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FIGURES WITH AN AXIS OF SYMMETRY WITH PHOTON ROBOT

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Abstract: *Ideas for creating symmetrical shapes using the Photon Coding mobile app for working with the Photon Robot are described. The results of working with some of the levels of Photon Coding and drawing with the Photon Robot are presented. Some recommendations are given on working with the robot and the use of auxiliary materials for drawing with it. The presented materials and videos are suitable for use in STEAM centers in the education of elementary school students, as well as in Mathematics and Computer Modeling classes. They provide another opportunity for propaedeutics of symmetry, when using robotic systems and game-pedagogical forms of learning in primary school.*

Keywords: STEAM, Photon Robot, programming, digital competence, symmetry, education, art
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MSC 2010: 97B50, 97M10, 97M50

1 INTRODUCTION

Digital innovations in the economy, healthcare, art, education, etc. in recent years, have been developing and entering the individual sectors at high rates (Minchev et al., 2019),

(Kostova et al,, 2020), (Dimitrova et al., 2012). The need for trained professionals who have the relevant competences to work with the constantly changing requirements related to new technical means and software environments was highlighted. As a result of the COVID-19 pandemic, people's use of information and communication technologies (ICT) in learning, work and daily activities has become commonplace and, in some cases, preferred. In the educational institutions in Bulgaria, with the support of the Ministry of Education and Science (MES), the national programs for the implementation of innovative methods and tools continue to help both pedagogical specialists and for the technical provision of school facilities (MES. Competency approach. For the support of pedagogical specialists).

2 NATIONAL PROGRAMS AND PROJECTS IN SUPPORT OF STEM EDUCATION IN BULGARIA

According to the National Program “Information and Communication Technologies (ICT) in the system of pre-school and school education” means for equipment (computer equipment, interactive displays); construction/upgrading of Wi-Fi networks; professional training software; electronic diary and others are provided (National Program “Information and Communication Technologies (ICT) in the system of preschool and school education”). The National Program "Innovations in Action" intends to support schools by introducing "innovative methods, new organization of learning, developing methodologies for integrative educational content and teaching in STEM" (National Program “Innovations in action”). Through the National Program "Building a School STEM Environment", school STEM centers are being built and the aim is "to create an integrated learning environment of a new generation in Bulgarian schools, that will encourage and support educational innovations in learning and teaching in the field of STEM, creativity and research". Part of the set goals with a STEM focus are “stimulating students to create and improve technological solutions in the fields of mechanics, programming and artificial intelligence; skills to create new technologies and their automation.” (National program “Building a school STEM environment”).

The national “Training for IT skills and career” Program aims to acquire new skills related to the professions of the future through programming training for the country's students in the profession of “Applied Programmer”; developing and supplementing learning content; teacher training related to the two activities mentioned (National program “Training for IT skills and career”). When becoming familiar with new

technologies and software, the creation of artistic works supports the motivation of the learners.

The use of technical and software tools for research and construction of symmetrical objects, as well as examples of gamification as a tool in the teaching of Mathematics, Information Technology, Architecture, Arts, etc. are presented in (Chehlarova, 2016), (Chehlarova, 2020), (Chehlarova, 2021), (Chehlarova, 2021a), (Chehlarova, 2021b), (Chehlarova and Chehlarova, 2014), (Chehlarova and Chehlarova, 2021), (Chehlarova and Gachev, 2021), (Chehlarova and Valkov, 2021), (Dunham and Shier, 2021), (Kovatcheva and Koleva, 2021), (Palócz and Katona, 2021).

The use of STEM materials in education is based on the use of modern solutions, including robotic systems and artificial intelligence in the training of personnel for the "professions of the future" (Zahariev et al., 2022), (Nikolov et al., 2022), (Tsanov, 2022), (Sharabov and Tsochev, 2020).

