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IO2 - Plan of training for teachers on innovative pedagogical practices to use with Mobile Robotics

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1. Introduction

Teaching any subject related to mobile robotics requires the teacher's extensive knowledge and competencies in many engineering and science disciplines. From mechanical to cognitive and social sciences, passing through other fields like electrical, electronics, and computer engineering (Nourbakhsh et al., 2005), a teacher in those matters is a person that can embrace knowledge from all of them. The technology-driven environment that we live in makes it possible for mobile robots to keep developing, to be smarter and more capable of performing complex tasks. A new paradigm arises, but the world is learning that robotics is not about replacing people, but about helping them in otherwise boring and repetitive tasks. In this scenario, teaching children how to do things with mobile robotics makes sense so their future can embrace living easily with this. Also, it becomes a priority to provide teachers with engaging content and custom-designed pedagogical approaches in this area, giving them tools to use robotics in every scientific area.

The proposed training plan addresses the need for new and innovative ways to improve the teaching of mobile robotics content that are applicable for children from 10 to 13 years old, by using new pedagogical approaches and open educational resources.

The main goal of this training plan on mobile robotics is to enhance the training outcomes and to facilitate tuition by providing teachers with an easy way to use mobile robotics to develop STEM competencies in children.

We believe that our training plan supports strengthening specific areas of knowledge and skills that the teachers will develop through the design, creation, assembly, and operation of the robot for their classrooms, as developed by the Robots for STEM Partnership's mobile robotics kit.

Our training plan was designed, as a six-unit self-paced course, with the following structure: Applied Concepts in mobile robotics; Types of mobile robots; Teaching with mobile robots; Building a mobile robot; Mobile robotics for STEM; and Further exploring Mobile Robotics.

2. State-of-the-art

Mobile robotics is a new field, already with an important role in education. Through a variety of activities, teachers can use this field to engage students in every STEM subject, depending on the complexity of the robot they are using. Starting with a basic course, a project, or some laboratory work, children can learn more by trying other learning environments. These could include blended learning in real-life scenarios, national (or international) contests, as well as robotics exhibitions and events held around the world. So, it is clear that the use of mobile robotics in education is an extremely large, diverse field and has applications in many domains (Rubio, 2019).

Society is slowly evolving as the rise of autonomous cars, mobile robot guides in urban environments, autonomous space exploration vehicles, remote-operated industrial vehicles, and even automatic vacuum cleaners shape the world we live in. Although mobile robotics has maintained exponential growth in the last decade, their application areas have not yet reached their full potential. Concepts and programs – like Industry 4.0, Smart City, Artificial Intelligence, Quantum Computing and others – are slowly entering everyone's life.

Recent OECD (2019) recommendations state that education should impart competencies to develop "the combination of creative, entrepreneurial and technical skills" and young students need to be prepared for the new jobs that will emerge in this changing society.

New teaching methods, instructional strategies, learning objectives and evaluation methods must be adopted so that teachers can adapt to the specific needs of target groups, keeping in mind the continuous changes in mobile robotics.

Due to that constant change, it is necessary to outline a global panorama of mobile robotics in education and some of the globally available *educational resources, before starting to design the training plan for teachers on Mobile Robotics.*

We can find several definitions of mobile robots but, generally, it is possible to say that we can call a 'mobile robot' a system that comprises both mechatronics and software modules. The mechatronic module has four main groups of elements: sensors, actuators, controllers and mechanical components (Crnokić, 2017). On the other hand, the software module includes all the commands and scripts that control the robot (Nourbakhsh et al. 2003).

Mobile robotics is a multidisciplinary area, consisting of four branches of knowledge: locomotion, perception, cognition and navigation (Siegwart, 2004). Locomotion gives you the fundamental knowledge of mechanisms, kinematics, dynamics and control theory. Problems concerning perception already require knowledge in some areas such as signal analysis, computer vision, and sensor technologies among others. Cognition is the complex process through which a set of input data generated by the sensors is analysed and actions are taken that depend on the problem the robot is intended to solve. Navigation usually involves the implementation of mapping and planning algorithms, information theory and artificial intelligence (Rubio, 2019).

Globally there is a wide range of different mobile robotics training environments, educational courses, and other tools: these are freely available online, having been both designed and accessed by a broad audience across a range of age groups (Crnokić, 2017). These may be either organized in formal settings – like introductory classes for small children (robotics simulations) and post-secondary degree programs – or other interactive learning environments.

