D1.2 – Intellectual Output #1 – Part #3

Deliverable 1.2 - Contents specifications, including needs analysis, content definition, methodology and pedagogical scenarios

AN EDUCATIVE PLATFORM BASED ON MAKECODE, CIRCUITPYTHON & SCRATCH FOR CREATIVITY AND PARTICIPATORY SCIENCES USING IOT BOARDS

STEAM

Let's STEAM

An educative platform based on MakeCode, CircuitPython & Scratch for creativity and participatory sciences using IoT boards

D1.2 – Contents specifications, including needs analysis, content definition, methodology and pedagogical scenarios

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Date: April 2020

LET'S STEAM is funded by the European Commission within its Erasmus+ Programme, under KA-2 Cooperation for innovation and the exchange of good practices, Strategic Partnership for School Education
Project Number: 2019-1-FR01-KA201-062946

Erasmus+

DOCUMENT INFORMATION

Document title	D1.2 – Contents specifications, including needs analysis, content ...
Document file name	D1.2___.pdf
Revision number	VF
Issued by	Georgios Mavromanolakis – Ellinogermaniki Agogi
Issue date	27 April 2020
Status	Final

LINKS WITH INTELLECTUAL OUTPUTS

IO	Describe links with IO
Output 1: Pedagogical scenarios	This deliverable is linked to the task TO1.2 – Analysis of the teachers' needs and specifications regarding pedagogical pathway towards this target: the overall objective is to identify within the scientific teaching community, the needs and requirements of the teachers, by presenting them the objectives of the project, and assessing their skills. Tools as the one developed by ARGET regarding the assessment of digital competences of teachers will be used. Dissemination of the collaborative behaviours that LET'S STEAM wants to promote will be organised. Pedagogical scenarios will be defined including the creation of a complete set of specifications regarding the contents to be created. AMU, UNICE, EA, ARGET, UNINA and DW will have access to a pool of potential teachers. These networks will be used to reach the expected number of users. In addition, the questionnaires and process of workshops will be sent to advisory board members if some of their networks of schools are also willing to benefit from the training. ARGET will provide a methodology for assessment of digital skills. EA will have the final responsibility to provide the partners with the specifications that will be gathered from the participation of all partners.

DISSEMINATION LEVEL

PU	Public	X

DOCUMENT APPROVAL

Name	Role in the project
Mickael Martin-Nevot	Coordinator
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DOCUMENT REVIEW

Date	Version	Reviewers
10 April 2020	V6	Sébastien Nedjar-Ballester
20/05/2020	VF	Manon Ballester, L.A.B, for integration in O1

ACKNOWLEDGEMENT

This report forms part of the Intellectual Outputs and additional work plan deliverables (as defined in appendix to the Consortium Agreement) from the "Let's STEAM" project which has received funding from the European Union's ERASMUS+ programme under grant agreement n°2019-1-FR01-KA201-062946. The Community is not responsible for any use that might be made of the content of this publication.

Let's STEAM aims at developing a training of teachers' programme dedicated to computational thinking and creativity skills using IoT board and digital tools at larger scale. The project runs from September 2019 to August 2022. It involves 8 partners and is coordinated by Aix-Marseille Université.

More information on the project can be found on the project website: www.lets-steam.eu

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1. INTRODUCTION

It is widely accepted that STEAM education represents a paradigm shift from traditional education methodology and philosophy. Moreover, it is expected that between 2017 and 2027, the jobs that will require STEAM skills and competences will grow by at least 13%. To tackle this challenge, schools in Europe must implement STEAM strategies and pedagogies to promote interdisciplinary and innovative initiatives within the classrooms focusing at the same time on development and enhancement of programming and coding skills and competencies of both teachers and students. LET'S STEAM project is run by partners from academia, research, education and industry and its aim is to develop a framework and platform to assist the teachers in secondary schools to develop new contents and new skills to motivate their students to become more actors than attendees in knowledge acquisition. This is the case of the platforms **Scratch, MakeCode and CircuitPython** that in the framework of LET'S STEAM will be utilized and interfaced to program, control and interact with an advanced **Internet-of-Things educational board entitled "STM32 Discovery kit IoT node"** offered by the world leader in the field the STMicroelectronics industrial company. However, at the moment most of school teachers are not yet motivated or trained enough to use these platforms.

In this context, the LET'S STEAM project has been designed to provide the set of skills for teacher to enhance their STEAM approach by training them in programming but more importantly to help them understand the potential in terms of pedagogy of interdisciplinary use of programming as a priority and thus be able to create innovative pedagogical content in class with and for their students. **LET'S STEAM is implementing in five different countries (Belgium, France, Greece, Italy and Spain) the following staged methodology:**

- Understanding the needs and the basic skills of teachers with respect to programming capabilities,
- Gathering the requirements of the teachers to enrich the current open source programming platforms of **Scratch, MakeCode and CircuitPython and their interface to STM32 board** with advanced and tailored functionalities,
- Creating a complete set of learning modules dedicated to certain teacher profiles providing a breakthrough **Trainings for Teachers** solution to enhance their skills and capacities to become creators and contributors of new pedagogies,
- Ensuring the motivation of both students and teachers by proposing creative, interdisciplinary and collaborative projects in the scope of the internet-of-things, citizen science, societal grand challenges, etc.

In this document we focus on the first two points. In particular, in the following, we first describe in section 2 the methodology for assessing the digital competencies of teachers. Then in section 3 we report the results from the survey of teachers in each country. In section 4 we discuss the general and specific recommendations regarding the overall design of the teacher training programme to be developed and conducted in the framework of the project. Taking into account the analysis and insights in the previous sections we then propose a comprehensive categorization and list of pedagogical scenarios (in short to be referred as modules in the rest of the document) which will be fully documented and developed by work-package 2. Section 5 provides a brief description along with the main considerations for each module and a proposed detailed template. We summarize the key points of this document in section 6.

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2. METHODOLOGY

The aim of the research was to assess teachers' digital competence in different participant countries, as well as teachers' previous experience with computational thinking and programming languages and expectations regarding their training. To this purpose, a questionnaire with 3 different sections was designed as it is explained as follows:

2.1 ASSESSING TEACHERS' DIGITAL COMPETENCE

The assessment of Teachers' Digital Competence (TDC) was based on the COMDID-A self-assessment tool (i-DEPOT number 116248), an instrument developed by the ARGET research group in previous years. TDC is defined as the set of capacities, abilities and attitudes that the teacher must develop in order to incorporate digital technologies into his or her professional practice and development (Lázaro Cantabrana & Gisbert Cervera, 2015). In particular, the TDC is concreted in 4 dimensions, as in the work of Lázaro Cantabrana (2015), which are the following:

- D1 - Didactic, curricular and methodological aspects
- D2 - Planning, organization and management of digital technological resources and spaces
- D3 - Relational aspects, ethics and security
- D4 - Personal and professional aspects

In each dimension, 4 different areas are considered in which the TDC takes place:

- Classroom: In this area teachers use digital devices in the classroom, design and program teaching and learning activities with digital technologies, they manage the classroom, provide feedback and evaluate students with digital technologies and design teaching and learning activities to promote digital competences of students.
- Educational center: In this area teachers use and take care of the digital infrastructures and technologies of the center, respect the organization's digital identity, carry out the follow-up and the coordination of the use of the institutional digital resources at the pedagogical level, and incorporate training strategies of the organization in the technological field.
- Educational community and environment: Teachers use and organize the resources of the center to foster social participation.
- Professional Development: Teachers configure their personal learning environment, work in a network manner, manage their digital identity, are trained permanently, model and lead the use of digital technologies.

These areas are relevant because they provide a clear picture of the different situations in which these set of functions and purposes of the TDC have implications and in which a teacher must be competent. Therefore, identified areas should be considered as a reference to know where to collect evidence for the evaluation of impact of educational strategies and/or for teachers' accreditation.

23 indicators are defined based on these 4 dimensions and areas. In the questionnaire, teachers are asked to choose at which level they feel they can carry out a particular action, which is related to an indicator. Based on their ratings, results of the questionnaire allow to define 4 different levels of development of the TDC (Lázaro Cantabrana & Gisbert Cervera, 2015):

- Beginner Level: Use of digital technologies as enabler and enhancement to the teaching and learning processes.
- Medium level: Use of digital technologies for the improvement of teaching and learning processes in a flexible way and adapted to the educational context.
- Expert level: Use of digital technologies efficiently to improve students' academic performance, the quality of their own teaching, and the quality of the educational center.

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- **Transformative Level**: Uses digital technology, researches on its use to improve teaching and learning processes and transfer the conclusions of their researches to address the needs of the education system.

2.2 ASSESSING TEACHERS' PREVIOUS EXPERIENCE WITH COMPUTATIONAL THINKING AND EXPECTATIONS

In a second part of the survey, additional questions were introduced to assess teachers' previous experiences with computational thinking and the use of programming languages, as well as to gather data about their expectations for the lets' STEAM teacher training. To avoid an excessive extension of the questionnaire, 4 additional questions were introduced to:

- Assess the perceived experience of teachers in terms of the time they have been using these resources and the type of resources they usually use in their lessons
- Assess the perceived overall competence when programming
- Assess teachers' expectations for training

The assessment of the perceived experience and overall competence on programming was assessed using a 5-point Likert scale. Type of resources and expectations about training were gathered through open questions. Analysis for the closed question was based on basic descriptive statistical methods, whereas open questions were content analysed to identify common themes and elements among participants.

2.3 IDENTIFYING TEACHERS' PROFESSIONAL PROFILE

Finally, in order to better interpret the gathered results and possible bias in the answers, additional information about participants' profile was asked. In particular, participants' gender, age, country, initial background, educational level taught, and years of teaching experience were asked.

Data gathered in all these questions was also analysed through basic descriptive statistical methods.

2.4 QUESTIONNAIRE

The final let's STEAM questionnaire can be accessed in https://pedagogia.fcep.urv.cat/application_src/index.php/quiz/view/51.

As well, a pdf version of the questionnaire was made in case some teachers had issues with their Internet connection. The on-line version of the questionnaire provides an immediate feedback for each participant's results after the completion of the questionnaire about their own level of TDC, based on the 4 levels described above. As well, some guidelines are provided, according to each participant level, which suggest possible improvements to increase the participants' teacher competence. Results about previous experience and expectations as well as professional profile were not included in the participants' personal report.

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3. RESULTS OF SURVEY

3.1 PARTICIPANTS' BIODATA

A total of 41 teachers have answered the questionnaire in the month of March 2020, leading to the issue of this first version of the Output 1. From these teachers, different features can be identified. The questionnaire remains on-line to collect additional data within the project, in an iterative commitment.

3.2 GENDER

The majority of participants are males (61%), as shown in hereunder.

Table 1 - Gender distribution of participant teachers

	Number	%
Male	25	61
Female	16	39
TOTAL	41	100

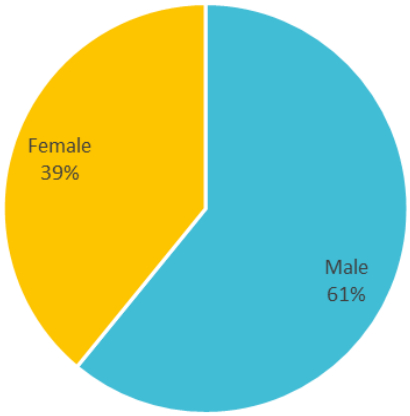


Figure 1 - Gender distribution on participant teachers

3.3 AGE

Most participants are in their 40s, being 36 the most frequent answer. As it can be seen in hereunder, participant most frequent age is comprised between 30 and 38 years old.

Table 2 - Descriptive statistics for the age of participant teachers

D5.2 [Age]	
Mean	40.6341463
Standard error	1.19692497
Median	40
Mode	36
Standard deviation	7.6640593
Variance of the sample	58.7378049
Curtosis	2.67337575
Asymmetry Coefficient	1.12501564
Range	38
Minimum	30
Maximum	68
Count	41

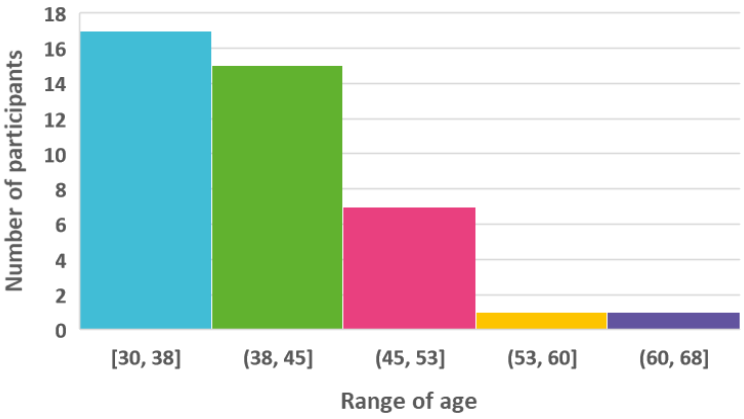


Figure 2 - Histogram of the distribution of age among participant teachers

3.4 COUNTRY

Gathered answers come from Greece (44%), Spain (29%), France (22%), and Belgium (2%). No answer has been gathered yet from Italy and Bulgaria, however the dissemination strategy towards these countries is expected to enable collecting additional data.

