ACTIVITY PLAN

Educational Robotics and Creativity Workshop (v1.0)

AUTHOR:

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Short description of the activity (Summary)

This workshops inspires students to think and dream about using robotics in real life. The students discuss and learn what a robot is and how robots can be used in everyday context through demonstration and creativity exercises. The activity is specially designed to develop skills as follows:

Creativity: within the workshop students learn and practice how to construct and generate innovative ideas to address real life problems using Tony Buzan mind-mapping techniques.

Digital fluency: Students discuss, learn and use the robotics key elements while generating ideas about the creative use of robotics and building and programing a real robot.

Communication: While working in team students build a robot following generic instructions. They have to clearly communicate their plans and ideas how to construct the body of the robot; to correctly connect the root electronics and to program the robot.

Collaboration: While students in each team are changing their roles during each task, they learn how to work effectively and respectfully with others in order and to build relevantly complex robotics system.

Robotics is intriguing and fun, which is why we believe it makes a wonderful tool to engage students in Science, Technology, Engineering and Mathematics. We know that learning by doing makes children fall in love with creativity and robotics and helps them maintain their in-born curiosity about natural life and technology.

The ER4STEM project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 665972

Focus, Set up and Requirements of the activity

CURRICULUM

NO ☑ YES ☐ Subject: …………………………

While creativity through mind-mapping could significantly contribute to the students' ability to learn[1], structure information and memorize[2], the workshop is not directly connected with the formal school curricula.

CONTENT

Choose categories and give a rating of the level of emphasis on concepts from each of the following domains

☑ Science	☑ Technology	☐ Business	☑ Engineering	☐ Arts	☐ Mathematics
(0-10)	(0-10)	(0-10)	(0-10)	(0-10)	(0-10)
5	10	0	10	0	0

OBJECTIVES

Subject related	**Digital fluency:** Students discuss, learn and use the robotics key elements while generating ideas about the creative use of robotics and building and programing a real robot. In particular students learn and discuss key robotics elements (technology); construct a robot (technology & engineering) , develop a visual program to control the robot and to execute tasks (technology); develop the creative thinking skills needed to find different applications of robotics in other fields
Technology use related	**Digital fluency:** The technology used by the students include: Arduino microcontrollers; motor drivers; ultrasonic sensors; Scratch or Snap visual programing software.
Social and action related	**Creativity:** within the workshop students learn and practice how to construct and generate innovative ideas to address real life problems using Tony Buzan mind-mapping techniques. **Collaboration:** While students in each team are changing their roles during each task, they learn how to work effectively and respectfully with others in order and to build relevantly complex robotics system.
Argumentation and fostering of maker culture:	**Communication:** While working in teams, students build a robot following generic guidelines. They have to clearly communicate their plans and ideas how to construct the body of the robot to correctly connect the electronics and to program the robot. Students are made aware by tutors that they would make mistakes and have to identify and rework the corresponding parts in order to build and program the robot.

[1] A study conducted at Newchurch Community Primary School in Warrington showed a variety of improvements in pupils learning after Mind Mapping was introduced. This evidence includes
improved concentration, staying on task for longer periods of time, improved questioning and
answering during class discussions and improved independence. (

[2] Toi, H (2009), ('Research on how Mind Map improves Memory'. Paper presented at the International Conference on Thinking, Kuala Lumpur, 22nd to 26th June 2009) shows that Mind Mapping can help children recall words more effectively than using lists, with improvements in memory of up to 32%. (Cain, M. E. (2001/2002), 'Using Mind Maps to raise standards in literacy, improve confidence and encourage positive attitudes towards learning'. Study conducted at Newchurch Community Primary School, Warrington.)