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Autonomous mobile robotics kits for education

Since their first use in schools and general STEM education, educational robotics kits have emerged from a variety of companies and universities worldwide. Either in the form of generic kits for several activities, or kits more specifically developed for specific tasks or competitions, educational robotics has grown as a field ever since thanks to those initiatives.

***Edumouse** is a project for an autonomous robot specifically designed to enter the Micromouse competition. Edumouse was designed by Juing-Huei Su and Chen Chao-Wei for educational and experimental purposes. By using observer-based sensor fusion algorithms to improve the encoder resolutions, this robot is capable of navigating through a maze and autonomously finding the best path to reach the centre. Currently, it continues to be used in project-oriented courses at Lunghwa University of Science and Technology in Taiwan.*

***Robotino®** is a mobile robotics platform developed by a company named Festo Didactic in Germany: the platform is designed for research and training in education (Festo Didactic, 2020; Crnokić et al. 2017). With an adaptable design and a modular structure, Robotino® can perform and be used to teach predesigned projects, although it is also possible for teachers to develop their applications should the3y need to facilitate a more-engaged learning experience (Prsic et al. 2018).*

***ROBO TX Training Lab** is a product from another German company, Fischertechnik. They offer training in robotics systems applying their kit and manual, based on previous mobile robotics projects. This allows a range of learning, from design to the programming of a mobile robot (Fischertechnik, 2017).*

***Lego Mindstorms EV3** (Lego Group, 2018) and **LEGO WeDo** (Lego Group, 2009) are two of the most complex educational mobile robot systems from the Danish company, LEGO. LEGO provides educational robotic kits targeted at all levels of education with online support, offering interactive ways to learn robotics through tuition in the principles of programming, physical science, and mathematics. LEGO is the founder and sponsor of two* *international mobile robotics events; FIRST® LEGO League and World Robot Olympiad. The events are targeted at developing knowledge, teaching life skills, and increasing self-confidence. In real-life scenarios, participants experience how to work like real scientists and engineers in mobile robotics, developing their problem-solving skills.*

Darwin-OP2 *(Dynamic Anthropomorphic Robot with Intelligence–Open Platform) is an anthropomorphic mobile robot developed by the Korean company ROBOTIS. launched in late-2017, Darwin-OP2 is intended to be used in education and research activities (Robotis, 2020). It is a miniature humanoid robot platform with advanced computational power, sophisticated sensors, high payload capacity and dynamic motion ability to enable research, education and other activities. It was designed as a collaborative research and development project between Robotis, National Science Foundation, Virginia Polytechnic Institute and State University, Purdue University and Penn School of Engineering.*

E-Learning and cloud-based platforms in robotics

To cope with the need for funding to buy physical robotics kits, online Robotics platforms offer extensive knowledge repositories and professional technical support, usually for free or at a fraction of the price. Usually developed through private-sector funding and financial resources from within international projects, some of them also work as an entry to the world of programming and robotics.

Examples of such platforms include the following examples:

***Arduino Project Hub** (https://create.arduino.cc/projecthub) is a cloud-based platform where developers and makers can share their projects and have them validated by the community. There we can find a variety of open-source robotics projects, including several in the area of mobile robotics. Arduino company, in partnership with UNDP, ARM, NVIDIA, AVNET, NXP and The Things Industries, developed this Project Hub as a web-based platform with a large repository of interactive open-source robotics projects. It also functions as a research community with real-time feedback features and personal project uploads. It is aimed at robotics enthusiasts of all ages.*

***Electronics Hub** (https://www.electronicshub.org/) is an interactive community platform with resources such as projects, tutorials, reviews, kits and many more for application in mechatronics and robotics. Targeted mainly at professional communities, the Electronics Hub is also an interesting resource for beginners in the area of robotics with its DIY projects and tutorials (https://www.electronicshub.org/robotics-projects-ideas/);*

***FAIR-SPACE Hub** (https://www.fairspacehub.org/), a name coined to represent 'Future Artificial Intelligence and Robotics for Space', is a UK national centre of research excellence in space robotics and artificial intelligence that was launched in November 2017. FAIR-SPACE Hub is a highly specialised creative web platform that brings together leading experts from academia, industry and governments who aim at pushing the boundary of AI robotics for future space utilization and exploration. Led by the University of Surrey with over 30 international partners, the FAIR-SPACE Hub consortium offers a unique combination of expertise and capabilities to address key challenges* *in space robotics and autonomous systems. The Hub helps in achieving sustained robotic operations in space, together with advanced knowledge and technologies in orbital manipulation, extra-terrestrial vehicles, along with robotic support for science-based professional astronaut missions.*