Table 3 - Results of participants' country

	Number	%
Belgium	1	2
France	9	22
Greece	18	44
Spain	12	29
N/A	1	2
TOTAL	41	100

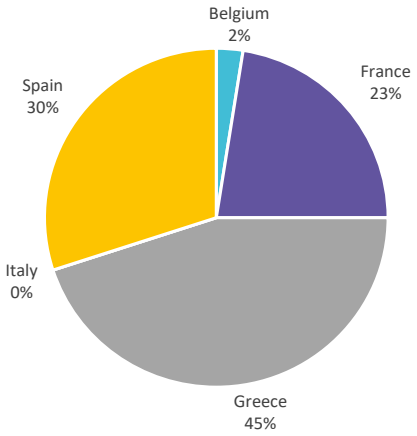


Figure 3 - Representation of distribution of participants' country

3.5 EDUCATIONAL LEVEL TAUGHT

This question has also experimented an issue in the questionnaire. From teachers who have answered, the majority of them are in secondary education (54%).

Table 4 - Teachers' educational level taught by number and percentage

	Number	%
Primary Ed.	8	20
Secondary Ed.	22	54
Interlevels	2	5
Others	0	0
N/A	9	22
TOTAL	41	100

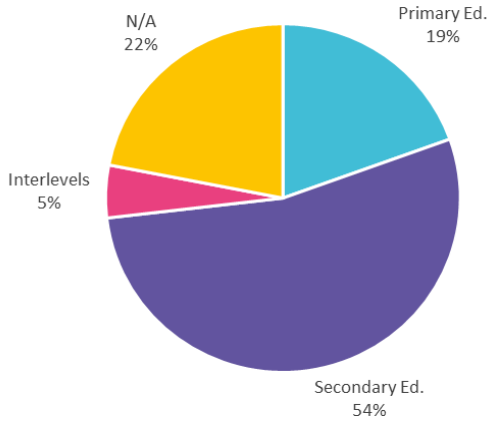


Figure 4 - Teachers' educational level taught by number and percentage

3.6 YEARS OF TEACHING EXPERIENCE

Most participants are experienced teachers, with more than 10 years of experience (61%) or between 5 and 10 (29%).

Table 5 - Participants' years of teaching experience

	Number	%
Less than 2	1	2
From 2 to 5	3	7
From 5 to 10	12	29
More than 10	25	61
N/A	0	0
TOTAL	41	100

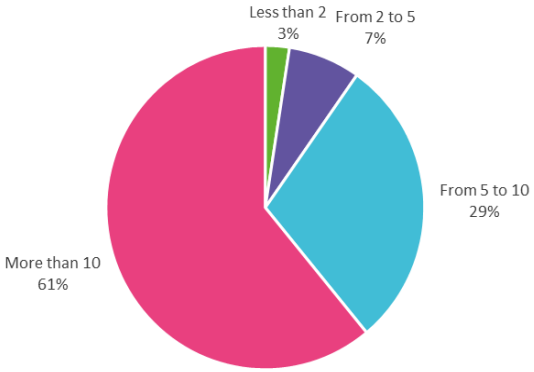
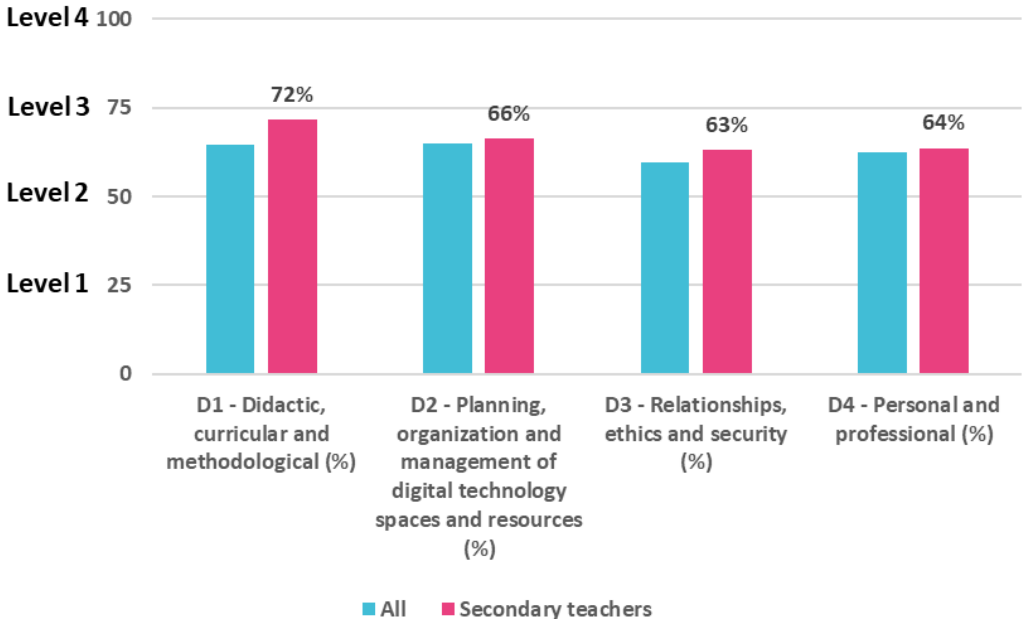


Figure 5 - Participants' years of teaching experience by number and percentage.

3.7 TEACHER DIGITAL COMPETENCE

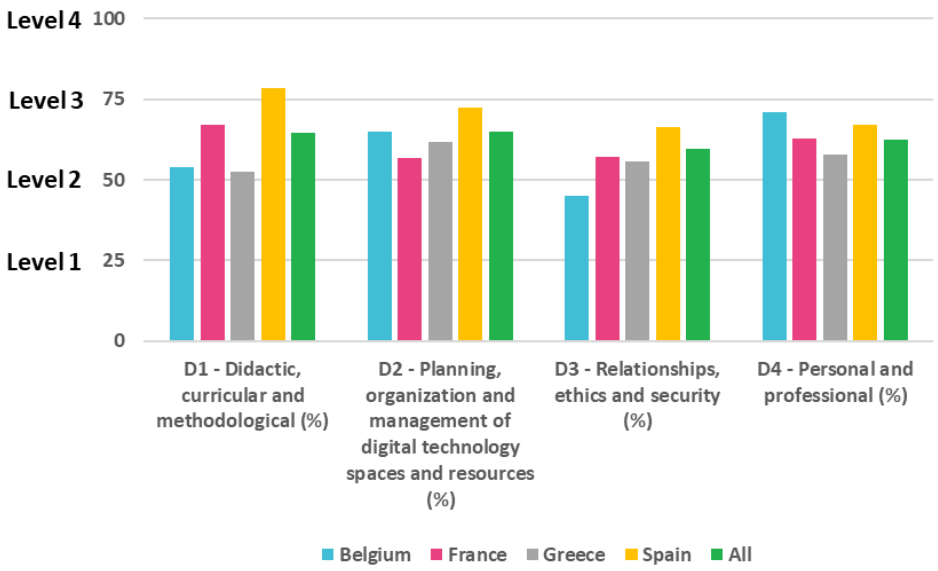
Teacher digital competence is relatively high in participant teachers. Overall, teachers display higher values in the planning, organization and management of digital technology spaces and resources (D2), as it is displayed in the following graph. However, in all dimensions, all participants' level is between Level 2 (Medium) and Level 3 (Expert) of the teacher digital competence. In this sense, participant teachers are expected to use digital technologies to improve the teaching process in a flexible way adapted to the educational context (L2), to improve efficiently students' academic results, their teaching action and the quality of the education centre (L3).



If only secondary teachers are considered, teacher digital competence is more focussed on the didactic, curricular and methodological dimension (D1) (72%), which is closer to the Level 3. Indicators of "Digital technologies as facilitators of learning" and "The students' digital competence in the didactic planning" display higher values in this dimension.

If the analysis is carried out by countries, Belgium teachers (1 teacher) stands out in the D4 – Personal and professional dimension, almost at the Level 3 (expert), over the overall mean. However, in the D3 – Relationships, ethics and security, their score is under Level 2. Score for the dimension 1 (didactic, curricular and methodological is also lower than the average sample). However, as only one teacher has answered the questionnaire, these results may have low significance in terms of country representation.

French teachers (9 teachers), score their highest values for the Didactic, curricular and methodological dimension (D1), a bit over the mean sample average. In second place, in the personal and professional dimension (D4), but at a similar level than the sample average. D2 and D3 are closer to the level 2 in these teachers and below the sample average levels. Thus, teaching resources would need to provide indications about how, for example, promote the responsible



and safe use of new digital technologies in the educational centre and with students.
Greek teachers (18 participants) display the lowest scores in the teacher digital competence on average. Their lowest scores, close to the Level 2, are in the didactic, curricular and methodological dimension (D1) and D3 (relationships, ethics and security). Highest values are displayed in the planning, organization and management of digital technology spaces and resources (D2), almost at the sample average. These teachers would benefit from strategies to use digital technologies efficiently to improve students' academic results, from a student-centred teaching, instructions about how to customize materials and digital teaching resources to meet the diversity of students, facilitate access to technology, and better assess their learnings.

Finally, participant Spanish teachers (12 teachers), score above the sample mean in all dimensions of the TDC, especially for the Didactic, curricular and methodological dimension (D1), which is above Level 3. Based on the results, Spanish teachers would benefit from teaching strategies addressing the relationships, ethics, and security dimension (D3), and personal and professional dimension (D4). For example, to manage digital spaces to share knowledge and promote the participation and interaction of the educational community, promote the responsible and safe use of new digital technologies in the educational centre, or transfer training in the digital field to improve your own professional practice and the quality of the educational centre.

No data has been gathered about Italian and Bulgarian teachers.

3.8 COMPUTATIONAL THINKING

Experienced and skilled perceptions in programming. Most participants feel they have experience programming in class and feel they are skilled teachers when it comes to use programming languages. If the statistics are carried out considering only answers from teachers in secondary school or inter-levels, results are very similar.

Table 6 - Results of teachers' own perception of their experience in programming

Experienced teacher (D5.6)				
	Count	%	Count_SEC	%SEC
I totally disagree	4	10	2	9
I disagree	8	20	3	14
I neither agree nor disagree	7	17	4	18
I agree	9	22	5	23
I totally agree	12	29	8	36
N/A	1	2	0	0
TOTAL	41	100	22	100

Table 7 - Results of teachers' own perception of their skills when programming

Skilled teacher (D5.7)				
	Count	%	Count_SEC	%SEC
I totally disagree	5	12	2	9
I disagree	8	20	4	18
I neither agree nor disagree	6	15	3	14
I agree	10	24	6	27
I totally agree	11	27	7	32
N/A	1	2	0	0
TOTAL	41	100	22	100

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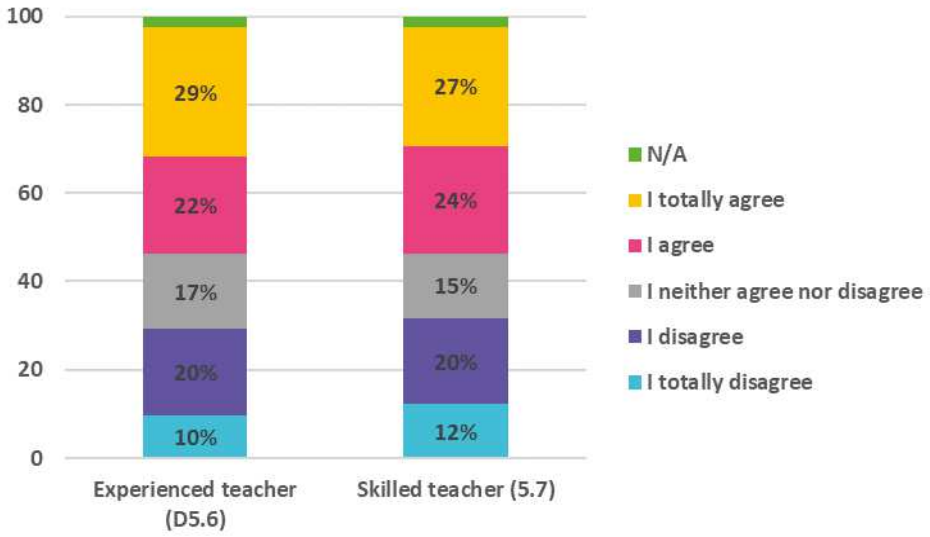

Figure 6 - Distribution of teachers' answers about their perception of their experience and skills when programming

Experience in programming languages and using robotics. Participant teachers mostly report using visual programming tools (19 teachers) to promote computational thinking with their students. Scratch is the most used software. General-purpose programming tools are less popular (15 teachers), though still significant. Within this category, **Python** and **C/C++** are the most popular ones (5 teachers mentioned them in both cases). Regarding hardware, **Arduino** microcontroller is the most popular one (8 teachers use it), followed by **Micro:bit** (4 teachers) and **Lego** hardware (4 teachers).