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TIME

Duration: 1-2 weeks (8 hours in total)

Schedule: 2 sessions, 4 hours per session

MATERIALS AND ARTIFACTS

Digital artifact	Students work with Scratch or Snap visual programming software; Arduino IDE, python s2a_fm and pymata are used to connect the robot to a computer and to control it, along with visual interfaces. Additional: BirdBrain Robot Server is used if Finch robot is used for the programming or demonstration games and the Choregraphe suite is used to demonstrate the NAO humanoid robot. **Students productions:** (i) Scratch code that programmed the robot to go forwards, backwards and stop; (ii) Scratch code that programmed the robot to turn left and right around one of the chains and around the center.
Robotic artifact	Robotic Arduino-based tank developed and specifically tailored for children's use by ESI CEE. The customized kit consists of: gearbox; chassis; chains and wheels; Arduino controller; motors driver; breadboard; wires and jump wires; ultrasonic module; Bluetooth module or USB cable; batteries and battery holders, safely designed pins suitable for children's use to avoid soldering. NAO and Finch robots for demonstration are optional. **Students productions:** tank robot
Student's workbook and manual	Visual Guide for constructing the robot; examples of Mind Maps. **Students productions:** mind-maps illustrating different creative applications of robotics.
Teacher's instruction book and manual:	Manual How to connect and program the robot. Mind-map presentation.
Note: the workshop artifacts are uploaded and maintained at: https://github.com/esirobot/practical-robotics-workshop-tank-with-USB-cable. The particular workshop was conducted with the artifacts attached as a zip. File	

Students and space

STUDENTS (TARGET AUDIENCE)

Sex and Age:	Boys & girls, 8-12 years;
Prior knowledge:	No prior knowledge required. The workshop is designed for "all students in the class";
Nationality and cultural background	Bulgarian, suitable for students of diverse cultural background, capital city and other cities
Social status and social environment	Mainstream public schools
Special needs and abilities	Students with the disabilities might need additional support by qualified personnel.

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SPACE INFO

Organizational and cultural context: Workshops in school, either in classroom or computer room during regular school time

Physical characteristics: indoor only

Social Orchestration

POPULATION

Students: up to 28 students

Tutors: 2-4; **School teachers:** 1

GROUPING:

Grouping criteria	No specific criteria – students or school teachers decide how to form the groups
Setting:	The workshop is conducted in a school classroom equipped with at least 7 computers for students and one computer for the tutors. The tables are arranged as “islands” for each team of 4 students. Enough space is left for demonstrations of robots. Large screen and white board with markers are positioned In a way to be visible by the students

INTERACTION DURING THE ACTIVITY (EMPHASIS)

Actions	Through creativity mind-mapping exercises students are motivated to think “out of frame” and to debate about the use of robots in everyday life. They exchange ideas and summarize them on a team level. While building and programing the robot students maintain dialogue about how to complete next steps. They debate and negotiate when they have doubts or have to fix any mistakes. When the robot is built and programmed students have to agree on how to play with the robot during the free time allocated for games and experiments.
Relationships	Tutors promote collaborative behavior within the teams and between the teams.
Roles in the group	The roles in the team are designer/builder – the student who builds the robot or programs the robot and team members who support the work as they directly help the builder or provide advices and check the quality of the work. The tutor requires that the students change their roles after every step of building the robot or programing it, so every student could gain experience by changing different roles within the team.
Support by the tutor(s)	During most of the time the tutors facilitate the activities through asking questions and maintaining debates and discussions. The tutors provide guidelines and explain definitions at the beginning of the robotics session when the key elements of the robots are taught and at the beginning of the creativity session when the key principles of mind-mapping are explained. In both cases instructions are provided after and if needed and are based on open discussions or direct questions and are followed by demonstrations and exercises. The principle which the tutors convey is “let’s first think how to solve the problem before asking the tutor”. When support by the tutors is essential the tutors ask questions but do not provide direct instructions.

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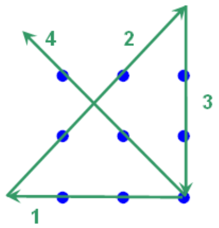
Learning Procedures

EXPECTED STUDENT ACTIVITY

Students during the activity are expected to engage in the following actions: construct, observe, communicate, create, present their work as a team to the tutors, exchange ideas, etc.

