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MEET MIRTE - USING AFFORDABLE OPEN SCIENCE ROBOTS IN ENGINEERING EDUCATION

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ABSTRACT

With the advances in robotics applications in society, it has become imperative to equip engineering students with practical robotics skills relevant to their field. However, incorporating robots into higher education poses challenges, particularly regarding cost, obsolescence, and maintenance. This workshop introduces engineering educators to the MIRTE Pioneer, an affordable, open-science, modular, mobile educational robot designed for use in upper secondary and university education settings. The Pioneer is part of a family of MIRTE educational robots for use in primary school to university developed at Delft University of Technology in the Netherlands. By being a truly multi-purpose, open science robot, with all its material available as open source, open hardware and open educational resources, MIRTE is a community where educators are not tied down to a specific goal or purpose and can endlessly adapt and expand MIRTE for their own needs and share their resources. This allows educators to provide students with hands-on experience in designing, programming, and electronics as they see fit.
The workshop aims to introduce participants to MIRTE and explore its use in their own education and, by doing so, contribute to an international community for open robotics education. It consists of a combination of hands-on experimentation with the MIRTE robot and the participant's own laptop, combined with group discussions, in which participants will explore the potential of integrating the MIRTE Pioneer into their educational environments.

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1 BACKGROUND AND RATIONALE

Using robots in education is not new, however, due to the rapid growth in robotics applications both in industrial and medical applications and in everyday society, we must prepare and educate all our engineering students in robotics relevant to their field. Yet many (higher) education institutes struggle when using robots in engineering education, especially when student numbers are high. Commercially available educational robots are expensive to buy, can become obsolete quickly and are time-consuming to maintain (Arvin et al., 2019). As a result, many open-source educational robot initiatives have sprung up over the last 10 years, such as the AWS Robotics curriculum and SUMO robots. However, many are limited in use as they are tied to a specific educational level or purpose or their open-source software repositories are often quickly abandoned leaving users stranded (Evripidou et al., 2020; Klomp et al., 2024).

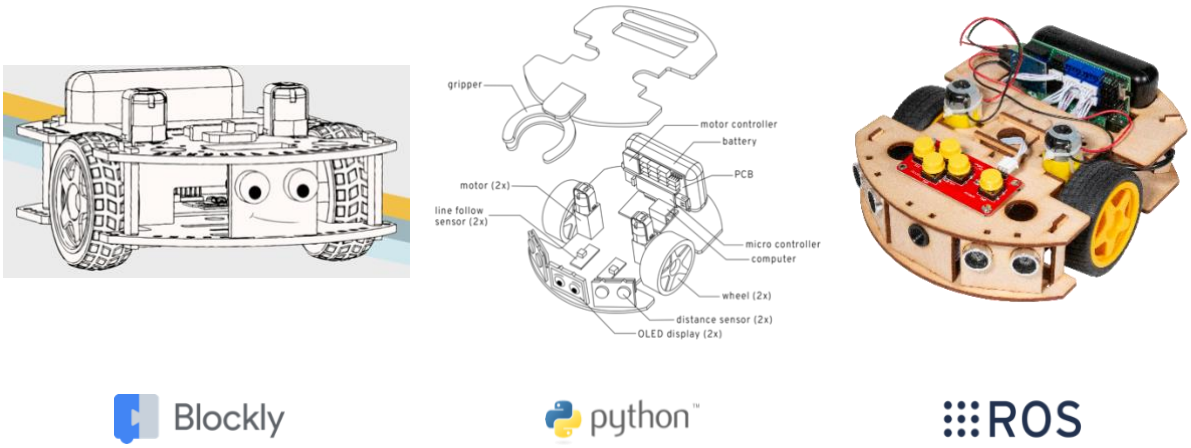
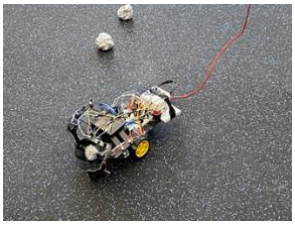


Fig. 1 MIRTE Pioneer (homebuilt: €100 – kit: €150)
The prizes shown based on sourcing components and self-assembly

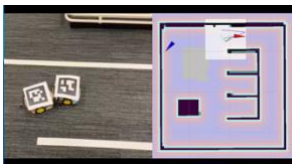
1.1 MIRTE

The lack of applicable, affordable and reliable Open Science robots led one of the workshop leaders, inspired by the “One Laptop per child programme” (Ames, 2019), to create MIRTE, which stands for: Mirte, an Inspiring Robot for Technology Education. MIRTE is designed as a semi to fully autonomous affordable mobile robot platform to be used in educational settings (Klomp et al., 2024). The platform is developed using a family concept, allowing it to be used from primary school to university and fit the corresponding needs. Whilst MIRTE Basic and Light are aimed at primary and lower secondary education, the MIRTE Pioneer is aimed at upper secondary and university education. Contrary to most educational robots, it is equipped with an Orange Pi computer and a dedicated PCB, on which a microcontroller sits, and which offers room for an array of sensors to allow MIRTE to run the Robot Operating System (ROS - www.ros.org). This allows for MIRTE to be adapted by more experienced robotics educators and developers to fit their specific needs, for instance, fitting grippers and servos. From the Pioneer, an even bigger spinoff robot has been developed the MIRTE Master, which is successfully used in MSc education and for research (Klomp et al., 2024; Van der Niet et al., 2023).
The MIRTE family has been developed using the framework of Biesta (Biesta, 2009, 2021) based on the principles of qualification (the foundational STEM knowledge at

the appropriate level), socialisation (being able to think critically across cultural and societal contexts by working together in diverse classrooms) and subjectification (teaching students to take responsibility for their choices). The MIRTE Pioneer is currently extensively used in BSc programmes in our institution and beyond, with over 300 MIRTE Pioneers being built and used by our BSc students each year.