3.9 EXPECTATIONS IN TEACHING AND LEARNING COURSES

In relation with the **content**:

- Teachers emphasize the need to focus in the interdisciplinary approach, using programming as a tool/medium, not only as a target itself.
- Almost a third part of the mentions, emphasize the use of programming in connection with other STEM disciplines and with the inquiry approach and in connection with the experimentation/modelling of the real-world phenomena.
- Another third of teachers emphasizes the connection of programming with the arts (visual arts, performing, etc.)
- The final third of the teacher only mention the need to stimulate curiosity and creativity through programming.
- A few numbers of teachers (2) manifest some programming skills to be included (e.g. IoT protocol like MQTT)

In relation with the **methodology**:

- Many teachers would like project-based learning activities (e.g. guiding question, with a finalised product, connection with inquiry skills…).
- Some teachers would also like the possibility to have different adaptations of the activities according to different educational levels or students' needs. 3 teachers specifically mention a need to have inclusive activities or activity variants to make the product more inclusive.

In relation with the **programming platforms**:

- Most of the teachers value to have a pool of good examples of project/ activities/ classroom proposals which are already-made and ready-to-implement.
- As well, teachers manifest a need to include explicit teaching strategies in the educational materials offered.

4. GENERAL AND SPECIFIC RECOMMENDATIONS

Teachers, and in general educators, develop practices of teaching with which they feel comfortable and confident. When they mature it is usually difficult to change them, or they feel insecure to adopt innovative methodologies, technologies or practices such as the educational approach and activities to be developed and proposed in Let's STEAM. However, when asked in surveys, most teachers express the willingness to adopt new methods and models of teaching, that have proven their effectiveness and that lead their students to better results in terms of concept understanding, content knowledge and behaviour or attitude change. A required condition is that they are thoroughly introduced in practicing these new methods before applying them to their everyday classroom teaching. In this respect Let's STEAM aims to develop and offer a comprehensive training programme, encompassing multiple modalities that include support educational materials, example best-practices and resources integrated in an online platform, hands-on practice workshops, that will not only help teachers to explore, adopt, implement and improve an already made educational activity or practice but also assists them to gain confidence and experience towards developing their own ones individually or in collaboration with other teachers and educators.

The Let's STEAM Teacher Training Programme, or also referred as "Train the Trainers", is the subject of the second intellectual output of the project. Herein we discuss and propose the main design considerations along with general and specific recommendations of features that such a programme can incorporate.

4.1 GENERAL RECOMMENDATIONS

In general, when developing educational activities, a training programme or curriculum in partnership it should be emphasized that alongside the process of how an activity is developed, key aspects of the activity itself like aims, learning outcomes, content, teaching and learning methods and assessment methods also need to be considered. Usually in literature (for example see Plomp 2009 and van den Akker 2007) an extended version of key aspects of an activity, and in general the curriculum, is shown in the shape of a spider web, thus metaphorically illustrating that placing additional focus on one of the key aspects this would inevitably influence the shape and the strength of the whole web.

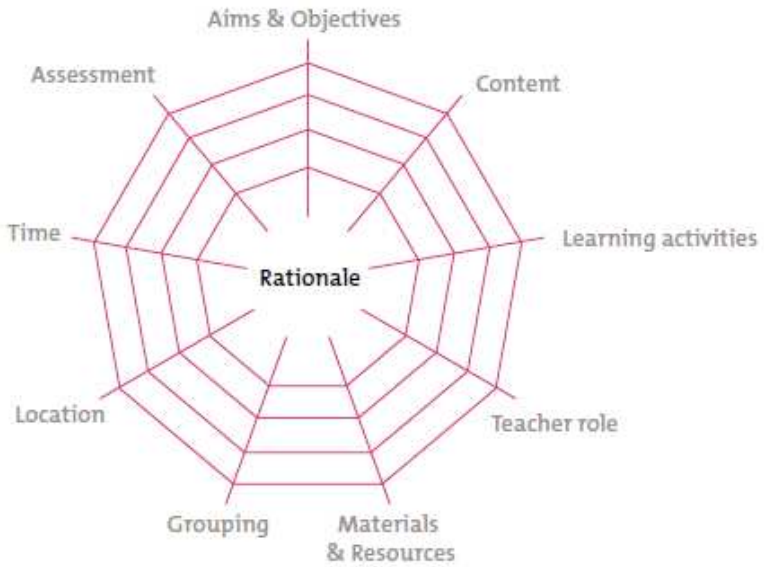

Figure 7 - Curricular spider web as proposed in van den Akker, J. (2007).

The key aspects of the curriculum as depicted in the following figure (Fig.**Erreur ! Source du renvoi introuvable.**) are: rationale, aims and objectives, content, learning activities, teacher role, materials and resources, grouping, location, time and assessment. We adopt this spider web model and we suggest that all these dimensions should be clearly defined, be in balance and be addressed in the developed programme. We believe this will strongly assist and facilitate teachers in better embracing the training concept and its objectives.

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Regarding the general process of educational design or development cycle of an activity we follow an approach that focuses on three phases: the analytical, the prototyping and the assessment phase (Plomp 2009). In the former phase teachers are introduced to an example, they practice it taking the role of learners and analyse it in a reflective and collaborative way. In the second phase, the prototyping, they envisage how to implement the activity with their students, taking the role of action researchers and critical observers. In the last phase, they assess their findings, collaboratively reflect on the results and outcomes. The whole process is implicitly of iterative nature and provide a well-founded overall framework for progressive and gradual acquisition of the proposed training modules or best-practices or the development of new ones. These three phases may not be explicitly imposed or practiced, for example in the mode of three separate distinct workshops, but they can be implicitly infused in the programme in a single session of hands-on training by well selected and designed learning modules with best-practices and example cases.

In this context, we recommend offering teachers dedicated workshops to help them to pre-practice by following examples, develop further and reflect on their practices, their understandings and past experiences, collaboratively reflect on the proposed instruction models, their main advantages and the common mistakes, etc. These workshops, and as a whole the Let's STEAM training programme, can be offered in parallel or within the framework of existing professional development programs, or even better in synergy with other similar projects and initiatives so that more teachers from more schools can be involved. They can also be grouped into consecutive cycles in line with the school year schedules in each country where workshops of training activities are implemented first in a small number of school teachers, feedback is collected, and findings are shared with other partners in different countries.

In conclusion, in the framework of Let's STEAM and complementary to its main objectives, the training programme is recommended at furnishing, touching upon or strengthening the following general educational objectives:

- To enable teachers trying new ideas in practice as a means of improvement and as a means of increasing knowledge about the curriculum, teaching, and learning opportunities within STEAM.
- To raise their level of critical thinking about teaching and learning, and in general about their practice or commonly adopted methodologies.
- To engage them in collaborative and reflective implementation and development of practices.
- To facilitate the adoption of innovative approaches in teaching and learning.
- To emphasize the importance of sharing experience, expertise and valuable outcomes with other teachers in their community and beyond.
- To strengthen their capacity and confidence to become active change agents.
- To empower them in engaging in similar approaches that affect their communities and well-being and for their particular needs or interests.
- To strengthen their capacity to become educational content creators.

4.2 SPECIFIC RECOMMENDATIONS

The Let's STEAM Training Programme is planned to be based on the comprehensive presentation and hands-on practice of specific modules focusing on particular areas of skills and competences. The training programme will support teachers in integrating programming and usage of the IoT board in the standard curriculum and it further aims to provide guidance on curriculum organisation, pedagogical methods, technical training on tools, platforms and resources.

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In the following we list and elaborate on specific features and characteristics that we recommend that such a programme should incorporate.

- Overall inclusive approach. The programme and its activities should attract and involve teachers of all disciplines, levels of experience, gender, social or ethnic backgrounds. Specifically:
  Gender balance. Training examples, proposed educational activities, projects or ideas should attract the interest of teachers and students of both genders avoiding common stereotypes.
  Social inclusiveness and integration. Similarly they should be accessible and attract the interest of teachers or students of social or economic disadvantaged areas or in rural or distant sites.

- Multidisciplinary/interdisciplinary collaborative approach. The programme and its activities should address or involve teachers of multiple scientific fields.

- Project-based/Inquiry-based learning approaches. The programme and its activities should preferably be structured or follow inquiry-based methodological/pedagogical processes with steps or phases and furthermore put emphasis on problem solving, creativity and collaboration.

- Modular structure. The programme and its materials should be modular and staged so that it can be followed by teachers with different level of needs, expertise, experience etc.

- Replication potential. The proposed approach, programme and activities should be easily transferable to other European countries.

- Low-threshold use of ICT technologies. The proposed online resources, the Let's STEAM e-learning platform and tools should enhance and complement traditional teaching and learning and promote digital literature of both teachers and students without any prerequisites of prior technical knowledge, requirements for pre-installed software packages etc.

- Asynchronous, open and online. This will greatly facilitate the participation of schools and teachers from distant areas that can follow the education programme at their own time, pace and frequency.

- Effective game mechanics. Incorporation of basic gaming elements in the offered training modules and activities of the Let's STEAM e-learning platform (e.g. star rating, award scheme of badges or certificates, scoreboard, wall of fame etc.) greatly attracts the interest of both teachers and students. However, this should be well-balanced and purposeful so to retain interest, enhance conscious learning and influence behavior or attitude change.

- Scientific and technological correctness. Training modules and accompanying materials, including links to online resources, public video instructions etc, should not create gray areas or matters that may create misconceptions to teachers or students, promote pseudo-science etc. Similarly any developed programs to be run in the proposed platforms should be tested in advance.

- Emphasis on experiential aspects, practical hands-on training and do-it-yourself implementation.

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5. PEDAGOGICAL SCENARIOS

In this section we discuss the pedagogical scenarios, in short referred as modules, that Let's STEAM will develop and offer to its teacher training programme. Taking into account the teacher digital competence survey data and their comprehensive analysis with respect to profiles, needs, experiences and interests/insights as presented in previous sections of the document we propose three focus areas, each having three levels, namely basic, intermediate and advanced. The proposed focus areas are: **"Programming and IoT board functionalities", "Interdisciplinarity and integration" and "Ethics, security and relationships".** This first proposal will be updated and modified depending on the WP2/O2 work.

The first set of modules focusing on programming and familiarization specifically with the IoT board aims to provide all necessary instructions, tutorials and sample code examples on how to program the IoT board and take full advantage of its sensors and functionalities using the proposed platforms in Scratch, MakeCode and CircuitPython. The three modules of this set are progressing from basic to intermediate and finally to advanced. They are all considered as compulsory and should be taken by all teachers, experienced or not, during the training programme.

The second set of modules is focusing on interdisciplinarity and practical integration of inquiry-based methodology of learning and teaching. It builds on the knowledge acquired from the first set of modules which is applied in developing more complex and multidisciplinary learning projects and activities using the IoT board and programming platforms. The three modules of this set are also progressing from basic to intermediate and finally to advanced so that can be followed by less or more experienced teachers accordingly.

The third set of modules covers the focus area of ethics, security, and relationships which although it is of highly importance, usually it is not adequately well addressed in trainings related to digital literacy and competencies. Therefore, Let's STEAM aims to fill this gap with three dedicated modules on these matters.