Open Roberta Lab *(https://lab.open-roberta.org/) is a project within the German education initiative "Roberta–Learning with robots". This is a cloud-based programming environment that wants to ease the task of making a robot work in a classroom environment (Williams, 2016). Open Roberta Lab uses the approach of visual programming to make it easier to learn how to code. As a cloud-based programming environment, no installation is needed and it works in any operating system;*

RoboHub *(https://robohub.org/) is an online communication platform that gathers experts in robotics, start-ups, business, and education from across the globe. To connect the robotics community to the rest of the world, RoboHub offers extensive learning and knowledge with a learning repository divided into 16 domains, including R&I, Education & DIY, Automotive, Space, Aerial, Mapping & Surveillance, and the like.*

International events on mobile robotics

Motivation may come from different factors, competition being one of its key sources. Identifiable achievements contribute to a student's independence and leadership skills and helps promote a positive educational process (Bazylev, Margun, Zimenko, Kremlev & Rukujzha, 2014).

The enchanting nature of robots for many children is noticeable in the success of animation movies, such as Wall-E and Robots, as well as in the robotic-toys market and construction sets, or the continued publication of robotics magazines and websites.

In this context, Robotic competitions are one of the most promising ways to attract students to the field of robotics, since winning an award at a competition not only gives students a sense of accomplishment but also gives pride and visibility to their schools (Silva, Soares, Valente, Barradas & Bartolomeu, 2015). Robotics competitions also encourage students to apply their knowledge to real-world problems and motivate them to learn new concepts on their own (Pack, Avanzato, Ahlgren & Verner, 2004). Participating in such a contest is a way of developing computational thinking and problem-solving skills.

Mobile robotics events can be appropriate for anyone, from children to adults. Some competitions have age-related restrictions for participants: all well-regarded mobile robotics competitions that primarily target young participants require their supervision by adult mentors who have trained skills in mechatronics and robotics, extensive programming experience, advanced competence in mathematics, and more still, depending on the competition level.

Examples of the worldwide competitions include:

***BEST Robotics** (https://www.bestrobotics.org/), founded by Texas Instruments, is a project-based STEM program. Held as a six-week robotics competition in the United States, it is designed to create interest in engineering careers. BEST (Boosting Engineering, Science and Technology) encourages the participation of students helping their development in technological literacy skills through robotics design and development.*

FIRST *(https://www.firstinspires.org/) is a global robotic community that implements four K12 STEM mobile robotic programs: FIRST Robotics Competition, FIRST Tech Challenge, FIRST LEGO League, and FIRST LEGO League Jr. They are developed by LEGO and implemented to inspire audiences to be science-and-technology leaders and innovators.*

FIRST LEGO League *(https://www.firstlegoleague.org/) is the most known of the FIRST programs. It introduces science, technology, engineering, and math (STEM) to children from 4 to 16 years old through fun and hands-on learning. Participants gain real-world problem-solving experience through a guided robotics program where students will understand the basics of STEM and apply their skills in an exciting competition while developing their learning habits, confidence, and teamwork skills. All competition divisions were designed to inspire youth to experiment and grow their critical thinking, coding, and design skills through hands-on STEM learning and robotics.*

Micromouse Portuguese Contest *is held by a small group of engineers from UTAD university in Portugal, from 2011 until now. The MMPC is an international contest where speed, orientation and precision are the main ingredients. Several types of mobile robots run a maze to achieve the quickest time from departure to the centre. This contest is part of the initiative "micromouse@utad.pt", a project to stimulate students' interest in STEM areas by promoting essential competencies of the XXI century. Alongside the annual competition, the initiative includes the development of Micromouse kits for education along with holding workshops for students and teachers. A complimentary symposium for research papers on related themes is also part of the initiative.*

RoboCup *(https://www.robocup.org/) is an international event created as a way to promote robotics and AI research by offering an appealing, though research-intensive, challenge through interactive team-based science and engineering activities. The event joins a wide range of audiences with a five-league structure (RoboCupJunior, RoboCupSoccer, RoboCupRescue, RoboCup@Home and RoboCupIndustrial). The organisers also promote a complementary symposium for research papers called RoboCup Symposium.*