STUDENT LEARNING PROCESSES

Designed Conflicts and misconceptions	One of the creativity games includes a planned conflict, aiming to question students' preconception of problem-solving. Students face a contradiction between the possible solution and their internal boundaries, set by themselves.  The game consists of 9 dots. Students are asked to cross out all the dots with 4 straight lines. The solution requires that students should inevitably draw outside the dots (allegorically outside the box). In another exercise, the students have to generate ideas about the applications of a paper clip and the non-applications of a paper clip (what you can't use a paper clip for). Students have to think within their team. Normally, students are thinking only about metal paper clips, which has not been stated in the task itself. With a little help from the tutor, they realize that the paper clip could be made of different materials, could be of different sizes, could be hollow, etc. and they realize that there are no "non-applications" of the paper clip. The goal of this game is to make children realize that their creativity is limitless and they should not base their ideas on mere practicality or preconceptions, but that it is important to train your creative thinking nevertheless.
Learning processes emphasized:	The focus of the workshop is to stimulate creativity, communication and collaboration while building a robotic kit. The students are encouraged to unleash their imagination and creativity and generate ideas about what a robot could do and present their ideas as Mind Maps. At the end of the workshops students have free time to play with the robots and to experiment with them.
Expected relevance of alternative knowledge	Although the robot has a predefined design, the way that the visual guide for its construction is presented, suggests that the students have to make experiments, to discuss within their team the possible solutions and reach conclusions within the group based on communication and experimentation. The visual guide provides just pictures of different stages of the building process and no instruction on how to connect parts. The same approach is applied when programing the robot – the students have to first "discover" what the movements of the motors should be for the robot to turn left and right around the opposite chain and around the center and then program it.

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"How to" in the classroom

Total duration of the activities will be within 8hours. The programming session, during which the students develop code and animate the robots is b used as a buffer in case other activities took less or more time for the students to complete.

Orchestration: teams of 3-4 students per table, equipped with one computer, preferably laptop with the required software installed (see digital artifacts for more information), and one robotic kit; enough free space in the center of the room for demonstrations; demo robots such as NAO; omnidirectional models, the Finch Robot or mobile telepresence robots;

Description:

MODULE 1 INTRODUCTION AND PRE-EVALUATION (40 MINUTES)

The tutors introduce themselves, explain what they do and why they came to the school. They also explain what they find fascinating about robots and what is the task for the specific day. Next they ask from the students whether they like robots, if they have had any experience with them in order to informally introduce themselves by their interest within the topic of robotics. The purpose is to become familiar with the students get to know some names and show that they are interested to learn with whom they are going to work with.

Following that, the rules and safety instructions are explained:

Rules:

- Everybody listens to the others and respects their ideas.
- No direct competition, lets cooperate and have a fun.
- Questions and strange ideas are highly encouraged.
- We are tutors but also your friends – everybody can argue with us regarding the content but not regarding the discipline.
- The parts you are given are only for construction, not for eating.
- Handle everything with attention in order to remain safe.
- Respect other team members' opinions and let everyone work equal amount of time – we all have to learn.

Tutors try and emphasize to the students that in order to complete the task they need to collaborate with other students. The work of one person, no matter how good it is, is not going to be better than the collective work. Disagreement in a group is not a bad thing, instead it can be very productive if the group knows how to handle it.

Handling disagreement involves:

a) asking questions that promote understanding (i.e. if a group member makes a suggestion then they others are expected to ask why this suggestion is appropriate for what the group attempts to do);
b) asking questions that challenge suggestions (why is this a good idea?);
c) being open to trying new ideas;
d) respect the other's opinions and do not offense the team members if an idea is not appropriate;
e) the group takes responsibility for all the choices made and responsibility is not an issue of the individual (the one who made a wrong suggestion);

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f) trying to identify what each member is good at and use his/her abilities to support group work;
g) try to engage all group members in the task.

Students fill out Pre-Workshop Questionnaire and complete the Draw a Scientist evaluation activity.

MODULE 2 WHAT IS A ROBOT (40 MINUTES)

The tutors ask students "what is a robot" to generate ideas what are the key components of the robots. Once an idea is generated by the students the tutors encourage other student to comment and contribute.

After most of the interested students have a chance to contribute the tutors use one of the demo robots to conclude the key elements such as processors, drivers, actuators and sensors. They demonstrate those parts with the robotics kits and give a chance to the students to examine the parts. Analogy with nature is provoked. E.g. the tutors explain how the ultrasonic sensor works and ask students to name an animal that uses the same principles (bat; dolphin, etc.). Finally, the origin of "robot" terms is explained.