With respect to pedagogical framework, the main approach adopted by Let's STEAM is project-based teaching and learning. We consider also implementing inquiry-based methodology which is also utilized by STEM teachers for effective learning. One may draw distinctions between project, inquiry or problem-based learning, however in reality the differences are minor, and all have proven their efficacy in comparison to traditional lecture and worksheet-based forms of teaching and learning. Great projects grow from inquiries in order to solve problems. School students and In general learners found them highly engaging because they are conducting work that is meaningful to them and can connect to real life problems and challenges. Learning begins with a problem to be solved, and the problem is posed in such a way that learners need to gain new knowledge before they can solve the problem. Rather than seeking a single correct answer, they interpret the problem, gather needed information, identify possible solutions, evaluate options and present conclusions. The whole process gives many opportunities to connect to real-life and real-world challenges, work across disciplines, learn to function and collaborate in teams, communicate their findings and solutions, engage with their peers, experts and communities.

In the following we first present in detail a generic inquiry-based model based on five phases (Orientation, Conceptualization, Investigation, Conclusion and Discussion) that may be useful teachers to follow in case of more STEM related educational activities. A variation of this is also adopted in the structure of the training modules with focus on interdisciplinarity and integration that will be presented in following sections. We also discuss in brief types of inquiry.

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Then we describe the training modules, pedagogical scenarios, of each focus area that we propose to develop in the framework of Let's STEAM. It should be noted that this is a proposed structure and content description at the current point of the project. During the project any necessary alterations, adaptations, improvements, and extensions will be added.

5.1 PROJECT AND INQUIRY-BASED PEDAGOGY

Inquiry-based learning (IBL) is an educational flexible strategy with phases that are often organized in a cycle and divided into subphases with logical connections depending on the context under investigation (Pedaste et al., 2015). This framework entails five general phases (Orientation, Conceptualization, Investigation, Conclusion and Discussion) and seven sub-phases (Questioning, Hypothesis Generation, Exploration, Experimentation, Data Interpretation, Reflection, and Communication). It can be used by teachers in order to conceptualize a structured way to implement inquiry activities and develop multidisciplinary educational projects in their classroom. IBL is not a linear procedure (see Fig.Erreur ! Source du renvoi introuvable.) and learners should be involved with various forms of inquiry, going through different combinations of the phases, not all of them necessarily. For example, if the data analysis is not satisfactory enough, students can return to the conceptualization phase and reconsider their question and/or their experimental design. When students come to a conclusion, new questions can be generated, and the process starts again in a progressive fashion. A description of the processes that each phase encompasses is provided below and the connections between these processes are presented in Fig.Erreur ! Source du renvoi introuvable. (Pedaste et al., 2015).

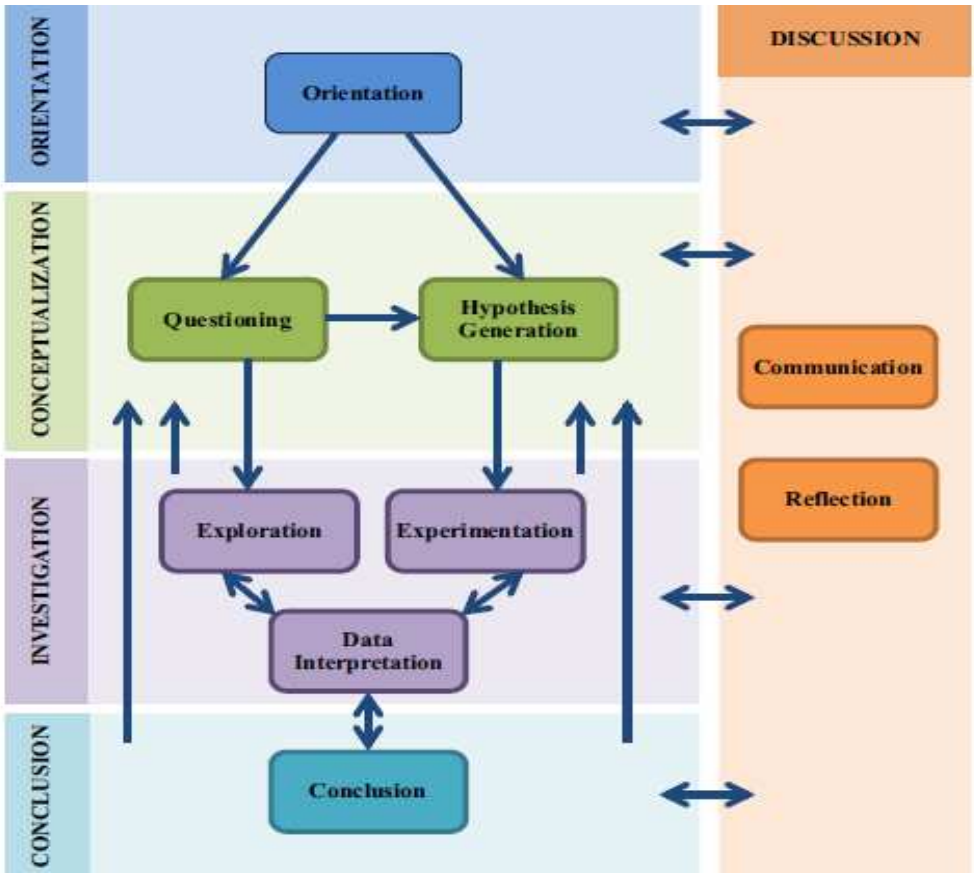

Figure 8 - Phases and subphases of inquiry-based learning and their relations as described in Pedaste et al., 2015

5.2 PHASES AND SUBPHASES OF INQUIRY ACTIVITIES

Orientation: Orientation is the phase where the identification of the problem occurs. The topic to be investigated is presented and interest about a problematic situation that can be answered with inquiry is stimulated. The topic under investigation must be relevant to students' daily life, interests and prior knowledge. The teacher's role in this phase is to encourage students to express ideas, prior knowledge and questions about the topic, while promoting interaction and communication between them. For example, students can create concept maps of what they know, do not know or want to know about the topic under investigation. These kinds of activities can also be useful for the next phases of inquiry.

Conceptualization: Conceptualization refers to the understanding of the concept, which relates to the problematic situation presented in the previous phase. It is divided in two sub phases (questioning and hypothesis generation) that lead the learner to the investigation phase. Now the teacher's role is to help students understand how they can formulate questions and/or hypotheses that can lead to an investigation. If students are not familiar with the questioning and hypothesis generation sub – phases, the teacher can choose a structured type of inquiry at first and then progress in more open types of inquiry in order to provide the appropriate guidance.

Questioning subphase: Questions are formulated in order to design an investigation that produces answers. As this skill is developed through inquiry, students can gradually understand which question can lead to investigation and which one is more generative and might lead to different or richer processes.

Hypothesis Generation subphase: A hypothesis is generated through providing explanations of how the identified variables relate (Pedaste et al., 2015). It explains how and why phenomenon functions based on former experiences and prior knowledge (National Science Foundation, 2000).

Investigation: Investigation is the phase where students collect evidence in order to answer their questions and/or test their hypothesis (National Science Foundation, 2000) and includes the sub – phases of exploration, experimentation, and data interpretation. The teacher provides materials that the students might need and keeps them on track so that the process they choose to follow is a process that answers the investigative question. Students should determine what constitutes evidence and collect it. If they are not familiar with this process, a structured type of inquiry can be chosen. The teacher can provide or encourage students to create means (e.g. tables, charts etc.) that can help them organize, classify and analyze the data.

Exploration subphase: Exploration is an open process which generates mostly data concerning the identification of a relation between the variables. It is chosen typically when the question that was formed in the previous phase was generative, because students do not have a specific idea of what to explore or how the identified variables relate to each other (Pedaste et al., 2015).

Experimentation subphase: Experimentation includes the design (e.g. choosing the materials and means to measure) and performing of experiments taking into consideration the variables that need to change, remain constant and be measured. The products of this subphase are data or evidence that can be used later on for analysis and interpretation.

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Data Interpretation subphase: According to the National Science Foundation (2000), data interpretation "includes finding a pattern of effects and synthesizing a variety of information" (p. 57). Depending on the concept under investigation and the inquiry procedures that were chosen, finding relations between the variables is sometimes the key for getting the desired outcome (answering the investigative question). Organizing and classifying the data (with graphs, charts, tables, pictures etc.) can benefit this process.

Conclusion: In this phase students draw conclusions based on the investigative question and the interpretation of the data. The teacher's role during this phase, a comparison between the interpreted data and the predictions and initial ideas (that students expressed during the orientation phase) can be stimulated. This process can also lead to new hypotheses and questions about the topic under investigation (as shown in figure).

Discussion: During the discussion phase students articulate their findings through communicating them to others and/or reflecting upon all or some of the stages of inquiry during the process or by the end of it (Pedaste et al., 2015). The teacher's role is to encourage collaboration so that students can present their findings and ideas, provide arguments and give feedback to others. If they are not familiar with these practices, the teacher can provide guidelines that will help them to communicate during all the phases of inquiry.

Communication subphase: Communication includes discussion with others and representation of results in a manner that is understandable to all (National Science Foundation, 2000). It can be applied to a single phase or the whole cycle of inquiry and is usually an external process (Pedaste et al., 2015).

Reflection subphase: In this subphase students reflect on their work, their results and the concept under investigation. Reflection can even give rise to new thoughts regarding the inquiry cycle or a single phase.

5.3 TYPES OF INQUIRY

The types of inquiry vary so that students are actively involved in the process to the extent that they are competent and able to do so. The type of inquiry a teacher may choose to follow is highly depended on the objectives of the lesson, the age of the students, their previous involvement with inquiry and the scientific skills they have already acquired. As shown below, the more responsibility the student has, the less direction is provided and more open the inquiry becomes (National Research Council, 2000).

The variations of inquiry types concern the increasing or decreasing involvement of the teacher and student in the process. Structured inquiry is directed from the teacher so that students reach a specific result, whereas in mixed inquiry students are more involved during an investigation with the teacher guidance still being the most dominant. These forms of inquiry usually are chosen when students are first introduced to inquiry practices and when there is a focus in the development of a specific skill or concept. Open inquiry provides more opportunities for developing scientific skills, given that during open inquiry the students work directly with the materials and practices in a way that resembles authentic scientific approaches (National Research Council, 2000).

For example, if students lack previous experiences with designing investigations and collecting data, a more structured or guided form of inquiry should be chosen. When students acquire the skills needed, they can progress to more open inquiry activities. Students should at some point participate in all the forms of inquiry, while gradually moving from one form of inquiry to another with the simultaneous progression of complexity and self-direction.

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	Learner self direction			
	Structured	Mixed	Guided	Open
Essential Features				
1. Learner engages in scientifically oriented questions	engages in question provided by teacher, materials, or other source	sharpens or clarifies question provided by teacher, materials, or other source	selects among questions, poses new questions	poses a question
2. Learner gives priority to evidence in responding to questions	given data and told how to analyze	given data and asked to analyze	directed to collect certain data	determines what constitutes evidence and collects it
3. Learner formulates explanations from evidence	provided with evidence and how to use evidence to formulate explanation	given possible ways to use evidence to formulate explanation	guided in process of formulating explanations from evidence	formulates explanation after summarizing evidence
4. Learner connects explanations to scientific knowledge		given possible connections	directed toward areas and sources of scientific knowledge	independently examines other resources and forms the links to explanations
5. Learner communicates and justifies explanations	given steps and procedures for communication	provided broad guidelines to use sharpen communication	coached in development of communication	forms reasonable and logical argument to communicate explanations

Figure 9 - Types of inquiry and their features regarding questions, evidence, explanations, connection of the explanations to scientific knowledge and communication. Adapted from Inquiry and the National Science Education Standards, National Research Council (20

5.4 TRAINING A: PROGRAMMING AND IOT BOARD FUNCTIONALITIES

This training consists of three modules which are progressing from basic to intermediate and finally to advanced. All three modules are proposed to be compulsory for all teachers participating in the training workshops. This is since this set of modules is particularly focusing on giving them the necessary baseline knowledge with respect to programming using Scratch, MakeCode or CircuitPython. Furthermore, through them they will also get introduced and familiarized with the IoT board, its sensors and functionalities. The three proposed modules are entitled “Blink a LED”, “Read sensors and activate”, “Make a wearable gadget or techno-art object” and are described further below. Each module follows a common structured template with makes it easier to transfer it in a synchronous or asynchronous online

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learning environment (e-learning platform) and on face-to-face hands-on workshops. The proposed structure includes the following elements (a complete template is also attached in the Appendix):

Introduction
- *Learning objectives*
- *Duration*

Module description step-by-step
- *Tutorial 1*
- *Tutorial 2*
- *Tutorial 3*
- *Conclusion – wrap-up*

Quiz or key questions for knowledge testing

Try this! (optional)
- *Exercise 1:*
- *Exercise 3:*
- *Exercise 3:*

References or additional resources

Appendix
- *Source code in Scratch*
- *Source code in MakeCode*
- *Source code in CircuitPython*

5.5 MODULE A.1: BLINK A LED

When first using a new hardware board or micro-controller a task to learn how to blink a LED with it is equivalent at software level with the case when one is first introduced to a new programming language and learns to develop a "hello world" program. The sense of accomplishment by learning to do it is not trivial and is critical to engage learners. The objective of this module is to train teachers to use simple electronic components, as the LEDs, already embedded on the board or to make a basic circuit with LED and connect it. The basic code to switch it on and off is easy and short even for very novice teachers, an example in MakeCode platform is shown in Fig.**Erreur ! Source du renvoi introuvable.** below. Therefore, it is the perfect starting point which then can be followed by further tutorials and practical exercises to introduce gradually the main structures and syntax of a programming language. These are: definitions of variables and functions; recursion through for loops and while loops; conditional statements etc.