ROBO-ONE *(https://www.robo-one.com/en/) is organized annually by the Japanese Biped Robot Association. This convention is focused on martial arts with bipedal walking robots and is open to participation from within all age groups. During the convention, five mobile robotics tournaments are held. The organisers also provide robot technology courses within the conference for beginners and advanced users who participate in the annual convention tournaments.*

World Robot Olympiad *(https://www.wro-association.org/) is a global mobile robotics competition with four categories, Regular, Open, WRO Football and Advanced Robotics Challenge. The Olympiad is dedicated to science, technology and education and gains participants from more than 75 countries. This is an effort to promote robotics in STEM education worldwide whilst developing core competencies like creativity and problem-solving skills. In the 2019 competition, alongside the 28000 teams that actively participated, around 35000 adult helpers were involved in the implemented activities.*

Mobile robotics courses and other learning resources

Study Portals *(https://studyportals.com/) is a web-based search portal for study options that is divided into separate Bachelors, Masters and PhD Portals. A Portals Bachelors search (as reviewed on 22 December 2022) revealed that there are 146 mobile robotics-related study programs available worldwide. Although most of the programs are based in USA and UK, bachelor study programs are also available in countries like Estonia, Sweden, Israel, Malta, Denmark, South Africa, Hungary, Turkey and Malaysia. According to Study Portals Masters, there are 132 Master's degree options worldwide in mobile robotics and mobile robotics-related areas, such as AI. PhD degree offers are far less than Bachelors and Masters, with only five programs related to mobile robotics showing up in Study Portals PhD.*

NULLSPACE *(https://sg.nullspace.co/robotics-adult-class-certification/), offers several certification programmes within its Adult Robotics Class Certification. Specific to LEGO platforms, the CSARCTM Certified Trainer and CSARCTM Certified Master Trainer are two certification programmes for adult robotics learners and teachers gaining professional development. Through the training programme, participants will learn how to use the LEGO Mindstorms EV3 or LEGO Education SPIKE Prime platform to plan, design, and deliver an engaging robotics class. The certification is done by passing a hands-on assessment at the end of the course to ascertain that recipients of the certification have the necessary technical proficiency to teach and troubleshoot common difficulties faced by students.*

Class Central *(https://www.classcentral.com/subject/robotics) offers over 100 free online robotics courses out of which 18 are specifically targeted at mobile robotics design, development and implementation.*

Several other online platforms with free course repositories are aimed at enhancing skills and competencies in the mobile robotics field. Also, other mobile robotics learning environments exist, such as local summer robotics camps, intensive certification classes and special education robotics.

The extensive research done by the project consortium revealed that, even though there is a high number of options on offer, there is a lack of *comprehensive teaching guidelines in mobile robotics designed specifically for STEM teachers for young children. They represent a unique target group of learners, with specific needs that require catering through targeted teaching methods adapted to mobile robotics and the distinctive features of young children.*

In this way, the consortium proposes a collaborative training plan, customised and tailored for those teaching mobile robotics to young children, as detailed in the next chapter.

3. Training plan structure

The target group of the training plan mainly comprises, but is not limited to, Teachers and Educators who are engaged in children's education.

The learning objectives are defined in accordance with Bloom's revised taxonomy for the cognitive domain, as described by Gershon M. in his work (Gershon, 2018):

Level 1 (L1) Remembering – recall of information;
Level 2 (L2) Understanding – interpretation of information in one's own words;
Level 3 (L3) Applying – use of knowledge or generalisation in a new situation;
Level 4 (L4) Analysing – break down of knowledge into parts and display of relationships among parts;
Level 5 (L5) Evaluating – judgement on the basis of given criteria;
Level 6 (L6) Creating – collation of elements to form a new functional whole.

Instructional Strategy is presented as it has been defined by White D. and Braddy A. (2017), associated with each course unit.

The recommended timeframe for the training plan is 12 weeks, with 4-hour weekly meetings. Each weekly meeting can be taught in one continuous 4-hour session or can be split into two separate weekly meetings: one for the interactive lecture (theory & interactive demonstrations) and one for the laboratory work (hands-on). In total, the course will have 12 interactive lecture hours and 36 laboratory hours.

As alternatives to traditional face-to-face teaching, depending on the resources available locally, or on when a specific course occurs, the trainer can choose to deliver the content in one of the following formats: Interactive Technology Fair, Live demonstration, Invited Technology presentation, Group workshops, Seminar on examples of good practice, IT Labs, Workshop on good practice examples, Product live demonstration, or others that may be available at the time.