The tutors ask student if they have a robot at home and to guess different types of robots. Once a student explains his/her ideas the tutors encourage other students to comment and contribute. The tutor structures the students' ideas to main categories such as industrial robots; home robots; humanoids; drones; toys and others. Then tutors ask student to further elaborate how their home appliances (automatic washing machine, autonomous vacuum cleaner, etc.). are similar to the robots. At the end the tutors ask students to further elaborate ho the robots will change when they grow up.

MODULE 3 CONSTRUCT A ROBOT (120 MINUTES)

The tutors remind the students about the **safety instructions:**

- Do not put the parts in your mouth – this can cause serious injury;
- Do not try to connect batteries before the instructors check the model for short circuits – the robot can cause fire.
- Be careful when using the jump wires and the pins – you can hurt yourself.

Students are once again encouraged to:

- learn from their experience and mistakes;
- have fun and play;
- discuss and respect the ideas of the others;
- shift their roles within the team after each step;
- contribute constructively to the team
- be helpful and make necessary compromises to accomplish the task
- solve the problems by themselves and to ask for tutors support only after they did their best to find a solution.

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Students are introduced to the robotic kit. Tutors say a few words about the parts and what are the parts used for. They show an example of the built robot, so as to motivate the students and give them an idea towards what they are working on. Tutors give recommendations for work, including, to put the small parts in the lid of the box in which the kits come. The application of some tricky parts is demonstrated by the tutors – for instance the Patafix glue and the pins.

Students build the robot using visual guides on printed cards or slideshow on computers. Instead of employing direct instruction to introduce a concept or explain an example, constructionist methodology is applied to provide students with an example and ask them to test it and observe.

MODULE 4 ROBOT'S TOUCH (40 MINUTES)

Ones the models are built the researchers demonstrate in action different type of robots such as NAO, VGo, omnidirectional robots or maybe the Finch robot and facilitate a Q&A session. When a student has a question the tutors first ask other students if they can answer the question and then elaborate based on the discussion.

During or after this and the previous module, students are asked in groups questions on what was most difficult for them during this session or what they consider to be their biggest achievement. They are asked questions about teamwork as well.

MODULE 5 LET'S IMAGINE (120 MINUTES)

The tutors ask students to discuss what is creativity and how important is it in the real life. They are using the predefined games and demos to demonstrate different aspects of creativity. Furthermore, tutors ask questions about the difference between a robot and a person ultimately reaching the conclusion that a person's brain and the person's heart is what ultimately makes a difference. Children are led to reach the consensus that the brain is that thing that helps us remember and help us make associations between different concepts. The heart on the other hand is what leads us to be imagine things and to apply our imagination to ultimately invent new things and new applications of things. Combined with the brain, they are what makes us creative.

Using games to illustrate the functions of the brain and the heart, children reach the point of creating a Mind Map on the applications of robotics in different aspects of their life. Different games include:

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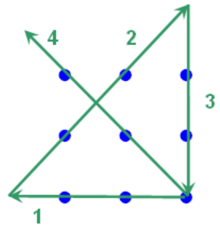
The intimidation of what seems impossible:

A memory game in which students try to remember 15 numbers in the order they were said by the lecturer. The game aims to show children that although a regular person is usually not able to remember this by hearing it only once, when you come to exercise your brain's creativity and memory potential every day you build the capacity to do that. This exercise also aims to show that the brain's potential is somewhat limitless and by making a conscious effort your brain's ability becomes limitless.

Thinking "out of the frame" while generating and constructing new ideas:

The game consists of 9 dots. Students are asked to cross out all the dots with only 4 straight lines. The solution requires that students should inevitably draw outside the dots (allegorically outside the box). This game aims to convey the idea that the only thing that puts borders to our capacity to solve problems is our brain itself. Listening carefully and thinking creatively is what helps us to find solutions as much as the knowledge we already have accumulated.



The paper clip

Students have to generate ideas about the applications of a paper clip and the non-applications of a paper clip (what you can't use a paper clip for). Students have to think within their team. Normally, students are thinking only about metal paper clips, which has not been stated in the task itself. With a little help from the tutor, they realize that the paper clip could be made of different materials, could be of different sizes, could be hollow, etc. and they realize that there are no "non-applications" of the paper clip. The goal of this game is to make children realize that their creativity is limitless and they should not base their ideas on mere practicality or preconceptions, but that it is important to train your creative thinking nevertheless.