a) Active Learning: Making your own Trash Sorting robot, 2nd year BSc



b) Challenge Based learning: Making a Cow herding robot for industry, MSc (Anon2, 2023)

Fig. 2 MIRTE robots in use in education

1.2 MIRTE PIONEER

MIRTE's hardware basis consists of a (wooden) chassis, wheels, motors, battery pack and light sensor which allows users to add additional off-the-shelf hardware depending on their needs (modularity) and is powered by a standard 5V power bank. The base itself is not an off-the-shelf product instead we provide the DXF, STL, and FreeCAD files for people to make their own, alternatively they can use an existing base. For the MIRTE Pioneer, users can use the Open Hardware solution of a breadboard combined with an MB102 Micro USB Interface Breadboard Power Supply Module and a splitter cable or a dedicated PCB, either using our design or by creating your own. See the MIRTE Docs for more information (https://docs.mirte.org). In addition, a variety of different sensors can be added to the robot, depending on needs and budget. A version of the MIRTE chassis that is partially compatible with LEGO Technics is available on GitHub to allow for more modularity.
MIRTE can be controlled using different software interfaces: a web interface in which Blockly or Python programming can be done for, to onboard programming in C++ or Python using ROS. MIRTE works on ROS1 and ROS2. All source code can be found in our GitHub repository (https://github.com/mirte-robot).

1.3 Open Science

Whilst many educational robots offer the use of the software, the CAD files, or the education material for free, they are often not truly open in that they only offer resources for use but protect part of their robot system and tend to not welcome developers to develop and grow their robots further. The MIRTE family is true to all Open Science principles in that it sees itself as a community in which users and developers develop, share and use code, robot designs, educational resources and much more. It welcomes people to work on MIRTE and develop the family so that more people may develop much needed robotics skills.

2 WORKSHOP OBJECTIVES

During this workshop, participants will be introduced to MIRTE Pioneer, its uses and explore its potential use in their own education. It consists of a combination of hands-on experimentation with the MIRTE robot, and group discussions, in which

participants will explore the potential of integrating the MIRTE Pioneer into their educational environments.

2.1 Target audience

The target audience consists of engineering educators and curriculum developers from any discipline, interested in discovering if using an Open Science robot is a potential alternative for teaching their students about electronics, programming, AI, robotics, and mechanical engineering in an active way. No prior knowledge is required (but can be helpful). Participants are asked to bring their laptop to connect to the MIRTE Pioneer to experience working with MIRTE using a web interface. No additional software needs to be installed.

2.2 Expected learning outcomes

At the end of the workshop participants will have:

- Basic knowledge of the MIRTE Family and its possibilities as educational robots
- Connected to and operated a MIRTE Pioneer to perform a small robotics mission controlled using their laptop
- Know where to find and how to use the MIRTE Open Science resources on GitHub and the MIRTE Docs
- Have first ideas on how to use a MIRTE (or alternatives) robot in your education and what it would take for that to happen
- Met other educators interested in using robots in education and found potential collaborators and friends

3 WORKSHOP DESIGN

3.1 Time plan

This one-hour workshop will primarily focus on hands-on robot experience as this is the best way to experience the fun and the challenges of using robots in education.

Table 1. MIRTE Workshop Time Plan

Run time	Activity	Notes
10 min	Introduction to MIRTE	The concept behind MIRTE, its modularity and use explained
30 min	Connecting to & operating MIRTE using Open (Educational) Resources	In small groups (4-6 people) connect to MIRTE and learn how to operate MIRTE using basic commands and complete a small mission with MIRTE
10 min	Brainstorming on potential use MIRTE in your education	In your group brainstorm, how you could use MIRTE (or alternatives) in your education and what you would need to achieve that
10 min	Conclusions & resource sharing	Wrap up and sharing of MIRTE Resources & collaborations

3.2 Interactivity

In this workshop, we will introduce the MIRTE Pioneer (see Fig 1). After a short introduction, participants embark on a hands-on trial of the robot, first connecting to the robot and learning how to operate it, followed by trying to complete a small mission in small groups. After this, participants discuss in their groups what possibilities, they see for using such a robot in the context of their education and what it would take to achieve that. The session ends by explaining where all resources can be found, and how participants can contribute to and collaborate in the MIRTE community to share ideas, support and learn from each other.

4 WORKSHOP RESULTS

The workshop was well attended with 18 participants, with 14 sharing their input for this section of the paper. When asked about insights gained, participants reported that they gained a better understanding of how to work with robots through their hands-on experience with MIRTE and of the flexibility and possibilities MIRTE offers at low cost in their own education. When asked what they would use MIRTEs for in their own education a variety of uses were reported that exceeded our own expectations as authors: In addition to using MIRTE for teaching robotics and STEM outreach, potential uses listed by participants were, using MIRTE as a shared object to work on together in a common entry programme to engineering, to teach control and algorithms, team building, teaching coding/programming and breaking fear of coding, electronics, sensors and even data science. Finally, when asked what participants would need to make that happen, they listed as their needs: Having MIRTEs (2x), funding (3x), ready-to-buy/use package robots, more resources including a python only web interface (no Blockly), support including resources and educational context, how to deliver activities for large cohorts.

In conclusion, as authors we found the workshop inspirational and loved the interaction with participants and the subsequent connections formed. We would like to thank all participants for their participation and look forward to future collaborations to build a community of educators who use and co-develop MIRTEs.

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