Table 1. Plan of training for teachers on innovative pedagogical practices to use with Mobile Robotics

Unit title	**Learning Objectives (Bloom's revised taxonomy levels)**	**Duration [hours]**	**Content**	**Resources and materials**	**Training Method & Instructional Strategies**	**Methods of Evaluation**
UNIT 01. Applied Concepts in mobile robotics Main reference for content development: (*Rubio, 2019*)	(L1, L2) To acquire specific knowledge of basic concepts used in mobile robotics. To accurately identify and explain the fundamental elements of mobile robotics: – locomotion, – perception, – cognition, and – navigation.	4 hours – Interactive lectures	**1.1. Definition and classification of locomotion system** **1.2. Definition and classification of perception** - Sensor classification - Types of sensors (tactile, force torque, encoders, infrared, ultrasonic, sonar, active beacons, accelerometers, gyroscopes etc.) **1.3. Cognition and control strategies** - Computed torque control methods - Robust control methods - Sliding mode control methods - Adaptive methods - Neural networks methods - Fuzzy logic methods - Invariant manifold method - Zero moment point control **1.4. Navigation** - Navigation skill - Localization and mapping - Path, trajectory, and motion planning - Tracking planning - Obstacle avoidance	E-learning platform Web resources Internet connection PPTX Printed presentation notes Lesson plan Printed speaker notes	Face-to-face and online courses which include lectures, presentations and videos from YouTube / Literature response Cooperative learning	Quiz-based assessment Oral discussions

Unit title	Learning Objectives (Bloom's revised taxonomy levels)	Duration [hours]	Content	Resources and materials	Training Method & Instructional Strategies	Methods of Evaluation
UNIT 02. Types of mobile robots Main reference for content development: (*Siegwart et al., 2004*)	(L2) To understand mobile robotic systems and the complementarity of the different disciplines that are involved. To explain the synergy between different types of mobile robotics platforms.	2 hours – Interactive lecture 8 hours – hands-on laboratory work	**2.1. Autonomous vs remote-controlled mobile robotics** **2.2. Stationary (arm/manipulator)** **2.3. Land-based mobile robots** - Wheeled mobile robot (WMR) - Walking (or legged) mobile robot - Tracked slip/skid locomotion - Hybrid **2.4. Air-based mobile robots** **2.5. Water-based mobile robots** **2.6. Other mobile robots**	IDEM U01 and Printed case study description	Face-to-face and online courses Webinars Tutorials / Debate Group roles Cooperative learning	Quiz-based assessment

Unit title	Learning Objectives (Bloom's revised taxonomy levels)	Duration [hours]	Content	Resources and materials	Training Method & Instructional Strategies	Methods of Evaluation
UNIT 03. Teaching with mobile robots Main reference for content development: (*Ferrarelli et al., 2017*)	(L4, L5) To understand the capabilities of the selected mobile robotics system and how to effectively use it in an educational context. To design new mobile robotics environments in learning spaces.	4 hours – Interactive lecture 8 hours – hands-on laboratory work	**3.1. Establish the input parameters of the teaching environment** - Target-group description - Identification of resources (human, financial, materials) - Definition of mobile robot role - Definition of trainer role - Identification of teaching disciplines in which the mobile robot will be deployed - Prerequisites for young learners and trainers **3.2. Identify the mobile robot that best suits the training scenario** **3.3. Define educational activities within a specific learning scenario** **3.4. Set assessment method for evaluation of the learning gain** **3.5. Test new pedagogical scenarios in focus groups** **3.6. Implement the newly developed and improved pedagogical scenario on a larger scale.**	IDEM U01 and Printed Best practice scenario Printed Model plan	Face-to-face and online courses Webinars Tutorials Invited lectures / Cooperative learning Portfolio development Idea builders	Oral questions Portfolio Quiz-based assessment