Using the mind-mapping technique to generate ideas:

Students are shown as a conclusion from the games that it is easier for us to remember things and to generate new things by stimulating our brains with structure and color. Based on the conclusion from the games the tutors conclude and demonstrate the key principles of the Mind Mapping

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technique. Then the students construct their first simple mind map.

Create a Mind Map about the applications of robotics in everyday life:

students are asked to generate ideas about use of robots and to present them as Mind Maps. They are encouraged to use drawings and colors to put emphasis on their ideas and to differentiate branches of ideas, exercising the importance of structure. Students work individually but are encouraged to share their ideas within a team and help each other to come up with ideas, exercising their collaboration skills in terms of an individual task.

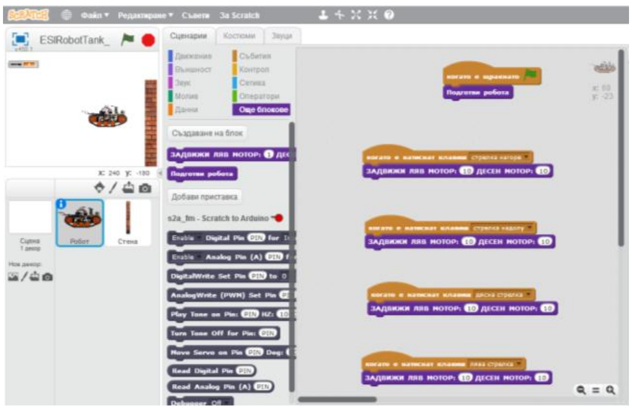
MODULE 6 PROGRAM THE ROBOT (90 MINUTES)

The tutors remind the students the safety instructions and the workshop approach from Module 3 This is every important in case that the Module 3 was conducted in different day.

The tutors explain to the students the basics of programing with Scratch and how specific blocks are used to control the motors and the sensor.

Each team uses the “set up” block to switch on the robot. The teams are left to play with the ultrasonic sensor and to measure distance between the sensor and obstacles.

The rationale of this activity is to familiarize students with the functioning of the robots and the importance of sensors. This activity is performed by every group. Then the tutors demonstrate how to use events (key boards push) to create simple program – a robot moving forward. Students are left to construct and program concepts how to control the motors to move he robot backward and to stop it. Once students complete this task, they are asked to “discover” how to control the motors in order the robot to turn left and right, to go backwards (using negative numbers), to turn around the opposite chain and around the robot’s center and create a separate program for each of these activities.



Instead of employing direct instruction to introduce a concept or explain an example, following the constructionist methodology, the tutors focus on providing students with an example and ask them to test it and observe the behavior of the robot with the aim of identifying the role of specific programming concepts and structures such as logical thinking and functions. This is a teaching and learning process which makes use of the affordances of

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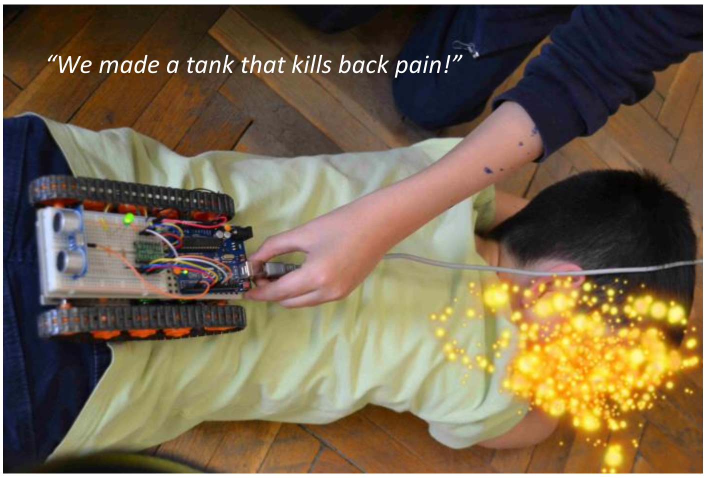
digital constructionist environments where the observation of the generated behavior (i.e. feedback) its analysis provide the grounds for the formulation of a hypothesis about how the robot works. The students are expected to generate ideas, based on the examples they are provided, how the robot can move in different directions by exercising logical and proportional thinking.

