactive as possible (between the trainers and trainees, and between trainees themselves) so as to facilitate the development of primary teachers' skills, such as collaboration, critical thinking, professional self-reflection, self-exposition.

⇒ **Scenarios**

The following image(s) illustrate a possible training scenario for this session.

Figure 1 – Possible training scenario of a talk and group discussion

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the framework for using tangible programming concepts to stimulate learning of STEM subjects at primary school (TangIn project - IO1[1] result).
- the examples of presentations about the topics (TangIn project – IO3[2] result) given by:
  - António Manuel Silva - "ICT in the curriculum" - António Manuel Silva, General Directorate for Education, Portuguese Resources and Educational Technologies Team
  - Maria José Loureiro - "Using tangible programming concepts to stimulate learning of STEM subjects at primary school" Maria José Loureiro (ICT Competence Center of the University of Aveiro (Portugal)
  - Pedro Beça - "From Tangible Programming to the Internet of Things. Physical computing in education" (Assistant professor at the University of Aveiro (Portugal).

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[1] http://www.tangin.eu/wp-content/uploads/2018/08/IO1-Final-Report_EN.pdf

[2] http://www.tangin.eu/lesson-plans-toolbox/

3.6.2 Talk/Workshops

Under the scope of this training course, a set of three workshops is suggested.

i) Computational thinking without computers: an approach to the development of algorithmics and problem-solving competences;

⇒ **Summary**

In this workshop, some activities that establish a very close relationship between mathematics and computer science (challenges and problems) will be explored. Each task will be contextualized within the computing logic in order to help the understanding of the way that the machine interprets data.

⇒ **Strategies**

First, the trainees should explore the algorithmic way of thinking which means the decomposition of a particular problem in all its parts, in order to solve it step by step. This kind of reasoning can be based on quotidian tasks like, for instance, the algorithmic of the "Clothes washing machine". Other specific example concerns the "Magic Cards Tricks" that is an algorithm giving the impression of guessing where the hidden chosen card is. The literature provides a diversity of examples to train the capacity of problem-solving, being the majority of them connected with mathematics and gamification.

In the TangIn Toolbox, the first lesson plan concerns the exploration of very interesting and common activity, challenging the trainee to program a "human-robot". The goal of the "human robot" activity is to make specific itineraries in the classroom, using simple commands such as "forward", "number of steps", "turn right and left". The activity should be solved by pairs: one plays the role of a programmer and the other plays the role of a "human-robot".

A big part of the activities suggested in this handbook are available in the TangIn Toolbox and should be implemented in this workshop to enrichen it and to make participants aware of the similarities between some daily challenges, algorithms and problem-solving.

⇒ **Scenarios**

The following image(s) illustrate a possible training scenario for this session.

Figure 2 – Possible training scenario of the talk/workshop discussion

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the example of presentation (TangIn project – IO3[3] result) about the topic given by:
  - Rui Gonçalo Espadeiro - "Computation without computers. An approach to the development of computational thinking" (ICT Competence Center of the University of Évora (Portugal)

ii) Tangible robotics in children's education in STEM and inclusion contexts

⇒ **Summary**

In this workshop several tangible robots will be explored in a hands-on strategy. There is a reasonable amount of resources delivered with educational games and didactic instructions that are very adequate to children from early ages, adapted to all educational, cultural, ethnical, gender and social backgrounds.

⇒ **Strategies**

The trainees should be divided in several heterogeneous groups from gender, region (rural/urban, and professional backgrounds). The groups should program the robots (see pictures below) having in

[3] http://www.tangin.eu/lesson-plans-toolbox/

mind real and practical learning examples in order to be used in a formal and informal educational context. It is expected that this strategy enrichens each participant with others contexts, knowledge, professional and personal experiences.

A very important issue is to have in mind, all over the course implementation, that the inclusion of children with special needs is a main concern. Therefore, several specific activities should be designed in those work groups, so conclusions can be taken about its practical application and feasibility in educational contexts.

⇒ **Scenarios**

The following image(s) illustrate a possible training scenario of this session.