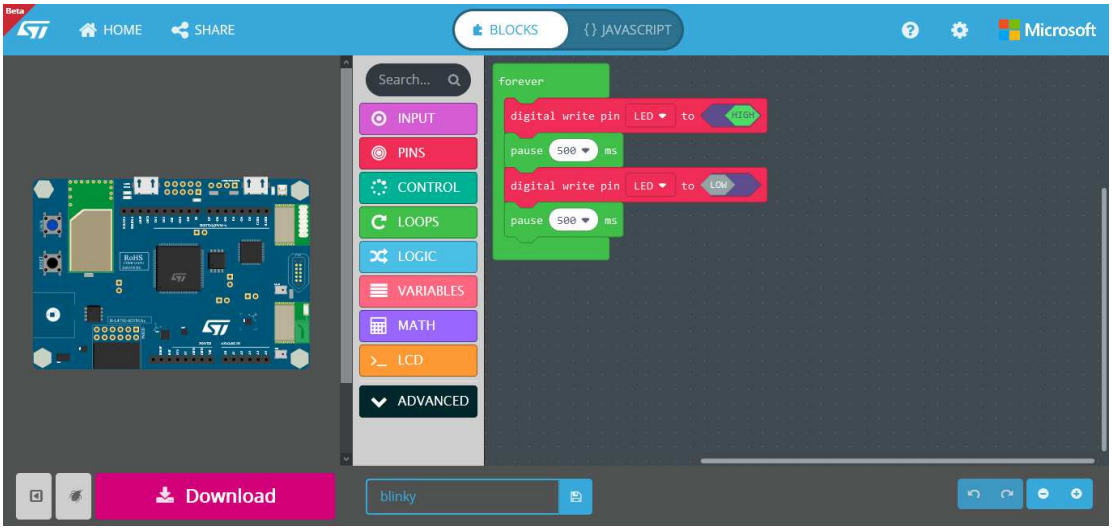

Figure 10 - Example program in MakeCode on how to blink a LED on the IoT board

5.6 MODULE A.2: READ SENSORS AND ACTIVATE BUZZERS OR LEDS

Once the first module is completed, we may proceed to learn on how to read the variety of sensors that the IoT board is equipped with. Then depending on their values, we want to make a program to activate and control simple devices, such as a LED to emit light or a buzzer to beep. In a nutshell, the learning objective of this module is to basically introduce one-by-one the sensors embedded on the IoT board.

These are: 3-axis accelerometer, 3-axis gyroscope, 3-axis magnetometer, proximity sensor, temperature sensor, pressure sensor, humidity sensor. Through detailed sample code provided, step-by-step instructions (see Fig.**Erreur ! Source du renvoi introuvable.**) and exercises the learner teacher at the end will be able to develop a program e.g. to read multiple sensors, to process their values in order to finally control an output device such as a LED or buzzer.

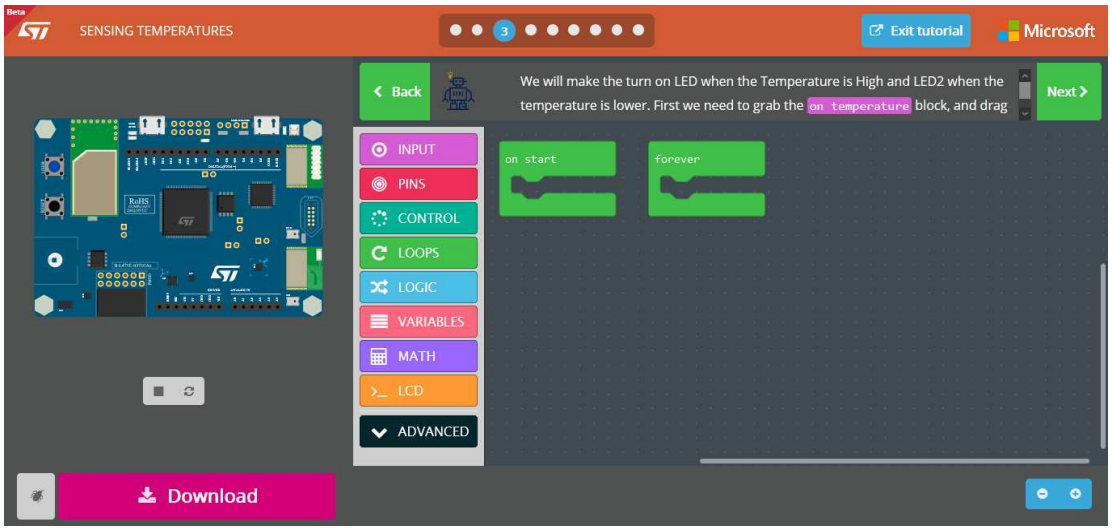

Figure 11 - Example of step-by-step instructions in MakeCode platform to develop a program to read the temperature sensor of the IoT board

5.7 MODULE A.3: MAKE A WEARABLE GADGET OR TECHNO-ART OBJECT

This module builds on the knowledge acquired from the previous ones and aims to extend it further. Its objective is to train learners to combine motion and additional sensors in a complementary way in order to activate built-in or external array of LEDs or/and sound devices, servos etc (e.g. see Fig.**Erreur ! Source du renvoi introuvable.**).

It also puts emphasis not only on the technological part but also on the creative aspects as teachers are requested to build at the end a wearable gadget, e.g. a hand-held tilt sensing gadget or a proximity alert device to attach at head-hat or glasses or a crazy-dance-meter etc.

Or similarly teachers can create an object, e.g. an interactive abstract artwork, that senses its surrounding and reacts to it with motion, light or sound. In this way, fun-based DIY activities engage teachers and teaches them practically more advanced features and applications of the IoT board and the coding platforms.

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Figure 12 - Example program in MakeCode on how to control servo and LEDs

5.8 TRAINING B: INTERDISCIPLINARITY AND INTEGRATION

The second set of modules is focusing on interdisciplinarity and practical integration of pedagogy of inquiry-based methodology of learning and teaching. It naturally builds on the knowledge acquired from the first set of modules which is then applied in developing more complex and multidisciplinary learning projects and activities using the IoT board and the proposed programming platforms. The three modules of this set are progressing from basic to intermediate and finally to advanced so that may be followed by less or more experienced teachers accordingly, depending on their score results obtained in the digital competence questionnaire.

The three proposed modules are entitled “Make a proximity or motion alarm”, “Measure reaction time”, “Study environmental parameters” and are described further below. As in the previous case, each module follows a common structured template with makes it easier to transfer it in a synchronous or asynchronous e-learning platform and on hands-on workshops. The proposed structure includes the following elements (a complete template is also attached in the Appendix):

- *General information or introduction*
  - *Description*
  - *Learning objectives*
  - *Links to curriculum*
  - *Duration*
  - *Extra materials required*
- *Module description step-by-step*
  - *Introduction*
  - *Preparation*
  - *Investigation*
  - *Conclusion*
- *References or additional resources*
- *Appendix*
  - *Source code in Scratch*
  - *Source code in MakeCode*
  - *Source code in CircuitPython*

5.9 MODULE B.1: MAKE A PROXIMITY OR MOTION ALARM

In this module, learners are guided step-by-step to put together what they have learned so far to create a proximity alarm or stop-light, like the ones that cars have in order to assist drivers when they are parking their cars or the alarms in museums near fragile or precious objects. The main idea of a proximity alarm or stop-light is to show green or beep slowly when there is plenty of room, turn yellow as distance is decreasing, and then red or make loud sound when a minimum distance is reached, i.e. the vehicle or visitor should stop. In addition to proximity distance, an alarming condition may be vibration, touch, increased temperature etc. The operation principle of measuring distance by emitting and receiving a signal is shown in Figure below.

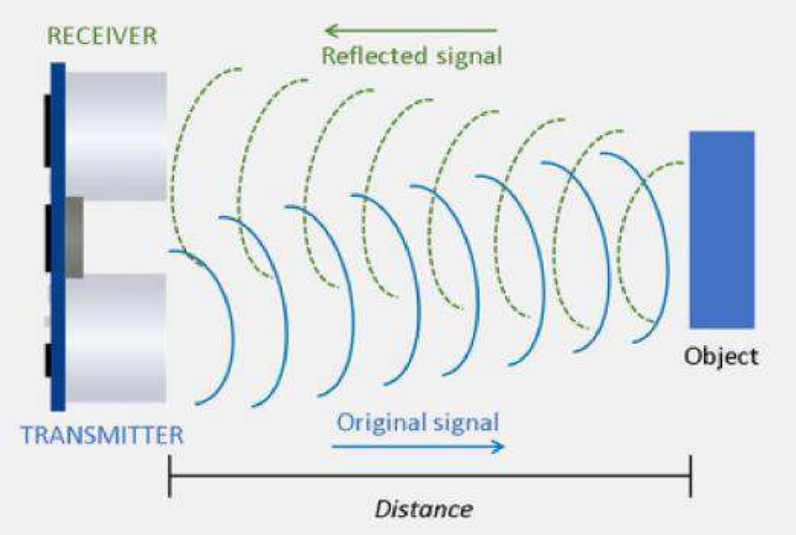

Figure 13 - Operation principle of distance sensor

The main objective of this module is on one hand to guide teachers to thoroughly understand and later feel confident to devise a programmatic flow of conditions and controls using the platforms and IoT sensors. On the other, to guide them with respect to pedagogical methodology by giving a practical example on how to link and integrate different disciplines towards an engaging and inspiring interdisciplinary educational project. For example, by implementing this module they have the opportunity to link not only to the Informatics/Computer Science standard curriculum, but also to the Physics curriculum with the subjects of motion, distance, speed, waves, propagation and reflection, sound waves, light waves, spectrum etc. To the curriculum of Mathematics with the subjects of trigonometry and of basic statistics. To the ones of History/Arts/Humanities by forming research questions and debates on what an invaluable object is to protect by alarm and why if we were museum curators ourselves, historians or citizens of societies in the past. Through this module teachers are also introduced to the main phases of inquiry (introduction, preparation, investigation, conclusion) as discussed in the previous section.

5.10 MODULE B.2: MEASURE REACTION TIME

With this module teachers will learn to build an experimental apparatus and conduct a scientific investigation following inquiry-based pedagogical model. The starting point is to program the IoT board and one of its push buttons (Fig.**Erreur ! Source du renvoi introuvable.**) to measure and record the reaction time to particular acoustic or visual signals. Then they use it to collect data from different users with respect to e.g. age or/and gender and under different conditions of e.g. noise, time of day, fatigue/stress, peer pressure etc. They then analyze the collected data and draw conclusions on which they reflect. Thus, in practice they conduct themselves a complete scientific

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investigation by pursuing separate inquiry phases, i.e. introduction/preparation, investigation, presentation/communication, discussion/reflection.