3 SYMMETRIES IN MATHEMATICS EDUCATION

Symmetry is an important concept related to both self-organization in nature and social relations. Research related to types of symmetries and their applications continues (Gruber, 2004), (Davvaz, 2021). Symmetry is important to professionals in several professional fields and is the subject of study by various age groups. Scholarly and educational literature is available both on the versatile representation of symmetry and on specific applications of symmetry as part of textbooks and aids (Agazzi and Darvas, 2012), (Darvas, 2007), (Gutiérrez, 2021), (Hargittai and Hargittai, 2009), (Weyl, 1952).

In the Bulgarian school, central symmetry and axial symmetry are introduced in mathematics education in the 6th grade, and their properties and applications are studied in the 8th grade. We believe the propaedeutics of different types of symmetries should start at an early age.

The creation of STEM centers in all Bulgarian schools is currently also related to the development of educational content, including elements from several fields, using new technological means (National program "Building a school STEM environment").

Here we will look at possibilities of creating symmetrical figures using specialized software for working with Photon Robot. This provides another opportunity for the

propaedeutics of symmetry when using robotic systems and game-pedagogical forms of learning in primary school. The suggested steps for creating symmetrical models are suitable for use by educators who have not previously worked with robotic systems or computer modeling software.

4 DRAWING WITH PHOTON ROBOT

In the present work, Photon Robot and the specially created mobile application Photon Coding for working with it were used (Photon Robot).

Figure 1: Photon Robot with an added 3D printed marker holder from a ready-made model at https://portal.photon.education/en/project/133-marker-holder .

A 3D-printed marker holder from a ready-made model available at https://portal.photon.education/en/project/133-marker-holder was added for drawing with the robot (Figure 1), (Photon Portal. Marker holder).

Here will be presented several options for creating the letter "T" through the different levels of the mobile application and drawing their results using Photon Robot.

5 LETTER "T" WITH PHOTON ROBOT VIA PHOTON CODING MOBILE APP

The Photon Coding mobile application contains four levels to work with, as well as the ability to use a joystick and Scratch. The app has a freely available mobile version on Google Play and an identical one for Apple users. Figure 2 shows a variant of the

printed letter "T". Through the Photon Draw level, the creation of a trajectory is done by dragging on the screen of the mobile device.

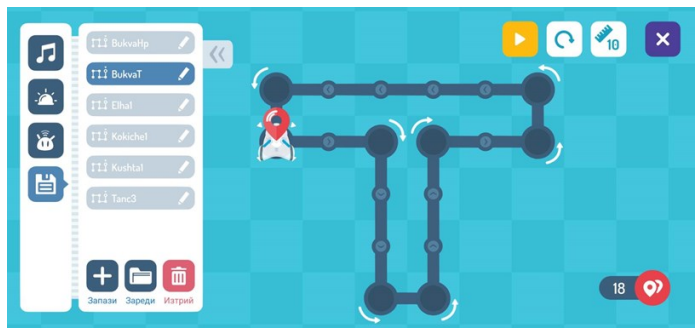

Figure 2: Variant of Letter "T" via Photon Draw (Beginner Level).

In this case, the minimum size is set at 10 cm. Files of this level are also convenient when looking at math problems related to building figures, finding the circumference and face of a figure, and others. The direction of rotation when changing the direction of movement is indicated by the white arrows.

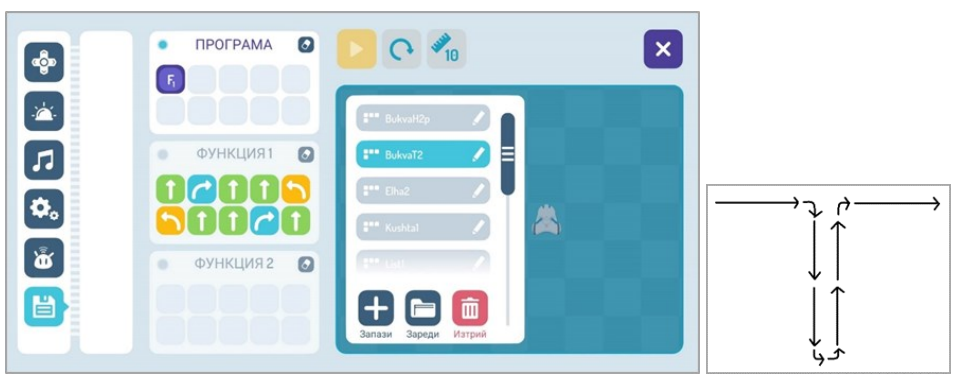

Figure 3: Variant of letter "T" via Photon Badge (Level Medium) and expected result.