Figure 3 – Possible training scenario of the talk/workshop discussion

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the example of a presentation about the topic given by:
    - Carlos Alberto Silva -"Tangible robotics in children's education and inclusion" (Porto de Mós School Cluster (Portugal)

iii) Hand-on activities with tangible robots. The example of Mi-Go

⇒ **Summary**

This workshop aims at exploring the MI-GO robot, used in the context of the TangIn Project. As it was mentioned in the introduction, this physical object allows to program instructions more directly and accessibly. Therefore, it is more stimulating for all learners also thanks to the blocks connected by Bluetooth that allow them to program and preview all the movements that the robot will do.

⇒ **Strategies**

The trainer begins the workshop by demonstrating the main technical functionalities of MI-GO robot, which is programmable in a tangible way through blocks that, after being connected to a central block, communicate with the robot via Bluetooth.

The robot is equipped with blocks that allow it to move forward and turn left and right. In addition to making 90º angles, the robot can also perform angles of another specific range between 1º and 360º defined by the user, this being one of the added values that MI-GO presents. In addition to the commands mentioned, it is also possible to use repetitions of a specific block or to create action cycles. These potentialities are recognized by all participants when compared to other similar robots.

Then, the trainees autonomously explore the technical potentialities of this robot, namely by using simple commands such as "forward", "number of steps", "turn right and left".

Finally, in a group, they should try to program more advanced and complex commands, such as the ones allowing to make the draft of complex geometrical figures (e.g. pentagons or hexagons) with a pen coupled to the robot. In addition, they can try to carry out complex measurements (e.g. to determine the perimeter of a trapezium) or other complex tasks envisaged by them.

⇒ **Scenarios**

The following image(s) illustrate a possible training scenario for this session.


Figure 4 – Possible training scenario of the workshop discussion with MI-GO[4]

[4] https://migobot.com/

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the MI-GO robot technical guide (TangIn project – IO2 result[5]).

3.6.3 Peer-observation in real school context - Tangible robotics in learning real-contexts activities with children

⇒ **Summary**

This outdoor session, in the sense that it is going to be attended in a school, should allow peer-observation of tangible programming activities, mainly in the context of the exploration of themes/topics of STEM articulated areas, according to a flexible curricular management, according to the latest indications from the Portuguese Ministry of Education.

⇒ **Strategies**

In this session, the trainees will have the opportunity to directly observe and interact with young pupils in learning contexts. Simultaneously, trainees will also be in direct contact with: i) the plans of the course; ii) facilities/difficulties when handling the robots; iii) the challenges that the group work demands from young pupils, excited because they have a new educational resource; iv) the adequacy of the plan to the children's' competences and background; v) the need (or not) to adapt the plans, the robot' special functionalities, the organization of the learning scenarios; and vi) the need of specific training to work collaboratively.

⇒ **Scenarios**

The following image(s) illustrate a possible training scenario for this session.

Figure 5– Possible training scenario of the peer-observation in a real school context

[5] http://www.tangin.eu/wp-content/uploads/2019/11/EN_Tangin-Teachers-handbook.pdf

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the TangIn curricular matrix (TangIn project – IO1 result[6]);
- the technical guide of the MI-GO robot (TangIn project – IO2 result[7]);
- the TangIn toolbox (TangIn project – IO3 result[8]).

3.6.4 Group/Autonomous work and oral presentation

⇒ **Summary**

These two sessions should aim to develop group work and autonomous work. The first of these modalities should focus on collaborative analysis, reformulation and elaboration of (new) didactic activities/plans to be integrated into the TangIn toolbox. The second modality has the same focus but will be accomplished in an individual work in order to develop autonomous competences.

⇒ **Strategies**

Firstly, the trainees should be organized in heterogeneous groups (e.g., gender; varied professional backgrounds; diverse competence levels). The group work should be focused on the appropriation and enrichment of the TangIn Toolbox. The collaborative work process should encompass cycles of design-implementation-evaluation-reformulation of the TangIn-TOOLBOX plans. Simultaneously, they will also reflect and adapt/modify the plans, as an individual work.

The plans are structured in the following way: i) summary of the activity; ii) expected duration (about 50-90 min), adapted according to any specific needs; iii) learning outcomes; iv) identification of curriculum topics to be explored in an articulated way; v) notes for teachers; vi) illustrated and detailed description of the activity and vii) resources list & support material (see Figure 9).