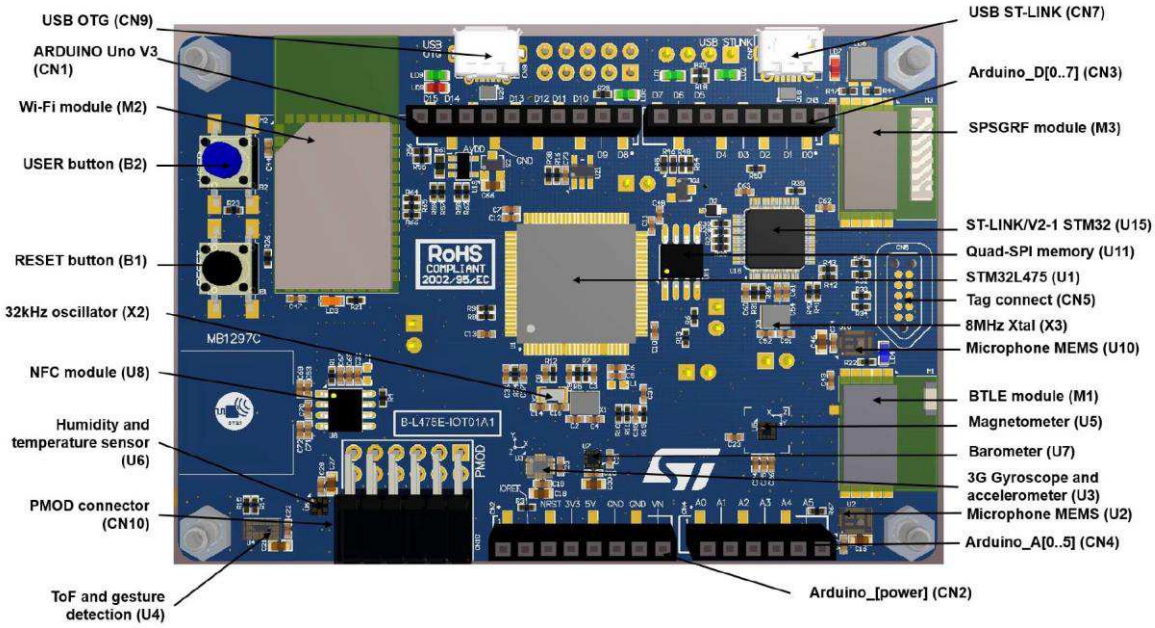

Figure 14 - Schematic layout of the IoT board. At top-left side can be seen the USER button (B2)

As before, this module has great potential to be linked to different disciplines and domains of the school curriculum and by the knowledge acquired through it to encompass a broader social scope touching upon social responsibility, health and road safety. In particular, it addresses the terms of speed, distance, time interval, linear motion, accelerated/decelerated motion from the Physics curriculum in relation to road safety aspects like reaction time and distance traveled before breaking, safety distance on road, speed limits, speeding violations, etc. In addition, it includes topics from Mathematics and Informatics curriculum, namely graphical representation of function/data points and basic statistics (Mathematics), use of spreadsheets and analysis of numerical data (Informatics). From Biology curriculum, brain functions, sensory inputs and reaction time in humans, effects of age, fatigue, drowsiness, sleep deprivation, consumption of drugs and alcohol.

5.11 MODULE B.3: STUDY ENVIRONMENTAL PARAMETERS

This module utilizes the variety of sensors with which the IoT is equipped so that learners can conduct a comprehensive study of various environmental parameters. Commonly, one logs versus time parameters such as temperature, atmospheric pressure and relative humidity to build a basic weather station as shown on the dashboard in Fig.**Erreur ! Source du renvoi introuvable.**. Magnetic field measurements can be included, as well as ground vibration sensing and acoustic noise to take advantage of the magnetometer, accelerometer and microphone embedded in the IoT board. The module can be expanded with an engineering perspective by including challenges like what if we wanted to monitor and study the environmental parameters of a different planet (in this case we need to build a rover or an autonomous vehicle to be piloted and controlled by the IoT board), or of an area of high temperature e.g. near fire or volcano.

The interdisciplinary dimensions of this module are plentiful and can be the cornerstone of an educational project with broad scope like global climate change, fragile habitats, environmental protection, natural hazards etc. The module encompasses links to subjects of most school science curriculum disciplines, including Physics, Biology,

Chemistry, Geography, Earth Sciences, Ecology but also Engineering and Technology. It offers also ample opportunities of collaboration between learners and schools at local, national or even international levels where e.g. teachers and their students monitor, study and share data collected across sites located at different areas in the same country or in different countries.

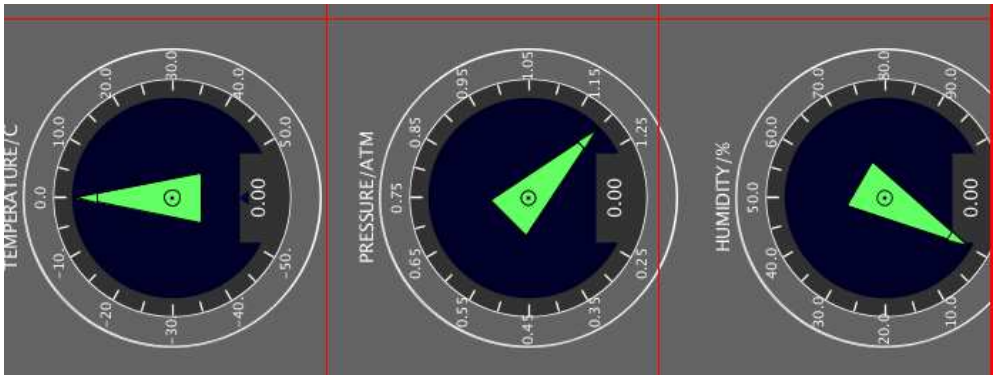

Figure 15 - Dashboard of a basic weather station monitoring temperature, atmospheric pressure and relative humidity

5.12 TRAINING C: ETHICS, SECURITY AND RELATIONSHIPS

The third set of modules covers the focus area of ethics, security and relationships. Although it is of highly importance, usually it is not adequately well addressed in trainings related to digital literacy and competencies. Therefore Let's STEAM aims to fill this gap with three dedicated modules on this subject. They are entitled: "Use online platforms and resources", "Share content and non-personal data" and "Create and respect digital identity and intellectual property". They are progressing from basic to intermediate and finally to advanced level to match with the current experience of the learner.

For the modules of this training set we do not propose a structured template at this moment as we believe a more flexible format of workshops may be more appropriate in this case. Even so, a general flow of hands-on tasks to span over a variety of learning elements is recommended as described in each module below. In other words each module should be considered as a scenario of use consisting of certain tasks that exemplify best-practice, common mistakes or misconceptions, ethical use and "do's and don'ts", followed by debate and reflection sessions among learners.

5.13 MODULE C.1: USE ONLINE PLATFORMS AND RESOURCES

In this module learners are guided through basic use of an existing or mock-up e-learning platform, online portal or repository of educational resources. Tasks to complete may include user registration, profile creation, download and upload of materials, meta-data editing. Learners may be asked to adopt and later exchange roles between passive user and active contributor of learning materials like the ones they developed in previous modules such as source code, lesson plans for in-school implementation, project ideas etc. The objective is that they get a better sense on one hand of the direct advantages of mutual benefit of resources that are made online and public but also on the other on the importance of ethical use and responsibility by retaining and asserting copyright and authorship. Each task can be followed or complemented by a round-the-table debate and reflection over previous experiences, common mistakes and best-practices.

5.14 MODULE C.2: SHARE CONTENT AND NON-PERSONAL DATA

This module is basically a follow-up of the previous one with the addition of the subjects of privacy and security. By a series of do's and don'ts tasks and exercises learners are role-playing certain situations where personal data, like

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home address, telephone numbers or any other sensitive information and details, that can easily put their privacy and security at risk are shared by mistake, thoughtlessness or misleading prompts. Each task can not only be complemented by reflection over previous experiences and common mistakes but also by discussions about broader challenges and opportunities at societal level with respect to privacy and security at the Internet-of-Things era, the commercialization of data, the needs for top-down and bottom-up regulation and standardization etc.

5.15 MODULE C.3: CREATE AND RESPECT DIGITAL IDENTITY AND INTELLECTUAL PROPERTY

This module aims to give learners a better understanding of the importance of the concept of digital identity at individual and organizational/school level. Its objective is to provide example best-practices so that teachers can feel confident to gradually become change agents and have transformative roles within their schools and community of colleagues and students. Topics to be included are: creation and maintenance of basic rules, protocols of practice, inclusion of visual institutional image in shared content at online repositories and portals/platforms, understanding the notion of intellectual property etc. Basic guidelines can be given also on how to initiate change by e.g. organizing training workshops or hands-on practice days in school for fellow teachers, coordinating work-groups for essential tasks, participating in related events for community building.

As in previous one, this module as well can consist of a series of do's and don'ts tasks, assigned exercises, tips and hints so that teachers interactively and collaboratively practice its content. It may conclude with an overall wrap-up section that summarizes the key points addressed in the training on ethics, security and relationships, along with a concise memory list of rules of conduct.

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6. CONCLUSION

The Let's STEAM project has been designed to provide the set of skills for teacher to enhance their STEAM approach by training them in programming but more importantly to help them understand the potential in terms of pedagogy of interdisciplinary use of programming so that can be able to create innovative pedagogical content in class with and for their students. In this context, **Let's STEAM is following a staged methodology to first survey and u**nderstand the needs and the basic skills of teachers with respect to programming capabilities; to gather requirements and compile recommendations to enrich the current open source programming platforms of **Scratch, MakeCode and CircuitPython and their interface to STM32 board** with advanced and tailored functionalities; to propose a training framework and content to be developed.

These stages were described in this document, in particular: in Section 2, the methodology for assessing the digital competencies of teachers; in Section 3, the results from the survey of teachers in each country; in Section 4, the general and specific recommendations regarding the overall design of the teacher training programme to be developed and conducted in the framework of the project; in Section 5, the pedagogical framework of inquiry-based learning and descriptions of training areas along with the main considerations for each proposed module. The proposed focus areas are: **"Programming and IoT board functionalities", "Interdisciplinarity and integration" and "Ethics, security and relationships"** and each has three dedicated modules. The figure below shows the proposed training modules per focus area and level.

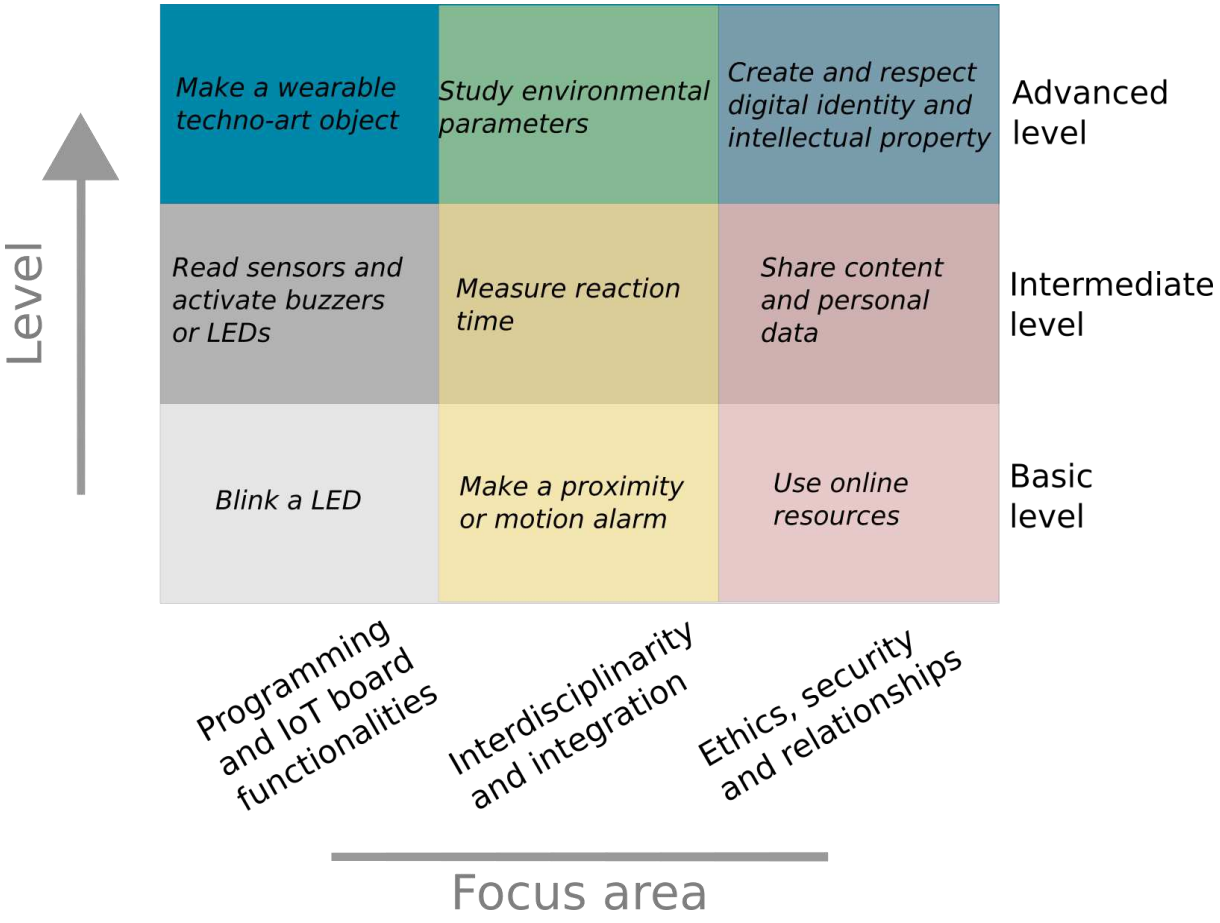

Figure 16 - Training modules per focus area and level

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APPENDIX 1 – QUESTIONNAIRE FOR ASSESSING TEACHERS' DIGITAL COMPETENCE

[Link to the digital version: https://pedagogia.fcep.urv.cat/application_src/index.php/quiz/view/51].