Based on the planed length of the module students might be asked also to complete other tasks such as: use sequence of commands to program the robot to go through predefined route; practice cycles to make the robot "dancing", program the robot to turn on predefined angle or to go to predefined distance, etc.

Finally, the students are left to play with the robot or to experiment with the variety of comments that they have created or even generate new once to fit their ideas and goals. Tutors are working with groups, asking them questions to guide them towards solutions.

Some groups even find solutions to quite everyday problems, such as back pain, as illustrated below. Students stated that they created the first robot that cures back pain and were willing to showcase their robot in action. This is an example of how children's creativity not only helps them find a new outlook on things, but also motivates and inspires them to create and maintain their interest in inventing.



MODULE 7 FINAL EVALUATION (30 MINUTES)

Evaluation session is held for students to present their achievements and evaluate their experience.

Group and/or individual interviews are conducted and students fill out Post-Workshops Questionnaires.

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Assessment Procedures

Regarding direct workshop objectives

Objective	**Activities to achieve the objective**	**Assessment (evaluation) procedures**
Subject related – technology, engineering, science	**Digital fluency:** Students discuss, learn and use the robotics key elements while generating ideas about the creative use of robotics and building and programing a real robot. In particular students learn and discuss key robotics elements (technology); construct a robot (technology & engineering) , develop a visual program to control the robot and to execute tasks (technology and mathematics); develop the creative thinking skills needed to find different applications of robotics in other fields	Opinions about STEM as well as preconceptions about scientists, scientists and robotics are measured by the pre and post workshop questionnaires as well as visualized through the draw a scientist exercise. Mind Maps are used as tools to boost and visualize creativity, skills. Group interviews assess and record concepts regarding collaboration and digital fluency. Tutor reflections and observations support the assessment of this objective.
Technology use related	**Digital fluency:** The technology used by the students include: Arduino microcontrollers; motor drivers; ultrasonic sensors; Scratch or Snap visual programing software.	Photos and videos of successfully constructed and programmed robots. Attention to detail and peer review during those processes is are a possible mechanism of evaluating the success of a team. Tutor reflections and observations support the assessment of this objective.
Social and action related	**Creativity:** within the workshop students learn and practice how to construct and generate innovative ideas to address real life problems using Tony Buzan mind-mapping techniques. **Collaboration:** While students in each team are changing their roles during each task, they learn how to work effectively and respectfully with others in order and to build relevantly complex robotics system.	Group discussions/interviews and focus group interviews are used as a tool to record students' progress, opinions and changing attitudes, along the with questionnaires. Attitudes towards team work are recorded and measured with the questionnaires as well. Tutor reflections and observations support the assessment of this objective.
Argumentation and fostering of maker culture:	**Communication:** While working in teams, students build a robot following generic guidelines. They have to clearly communicate their plans and ideas how to construct the body of the robot to correctly connect the electronics and to program the robot. Students are aware made aware by tutors that they would make mistakes and have to identify and rework the corresponding parts in order to build and program the robot.	Group discussions and interviews, alongside with photos and videos are used to record children's attitude and productions. All forms of evaluation, applied within the ER4STEM projects are further relevant for measuring this objective. Tutor reflections and observations support the assessment of this objective.

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Regarding research questions and tool for assessment

Research Question	**Assessment Method or Tool**
Are popular gender stereotypes about STEM held?	• Draw a scientist • Pre-Questionnaire • Post-Questionnaire • Interviews • Team Reflections • Tutor Observations & Reflections
Past experience and existing attitudes to STEM subjects and careers	• Pre-questionnaire • Interviews • Team Reflections
Past experience and existing attitudes to STEM subjects and careers Includes questions about the activities to help understand learners' experiences of the workshop as a whole, what participants feel they have learned and what their future intentions are	• Pre-Questionnaire • Post-Questionnaire • Interviews • Team Reflections
Understand the experience of participants and their reasons for particular actions	• Post-Questionnaire • Interviews • Team Reflections • Tutor Observations & Reflections

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