[6] http://www.tangin.eu/wp-content/uploads/2018/08/IO1-Final-Report_EN.pdf
[7] http://www.tangin.eu/wp-content/uploads/2019/11/EN_Tangin-Teachers-handbook.pdf
[8] http://www.tangin.eu/lesson-plans-toolbox/

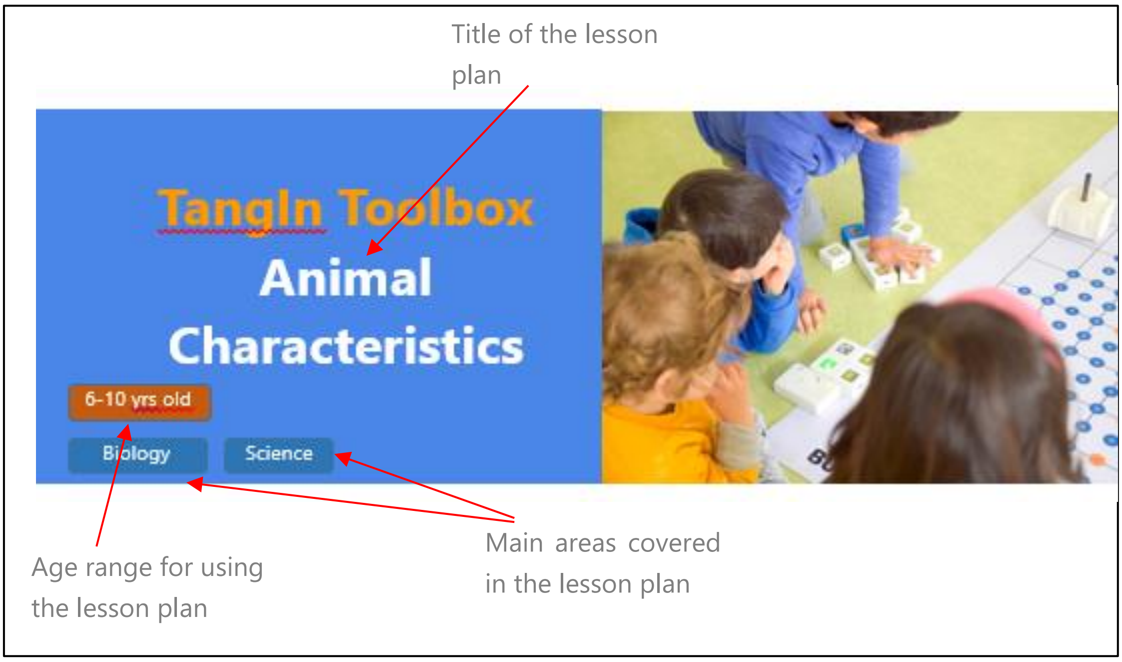

Figure 6 – Cover plan example of the TangIn toolbox

The following table presents a summary of the plans integrated into the TangIn toolbox and their links:

Table 3 – Summary of the plans

Lesson plans in the TangIn Toolbox		
Lesson Plan	**Summary**	**Subjects**
01_Intro Programming	Introduction to Computational Thinking, Programming and Robotics by using commands and role play dynamics. Simulate inputs and outputs and predict outcomes. Give examples of programming and algorithms in everyday life. Age group: **all.**	• Computational Thinking • Robotics & Algorithms • Itineraries
02_Introducing MI-GO	MI-GO is a tool that embodies the tangible programming concepts. This session is aimed to the introduction of the story of MI-GO and the explanation on how it is programmed. The first part of the session is dedicated to the customization of MI-GO where students use their imagination and art skills to build a character. Students will also learn that the robot is programmed through the use of blocks and the function of each block. At the end of the session, they will be able to execute simple instructions. Age group: **all.**	• Robotics & Algorithms • Length measure • Rotation • Itineraries
03_Animal characteristics	Animal cards scattered around a grid. Using the BOT to travel to them according to specific characteristics Age group: **6-10 years old.**	• Distinct Aspects • Classification • Probotic • Itineraries
04_Magic Square	Using the BOT to go to all squares without repeating in a chessboard using only the knight movement while doing it building magic squares. Age group: **9-12 years old.**	• Calculus • Logical Reasoning • Probotic • Itineraries
05_Maps and Traffic signs	Learn that maps are a representation of reality on a different scale. Use coordinates to find the correct correspondence between the small and big scale. Identify traffic signs and what they mean. Age group: **6-10 years old.**	• Scales • Coordinates System • Traffic Signs • Probotic • Itineraries
06_Minecraft	Using the BOT to mine minerals in the correct sequence according to their properties. Age group: **8-12 years old.**	• Minerals • Seriation • Probotic • Itineraries
07_Multiplication	Multiplication Tables are not only about memory there is a logic behind it, and fun also. With the BOT's help, we will build them by counting squares (areas). Age group: **7-9 years old.**	• Area model • Coordinates • Probotic • Itineraries
08_Recycling	Learn about the different types of waste and where they should be placed. Plastic, metal, glass and organic waste are valuable resources that must be reused and recycled. With the help of the robot, students sort different types of waste and put it in the correct recycling bin. Age group: **6-10 years old.**	• Natural Resource • 3R's Policy • Trial and Classification • Probotic • Itineraries