As teachers, we ask you to participate in the evaluation of the impact of the activities of Let's STEAM project. The aim of the project is to develop teachers' professional skills to participate creatively and collaboratively in the creation of new STEAM educational contents fostering interdisciplinary and creative thinking in STEAM education with IoT technologies. The project is lead by the Institute Universitaire de Technologie (Aix en Marseille Université) and financed by Erasmus+ programme (2019-1-FR01-KA201-062946). In order to inform and help us in the design of effective educational materials, we would like to ask you to participate answering the following questionnaire. This questionnaire aims at measuring teachers' perception of their own Teacher Digital Competence (TDC), which are the skills that teachers need to use digital technology effectively and appropriately for educational purposes. Again, this questionnaire is not an assessment, but their results will highly contribute to improve the outputs of the let's STEAM project. This questionnaire was developed by the ARGET research group (ref. 2017SGR1682) of the Universitat Rovira i Virgili (Spain). The questionnaire takes around 15 minutes and is structured around the four dimensions that make up TDC: (1) Didactic, curricular and methodological; (2) Planning, organization and management of digital technology spaces and resources; (3) Relationships, ethics and security; (4) Personal and professional. The questions are based on these four dimensions and TDC indicators. They assess the skill level the person considers they have at the time of answering the questionnaire. In addition, other data (such as biodata, and personal opinion about your experience) is asked to better interpret the results. We would like you to answer this questionnaire with the utmost rigor and responsibility possible.

Ethical commitments of the data gathering: The Let's STEAM project operates within an ethic of respect for any persons involved in or touched (directly or indirectly) by the research project, including the consortium involved in the project. The commitment of the consortium is to treat participant individuals fairly, sensitively, and with dignity and freedom from prejudice, in recognition of both their rights and of differences arising from age, gender, nationality or any other significant characteristic. Your participation in the survey involves no risks of any kind. If you consent your participation, your identity will be kept confidential and only members of the research team will have access to the project data. Participation in the questionnaire is completely voluntary. There is no penalty for opting not to take part. You can also withdraw from the questionnaire at any time without giving explanations and with no negative consequences, just by letting us know through any communication channel. As well, you can, if you wish, exercise your rights under the European General Data Protection Regulation concerning this project's data filing system (SR0071) by making a request to (carme.grimalt@lets-steam.eu), and enclosing your ID document with the request. In all cases you will receive a written response stating what action has been taken within the legal time limit.
One year after the end of the project, the research data and database will be anonymised and made available to other interested researchers. Personal identifiers will be destroyed in this case.

Please, check the following boxes if you agree:

☐ I have read and understood the information about the research project, and I have had the opportunity to ask questions which have been answered to my satisfaction, through email.

☐ I consent to my voluntary participation.

☐ I consent to my contributions being cited literally, provided there is no mention of any information which can make my answers identifiable.

☐ I understand that the anonymised information (with no personal identifiers) on this project will be placed at the disposal of other researchers sometime after the project has ended.

We appreciate your collaboration in advance.

DIMENSION 1: DIDACTIC, CURRICULAR AND METHODOLOGICAL

DIGITAL TECHNOLOGIES AS FACILITATORS OF LEARNING

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use support software in the classroom to carry out teaching activities.
- ☐ **Level 2.** Do activities with the students that involve resolving problems collaboratively using digital technology resources.
- ☐ **Level 3.** Propose activities with the students that involve analysing a problem in a group, proposing alternative solutions, negotiating the results and publishing them using digital technology resources.
- ☐ **Level 4.** Stimulate autonomous learning and collaborative work by transforming and creating knowledge based on problems that must be solved using digital technology resources.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

THE STUDENTS' DIGITAL COMPETENCE IN THE DIDACTIC PLANNING

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Design teaching activities that use digital technologies.
- ☐ **Level 2**. Include searching for, treating, storing and sharing digital information in different formats in the didactic planning.
- ☐ **Level 3.** Guide and collect in the didactic planning the use and good use of digital technologies for publishing information and working collaboratively.
- ☐ **Level 4.** Design competence-rich activities (functional, transversal and oriented to autonomy) that involve using complex skills (solving real problems and situations, interpreting, communicating, etc.) and in which there is a "good use" of digital technologies.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

PROCESSING INFORMATION AND CREATING KNOWLEDGE

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1**. Teach how to search for information by accessing different sources of different types.
- ☐ **Level 2.** Teach how to use information sources of different types according to criteria of quality, truthfulness and pertinence.
- ☐ **Level 3.** Teach how to classify, sort and select information from different sources applying criteria of quality, truthfulness and pertinence.
- ☐ **Level 4.** Teach how to create and transform information that has previously been stored and recovered following a system that allows a shared use.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

ATTENTION TO DIVERSITY

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1**. Use digital technologies to increase motivation and facilitate the learning of students with specific educational support needs (SESN).
- ☐ **Level 2.** Use digital technologies to respond to SESN as an element of accessing the curriculum, taking into account the inclusion of students.
- ☐ **Level 3.** Elaborate materials and personalized resources to attend to the SESN of the students and compensate inequalities in access to technology.

- ☐ **Level 4.** Share with other professionals the digital didactic material resources to meet SESN taking into account the concept of "design for all" and accessibility standards.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

METHODOLOGICAL LINE OF THE CENTRE

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Know the centre's guidelines for including digital technologies in the classroom and take them into account in the teaching plans.
- ☐ **Level 2.** Program and carry out activities aimed at developing digital competence according to the methodological guidelines and resources available.
- ☐ **Level 3.** Include DC in significant activities (functional, transversal and favouring autonomy) that involve the use of digital technologies to build and share knowledge.
- ☐ **Level 4.** Propose new innovative methodological strategies and be a teaching model for Digital Competence work.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

STUDENT ASSESSMENT, TUTORING AND FOLLOW-UP

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use digital resources for tutoring and following up students (meetings, attendance, assessment, reports, etc.).
- ☐ **Level 2.** Use shared digital resources to assess and monitor students together with the other professionals of the centre.
- ☐ **Level 3.** Use a digital resource to share the assessment and monitoring of students with their families.
- ☐ **Level 4.** Manage and use digital resources (environments, digital portfolios, etc.) to monitor school performance and assess students at the centre and educational administration levels.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

DIMENSION 2: PLANNING, ORGANIZATION AND MANAGEMENT OF DIGITAL TECHNOLOGY SPACES AND RESOURCES

MANAGEMENT OF DIGITAL TECHNOLOGIES AND SOFTWARE

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Evaluate and select the existing resources and tools for the work in the classroom.
- ☐ **Level 2.** Select and use the most appropriate resources and tools for different teaching situations.
- ☐ **Level 3.** Combine the use of different digital technologies according to their potential, reflectively analysing the students' performance based on the use of these technologies.
- ☐ **Level 4.** Research into teaching situations based on using digital technologies and innovate according to the results obtained.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

LEARNING ENVIRONMENTS

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use the digital technologies of the classroom (fixed and mobile devices, etc.) depending on each teaching situation.
- ☐ **Level 2.** Adapt the teaching activities to the available spaces and digital technologies in the centre.
- ☐ **Level 3.** Modify teaching spaces with digital technologies to improve them and optimize the available infrastructure based on shared criteria.

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- ☐ **Level 4.** Organize and manage the centre's spaces according to criteria of optimizing and providing digital technologies according to a previous analysis of needs.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

SPACES WITH DIGITAL TECHNOLOGIES IN THE CENTRE

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Identify the spaces at the centre that have digital technologies and know how they work.
- ☐ **Level 2.** Use the different spaces and digital technologies of the centre responsibly with the students.
- ☐ **Level 3.** Include innovations in the use of digital technology resources and virtual spaces in my daily activities with students.
- ☐ **Level 4.** Manage spaces with digital technologies based on the results obtained in the analysis of their daily practice.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

PROJECTS FOR INCLUDING DIGITAL TECHNOLOGIES

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Follow the centre's guidelines on the use of digital technologies in teaching.
- ☐ **Level 2.** Be an active part of the centre's teams and contribute personal experience and knowledge about digital technologies.
- ☐ **Level 3.** Lead a team working at the centre taking charge of managing the use of digital technologies in the daily teaching practice.
- ☐ **Level 4.** Lead and coordinate inter-institutional projects on including digital technologies in teaching.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

DIGITAL TECHNOLOGY INFRASTRUCTURES

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use digital technologies responsibly and use a protocol to resolve incidents.
- ☐ **Level 2.** Adopt the innovations on the responsible and updated use of resources in my teaching practice.
- ☐ **Level 3.** Resolve problems with the equipment for personal and classroom use autonomously and make suggestions for improving its use.
- ☐ **Level 4.** Manage the use of digital technologies and promote the maintenance and good use of the technological infrastructure of the centre.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

DIMENSION 3: RELATIONSHIPS, ETHICS AND SECURITY

ETHICS AND SECURITY

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Respect copyright in the teaching materials and use personal digital technologies responsibly and safely.
- ☐ **Level 2.** Serve as a model for the ethical use of digital technologies during activities with students.
- ☐ **Level 3.** Serve as a model for other professionals in the responsible and safe use of digital technologies.
- ☐ **Level 4.** Propose guidelines for the responsible, ethical and safe use of digital technologies.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

DIGITAL INCLUSION

I feel I can...

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(Mark the option that relates to you the most)

- ☐ **Level 1.** Enhance the access and use of digital technologies for all students to compensate for inequalities.
- ☐ **Level 2.** Participate in the centre's organization of attention to diversity, taking actions to compensate for inequalities in access and the use of digital technologies.
- ☐ **Level 3.** Promote the use of the centre's digital spaces and technological resources by the educational community, through participation in actions aimed at compensating for inequalities.
- ☐ **Level 4.** Train members of the educational community with actions aimed at generalizing the use, management and dissemination of good practices in the use of digital technologies.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

COMMUNICATION, DISSEMINATION AND KNOWLEDGE TRANSFER

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use digital tools to communicate and share personal knowledge with other teachers.
- ☐ **Level 2.** Manage open network resources to publish experiences and share them.
- ☐ **Level 3.** Train teachers in the use of digital technologies to share and create knowledge through activities recognized by the educational administration.
- ☐ **Level 4.** Be a reference in the use of technological resources to disseminate and share my knowledge, transforming the school institution into a centre of innovation at the service of the community.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

THE CENTRE'S DIGITAL IDENTITY

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Know the centre's digital identity, and the need to respect the documentation models and protocols related to the visual identity of the centre.
- ☐ **Level 2.** Include the centre's visual identity in my documentary creations and virtual spaces.
- ☐ **Level 3.** Participate in maintaining the institutional image in the centre's virtual spaces.
- ☐ **Level 4.** Manage the centre's virtual spaces to transmit the centre's digital identity.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

DIGITAL CONTENT AND EDUCATIONAL COMMUNITY

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Access and comment on the contents distributed in different digital spaces in the centre.
- ☐ **Level 2.** Use the digital spaces of the centre as the editor of some of them with the aim of sharing knowledge and experiences.
- ☐ **Level 3.** Manage my own digital space to publish and disseminate my professional knowledge and involve the educational community.
- ☐ **Level 4.** Create and manage virtual spaces to disseminate collective knowledge and encourage communication and interaction among the members of the educational community.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

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DIMENSION 4: PERSONAL AND PROFESSIONAL

PERSONAL LEARNING ENVIRONMENT (PLE)

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use different desktop and web applications to manage classroom contents and access information.
- ☐ **Level 2.** Set up my PLE using digital tools for learning, information sources and a personal learning network.
- ☐ **Level 3.** Collaborate with the teachers of the centre in the creation of their PLE.
- ☐ **Level 4.** Advise on the use of PLEs in the educational community.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

IDENTITY AND DIGITAL PRESENCE

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Have a digital profile and an updated online professional curriculum.
- ☐ **Level 2.** Encourage online learning among members of the educational community. Use social and professional networks as a means of communication and professional interaction.
- ☐ **Level 3.** Use professional development networks to promote the use and awareness of their importance to the community members.
- ☐ **Level 4.** Use professional digital identification in communications on a regular basis and update my profile in the virtual spaces of the centre.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

LEADERSHIP IN THE USE OF DIGITAL TECHNOLOGIES

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Use digital technologies with students and act as a reference in terms of their use.
- ☐ **Level 2.** Use digital technologies, integrating them into my teaching, and sharing experiences with colleagues.
- ☐ **Level 3.** Coordinate the use of digital technologies at the centre level.
- ☐ **Level 4.** Advise the centre on the use and management of digital technologies and share experiences and good practices.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

VIRTUAL LEARNING COMMUNITIES: FORMAL, NON-FORMAL AND INFORMAL

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1**. Access and use shared educational materials in a network for classroom teaching.
- ☐ **Level 2.** Use online learning as a means of lifelong learning.
- ☐ **Level 3.** Encourage online learning among members of the educational community.
- ☐ **Level 4.** Manage a learning ecosystem among the members of the educational community and other institutions.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

LIFELONG LEARNING

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1**. Do training activities, recognized by the educational administration, related to digital technologies.
- ☐ **Level 2.** Learn continually ("anywhere and anytime") through training activities related to digital technologies and recognized by the educational administration.