Unit title	Learning Objectives (Bloom's revised taxonomy levels)	Duration [hours]	Content	Resources and materials	Training Method & Instructional Strategies	Methods of Evaluation
UNIT 04. Methodologies	To understand thirteen concepts of pedagogical innovation for their effective use in an educational context.	6 hours – Interactive lecture	**4.1.Gamification** **4.2.Game-based learning** **4.3.Educational robotics** **4.4.Robotics competitions** **4.5.Problem Solving** **4.6.Learning by Doing** **4.7.Cooperative Learning** **4.8.Problem Solving, Learning by Doing and Cooperative Learning, interconnected methodological strategies** **4.9.Project-based Learning** **4.10.Digital Storytelling** **4.11.Flipped Learning** **4.12.Explore First** **4.13.Co-Creation**	E-learning platform Web resources Internet connection PPTX Printed presentation notes Lesson plan Printed speaker notes	Face-to-face and online courses Webinars Tutorials Invited lectures	Oral questions Portfolio Quiz-based assessment

UNIT 05. Building a mobile Robot Main reference for content development: (*Rubio, 2019*)	(L3, L4, L5) To develop hands-on experience building and programming mobile robots to accomplish problem-based mission objectives.	8 hours – Interactive lecture 20 hours – hands-on laboratory work	**5.1. Robot Programming Software** **5.2. Actuators and Sensors** **5.3. Design of Robot Vision** **5.4. Design of Robot Control** **5.5. Plan of Robot Behaviours** **5.6. Control Architectures Building** **5.7. Applied Navigation Strategies** **5.8. Robotic Map Building**	IDEM U01 and Mobile robot kit; Basic mechanical tool kit; Graphical illustrations; Flow charts; Assembly files; Activity videos; Program files;	Face-to-face and online courses Laboratories Workshops Field visits / Interactive instruction Independent study Reciprocal teaching	Practical applications – perform a given task with a mobile robot Quiz-based assessment

UNIT 06. Mobile robotics for STEM Main reference for content development: (*Lego Group, 2020*)	(L5, L6) To plan, design and conduct mobile robotics curriculum for use in STEM (Science, Technology, Engineering, Mathematics) learning environments.	6 hours – Interactive lecture 8 hours – hands-on laboratory work	**6.1. Design a mock-up curriculum based on project-based learning** **6.2. Develop research prototype projects (RPP) and establish investigation targets (IT)** **6.2.1.** RPP: ***The way forward*** – Program the robot to go forward/ IT: control the distance of the robot's movements. **6.2.2.** RPP: ***Right turn*** – Program the robot to turn/ IT: Measure turns and control the angle of the robot's turns. **6.2.3.** RPP: ***Make it sing*** – Start and stop with the sound sensor/ IT: differentiate between frequency and amplitude and learn what a sound sensor detects. **6.2.4.** RPP: ***Follow the Leader*** – Use the light sensor to track a line/ IT: ensure faster line tracking and master driving backwards. **6.2.5.** RPP: ***Obstacle ahead*** – Detect objects with different sensors/ IT: evaluate the field of view through breadth, depth and blind spots. **6.2.6.** RPP: ***Gear-Up*** – speed the robot up/ IT: coordinate gears and speed by ensuring proportionality and measured speed.	IDEM U04	Face-to-face and online courses Case-study seminars Laboratories / Interactive instruction Cognitive Organisers Strategic questioning Learning logs	Practical application – write and compile software programming for a specific task Peer-assessment Quiz-based assessment

UNIT 07. Further exploring Mobile Robotics Main reference for content development: (*Arduino Project Hub, 2020*)	(L6) To gain familiarity in troubleshooting and debugging common issues faced by learners. To promote the use of mobile robotics in innovative pedagogical approaches by trainers and learners.	4 hours – Interactive lecture 12 hours – hands-on laboratory work	**7.1. Main sectors with intensive use of mobile robotics – applications** - Research & Innovation - Business & Finance - Health & Medicine - Politics, Law & Society - Arts & Entertainment - Education & DIY - Events - Military & Defence - Exploration & Mining - Mapping & Surveillance - Environment & Agriculture - Aerial - Automotive - Industrial Automation - Consumer & Household - Space **7.2. Healthcare mobile robotics applications** - Pulse and temperature scanning **7.3. Industrial automation mobile robotics applications** - Product barcode scanning - Gripping, transporting and placing a load **7.4. Environment & Agriculture mobile robotics applications** - Testing soil humidity - Delivering water at programmed time intervals **7.5. Mapping & Surveillance mobile robotics applications** - Retrieving coordinates of a specific object - Motion sensor-activated tasks	IDEM U04	Face-to-face and online courses Field visits Live demonstrations Invited technology presentations / Interactive instruction Brainstorming Live demonstration Portfolio development	Group pool Feedback Self-assessment Quiz-based assessment

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