09_Symmetry	Finding the symmetry plan of geometrical figures drawn by MI-GO and divide into halves. Age group: **7-10** years old	• Reflection Symmetry • Probotic • Itineraries
10_Triangles	Locate and group different triangles in a geometrical figure drawn by MI-GO. Age group: **9-12 years old.**	• Triangle Classification • Decomposition of figures • Golden ratio • Probotic • Itineraries
11_Patchwork	Areas puzzle. Rotating Tetris like pieces to see where they fit. Some puzzle requires the teamwork of different groups to solve it. Age group: **9-12 years old.**	• Paving • Rotation • Scales • Probotic • Itineraries
12_Circulatory System	Drawing the circulatory map, connecting organs while separating venous and arterial blood flows Age group: **7-9 years old.**	• Human Circulatory System • Probotic • Itineraries •
13_Angles	First introduction to angles, and distinguish between a right angle, acute and obtuse. Age group: **6-10 years old.**	• Regular Geometric Figures • Internal and External Angles • Probotic • Itineraries
14_Connecting Dots	Some puzzle to train/introduces loops that increase gradually the level of complexity. Ideal to assess the current level of proficiency. Age group: **8-12+ years old.**	• Regularities and Patterns • Loops • Probotic • Itineraries
15_Space Train	Activity to create circuits and time-tables using the solar system as a theme. Age group: **6-10 years old.**	• Uniform velocity • Time tables • Loops • Probotic • Itineraries
16_Water Cycle	Competitive game with the water cycle as a theme. Age group: **6-12 years old.**	• Water Cycle • Probotic • Itineraries
17_Words	Scrabble-like game using MI-GO to create words for a subject at choice. Age group: **6-12 years old.**	• Multiple subjects • Loops • Probotic • Itineraries
18_Constellations	Drawing constellations with MI-GO and using scaled cards/maps to measure angles and lengths and convert to the *Set* dimensions. Age group: **9-12 years old.**	• Constellations • Angles • Scales • Probotic • Itineraries

19_Calculations	Matching cards with basic arithmetic operations and numbers on the Set as possible solutions Age group: **8-10 years old.**	• Operations and Properties • Algebraic Expressions • Probotic • Itineraries
20_Countries and Flags	Matching flag cards with countries and capitals. Age group: **6-10 years old.**	• EU Countries Characteristics • Maps • Citizenship • Length and angles • Probotic • Itineraries
21_Measuring Units	Using MI-GO to measure the classroom and use the data to create maps at scale. **8-10 years old.**	• Length measurement • Scales • Velocity • Floor plan • Probotic • Itineraries

The analysis, reformulation of the plans will be done according to the example given and they will become didactic plans to be integrated into the TangIn toolbox. They should be registered in the evaluation template of the TangIn-TOOLBOX plan. This instrument will allow to critically analyse the educational resources, and the respective materials included in the TangIn-TOOLBOX, aiming at the improvement and/or extension of such proposals, adapted to each educational reality.

This template will also serve as a basis to the elaboration of original plans, promoting practices of collegiality, in order to involve primary teachers as "curriculum developers" of creative activities on tangible programming in STEM areas. These plans should be designed underlying principles such as: curricular integration of tangible programming in STEM areas in articulation with the curriculum matrix developed in the TangIn project, previously mentioned.

The **group work** should be organized in the following points:

1. Analysis of, at least, two pilot session plans presented;
2. Elaboration of an original plan according to the example given;
3. Oral presentation of the plan designed in the last session and its reformulation integrating the suggestions given.

Another strategy might consist in inviting the other groups to solve the challenges suggested on the (new) plans elaborated by each group. This strategy can lead to a more proactive and interactive participation and can also promote more discussion and deeper knowledge about tangible programming.