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- ☐ **Level 3.** Transform my teaching practice by including digital technologies in it, including the knowledge gained in training activities: "training transfer".
- ☐ **Level 4.** Participate as an educator in lifelong learning activities for teachers in relation to digital technologies.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

CREATION AND DIFFUSION OF DIDACTIC MATERIAL WITH OPEN LICENSES

I feel I can...

(Mark the option that relates to you the most)

- ☐ **Level 1.** Share didactic materials reworked and freely distributed in the network.
- ☐ **Level 2.** Prepare open didactic materials and share them in the network following a standard that facilitates the search and accessibility.
- ☐ **Level 3.** Organize, label and catalogue open educational resources (OER) by types, areas and educational stages according to the needs of the educational community.
- ☐ **Level 4.** Promote the use of OER through the creation and/or dissemination of open repositories of teaching materials.
- ☐ **Level 0.** I don't feel I can do what is described in this level.

EXPERIENCE IN ACTIVITIES ABOUT COMPUTATIONAL THINKING

To which extent do you agree with the following statements?

(Mark the option that relates to you the most)

	I totally disagree	I disagree	I neither agree nor disagree	I agree	I totally agree	I don't know/no comment
In relation to coding, I am an experienced teacher: I have been working with at least one coding language from time ago.						
In relation to coding, I am a skilled teacher: I feel competent coding						

Could you tell us your experience promoting computational thinking skills with your students? Please, be as concrete as possible (e.g. which activities have you developed, which coding languages have you used, if any...)

What would you like to find in a course/training content for teachers aimed at providing more creativity to STEM education through programming? Please, be as concrete as possible

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BIODATA

With which gender do you most identify?

(Mark as applicable)

- ☐ Male
- ☐ Female
- ☐ Other (please, provide your answer): _____

Age

Please, provide your age (in numbers): _____

Country

(Mark as applicable)

- ☐ Belgium
- ☐ France
- ☐ Greece
- ☐ Italy
- ☐ Spain

Background

In which field did you carry out your main training? (e.g. degree, graduate…)

(Mark as applicable)

- ☐ Science field
- ☐ Maths field
- ☐ Technology/ Engineering field
- ☐ Social Sciences
- ☐ Language and humanities
- ☐ Arts
- ☐ Physical education
- ☐ Culture and values
- ☐ Other (Please, specify) _____

Educational level where you teach

(Mark as applicable)

- ☐ Primary Education (from 6 to 12-year-old students)
- ☐ Secondary Education (from 12 to 16-year-old students)
- ☐ Interlevel
- ☐ Other (please, provide your answer): _____

Years of teaching experience

(Mark as applicable)

- ☐ Less than 2
- ☐ From 2 to 5
- ☐ From 5 to 10
- ☐ More than 10

Email

Please, provide your email for receiving the report of this questionnaire: _____

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APPENDIX 2 – TEMPLATE FOR MODULES ON PROGRAMMING AND IOT BOARD FUNCTIONALITIES

8. MODULE A.1: TITLE

8.1 INTRODUCTION

Start text here

8.1.1 LEARNING OBJECTIVES

Write here the learning objectives of this module or educational activity.

8.1.2 DURATION

Give an estimate of how much time is needed to complete this

8.2 MODULE DESCRIPTION STEP-BY-STEP

Here is the full description of the module. Give as many details and explanations as possible.

The structure of the learning flow must be clear and consistent. You can divide your learning module in smaller parts or progressive steps (tutorials, phases or/and clear tasks and subtasks) so that a teacher or educator can easily replicate it with other colleagues, or with her/his students at school.

To emphasize certain parts of text, definitions or important instructions you may use **bold** or ***bold italics*** fonts. Dividing tasks and instructions in smaller parts or steps using numbered/indexed lists or bullets can be useful and helpful for learners to follow

Finally, you can include additional audiovisual learning resources, such as:

- Images, photos, circuit diagrams etc
- Links to online instructions and how-to videos
- Links to repositories of educational resources, source code, interesting projects

You can divide a module in tutorials or/and clear tasks and subtasks so that a teacher or educator can easily follow and replicate it by him/herself or with her/his colleagues and students at school.

8.2.1 TUTORIAL 1

8.2.2 TUTORIAL 2

8.2.3 TUTORIAL 3

8.2.4 CONCLUSION – WRAP-UP

Here is conclusion part where main points and steps are summarized

8.3 QUIZ OR KEY QUESTIONS FOR KNOWLEDGE TESTING

The training content is accompanied by a quiz of about five key questions that can be used to check the learners' knowledge acquisition for this module. Correct answers in multiple choice questions are marked in **bold**.

Question 1:
answer 1
answer 2
correct answer
Question 2:
answer
correct answer
answer

8.4 TRY THIS! (OPTIONAL)

For testing your knowledge and practising further we propose some exercises or ideas to try. These are recommended to be done after each tutorial and include the followings:

Exercise 1: title here
Exercise 2: title here
Exercise 3: title here

8.4.1 EXERCISE 1: TITLE

In this exercise try to do – modify – code ... circuit and code you developed in Tutorial 1 in order to …

8.4.2 EXERCISE 2: TITLE

8.4.3 EXERCISE 3: TITLE

8.5 REFERENCES OR ADDITIONAL RESOURCES

Mention here any references or additional resources related to this module.
…
…
…

8.6 APPENDIX

Attach or include here any additional items such as worksheet, spreadsheet, complete ready-to-run source code etc., that accompany the module.

8.6.1 SOURCE CODE IN SCRATCH

8.6.2 SOURCE CODE IN MAKECODE

8.6.3 SOURCE CODE IN CIRCUITPYTHON

9. MODULE B.1: TITLE

9.1 GENERAL INFORMATION AND INTRODUCTION

Start text here

9.1.1 BRIEF DESCRIPTION

Give a short description of the module and educational activity

9.1.2 LEARNING OBJECTIVES

Write here the learning objectives of this module or educational activity.

9.1.3 LINKS TO CURRICULUM

List here the curriculum domains, subdomains, subjects/topics that the module as lesson plan or educational activity can be linked to.

9.1.4 DURATION

Give an estimate of how much time is needed to complete this e.g. in classroom

9.1.5 EXTRA MATERIALS REQUIRED

List here all materials required (per student or per classroom) for the module to be implemented as lesson plan or educational activity.

9.2 MODULE DESCRIPTION STEP-BY-STEP

Here is the full description of the module. Give as many details and explanations as possible.

The structure of the learning flow must be clear and consistent. You can divide your learning module in smaller parts or progressive steps (tutorials, phases or/and clear tasks and subtasks) so that a teacher or educator can easily replicate it with other colleagues, or with her/his students at school.

To emphasize certain parts of text, definitions or important instructions you may use **bold** or ***bold italics*** fonts. Dividing tasks and instructions in smaller parts or steps using numbered/indexed lists or bullets can be useful and helpful for learners to follow

Finally, you can include additional audiovisual learning resources, such as:

- Images, photos, circuit diagrams etc
- Links to online instructions and how-to videos
- Links to repositories of educational resources, source code, interesting projects

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Here is how you can include a table.

Table 1. Title/text

Column1	Column2	Column3

Here is how you can include an image. Remember to include the titles and sources as captions, like:

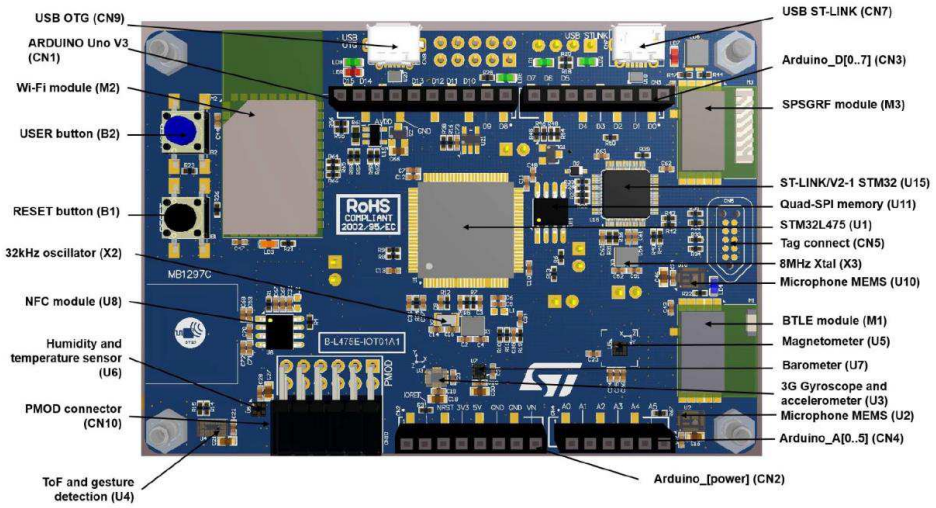

Figure 17 - Schematic layout of the IoT board

You can divide a module in inquiry phases or/and clear tasks and subtasks so that a teacher or educator can easily replicate it with her/his students.

9.2.1 INTRODUCTION

9.2.2 PREPARATION

9.2.3 INVESTIGATION

Here is investigation phase. You can divide this phase in subphases or/and clear tasks and subtasks. For example:

Collection of data

Analysis of data

Presentation of results

9.2.4 CONCLUSION

Here is conclusion phase where main points, results and steps are summarized

9.3 REFERENCES OR ADDITIONAL RESOURCES

Mention here any references or additional resources related to this module.

…

…

…

9.4 APPENDIX

Attach or include here any additional items such as worksheet, spreadsheet, complete ready-to-run source code etc., that accompany the module.

9.4.1 SOURCE CODE IN SCRATCH

9.4.2 SOURCE CODE IN MAKECODE

9.4.3 SOURCE CODE IN CIRCUITPYTHON

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LET'S STEAM is funded by the European Commission within its Erasmus+ Programme, under KA-2 Cooperation for innovation and the exchange of good practices, Strategic Partnership for School Education.

Erasmus+

Creating a training of teachers programme dedicated to computational thinking

1. Develop the programming skills of teachers to benefit fully from the advantages of digital solutions in the classroom
2. Enhance interdisciplinarity and creativity in the learning process by developing computational thinking approach for teachers
3. Provide best practices and examples of innovative pedagogies in teaching STEAM at secondary schools

Institut Universitaire de Technologie Aix-Marseille Université

UNIVERSITÉ CÔTE D'AZUR

ELLINOGERMANIKI AGOGI

Università Degli Studi di Napoli Federico II

UNIVERSITAT ROVIRA i VIRGILI

DIGITALE WOLVEN

EUROPROJECT BULGARIA

LET'S STEAM
CREATIVITY
INTERDISCIPLINARITY
CITIZEN SCIENCE