The autonomous work could integrate an individual e-portfolio with the learning documents produced by the trainees during the course.

During the last session of the course, the trainees should present their work orally, discuss it and reflect on the work developed during the training.

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the TangIn curricular matrix (TangIn project – IO1[9] result);
- the technical guide of the MI-GO robot (TangIn project – IO2[10] result);
- the TangIn toolbox (TangIn project – IO3[11] result);

[9] http://www.tangin.eu/wp-content/uploads/2018/08/IO1-Final-Report_EN.pdf
[10] http://www.tangin.eu/wp-content/uploads/2019/11/EN_Tangin-Teachers-handbook.pdf
[11] http://www.tangin.eu/lesson-plans-toolbox/

- the evaluation template of the TangIn-TOOLBOX plans (TangIn project – IO3[12] result).
- the elaboration template of the TangIn-TOOLBOX plans (TangIn project – IO3[13] result).

3.6.5 Individual reflection about the course

⇒ **Summary**

Individual reflection about the course according to a specific template, previewed in the toolbox, and answering an evaluation questionnaire about the training.

⇒ **Strategies**

The trainees are supposed to make a reflexive document about the effects of their training in their professional practices, focusing on the following topics:

- Potentialities and constraints of the course;
- Implications of the course in their professional activity;
- Suggestions for future editions of the course.

Finally, trainees can fill an optional e-questionnaire that aims to get their perceptions about using the lesson plans/exercises of the TangIn toolbox. When filling in the e-questionnaire, teachers will have to select, at the beginning, the name of the lesson plan/exercise implemented. Teachers are recommended to fill it immediately after each plan implementation in real learning context, in order to obtain relevant feedback.

⇒ **Recommendations**

To support the preparation of this session the trainer can analyse:

- the suggested literature review;
- the TangIn teachers' evaluation course template (TangIn project – IO3[14] result).
- the TangIn e-questionnaire[15] (TangIn project – IO2 result);

[12] http://www.tangin.eu/lesson-plans-toolbox/
[13] http://www.tangin.eu/lesson-plans-toolbox/
[14] http://www.tangin.eu/wp-content/uploads/2019/11/PT_TangIn_TEACHERS-TRAINING-HANDBOOK.pdf
[15] https://tangin.typeform.com/to/QVqC1Yhttps://tangin.typeform.com/to/QVqC1Y

3.7 Assessment

Trainees should be evaluated within a "Continuous evaluation" framework, which means that it will focus both on the whole training process involving their productions and active participation in group and autonomous work, but also on their self and peer-evaluation.

The percentage of the summative evaluation is divided in:

- group work (70%)
- individual written reflection (30%).

⇒ **Recommendations**

To support the preparation of the assessment the trainer can adapt:

- the TangIn teachers' assessment grid template (TangIn project – IO3[16] result).

[16] http://www.tangin.eu/wp-content/uploads/2019/11/PT_TangIn_TEACHERS-TRAINING-HANDBOOK.pdf

4 Final considerations

Nowadays, in the European and national context, one of the main concerns in education regards the adequate professional preparation of the education agents, specifically one of the teachers. Additionally, School has to follow the digital challenges present in society in order to prepare pupils for the challenges of their future professional work. This reality really demands that all citizens develop e-skills, but particularly that teachers do. In fact, they are one of the key elements of the educational patchwork.

At the same time, they have to become more and more autonomous, reflexive and must own metacognitive skills in order to be able to observe their practices, as if they were observing themselves from outside, so that they can be able to see their strengths and fragilities in their daily actions. Thus, teachers can recognize their professional lacks and insecurities and therefore search for training and further professional knowledge. On the other hand, each teacher is unique, meaning that teachers have to make knowledge and procedures their own, according to their needs and motivations, so they become confident, authentic and captivating facilitators of their pupils' learning.

This handbook provides a set of recommendations and suggestions to the implementation of tangible programming within STEM areas, in a more inclusive context, in all young children's learning. However, one has to be aware that to teach and to facilitate and promote learning cannot be developed following a prescription handbook. Teaching has pedagogic and didactic principles, but it also means being creative, in an innovative way, in order to gain children's confidence, so teachers can be able to support them and help them become the best person they can become, so they become critical citizens, able to use and workout their rights and duties in a full citizenship practice.

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