Through the second-level Photon Badge, a variant of the letter "T" in the "Function 1" field of Figure 3. The symmetry in "Function 1" is noticeable - the code is a palindrome.

This level allows to repeat up to 10 times the path created in "Function 1" or "Function 2" in the "Program" field. This possibility of repetition is suitable when creating figures through rotational symmetry (Chehlarova, 2023). Here we can also use the created function to get a composition from the constructed letter (Figure 4).

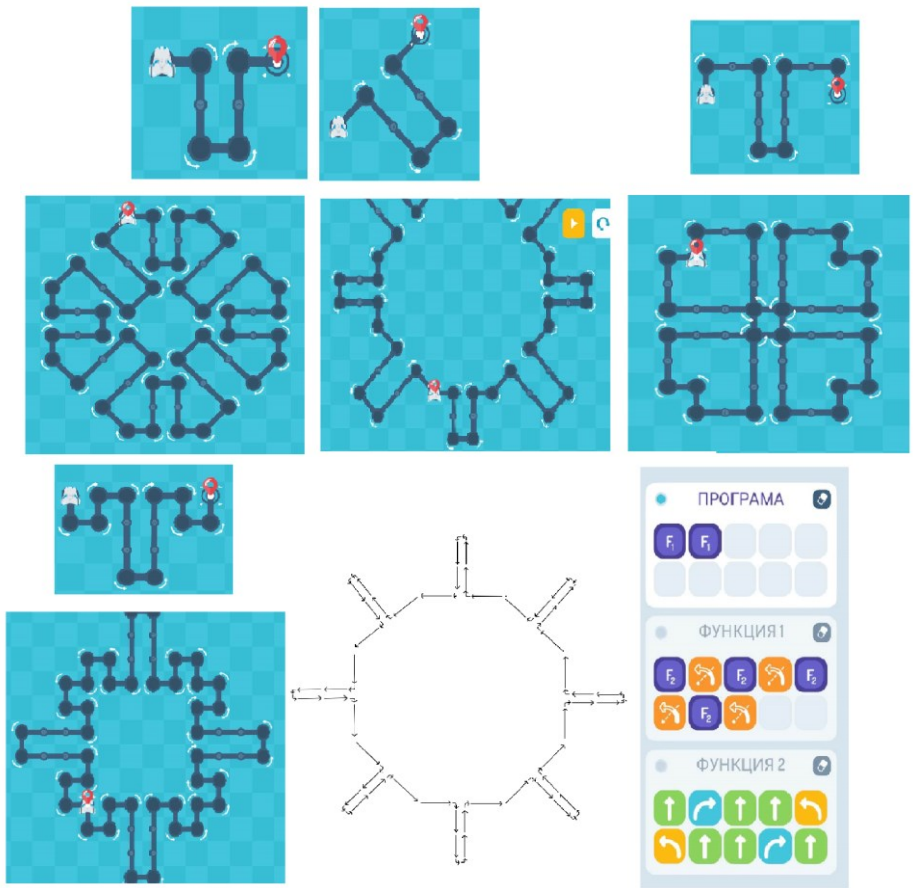

Figure 4: Variants of symmetrical figures with letter "T" via Photon Draw and Photon Badge.

Figure 5 presents the same variant of the letter "T" through Photon Blocks (Expert Level). At this level, the distance traveled in each step can be specified with an accuracy of 1 cm. The minimum value is 5 cm and the maximum 100 cm per step.

Figure 5: Variant of Letter 'T' via Photon Blocks (Expert Level).

The adjustment of the angle of rotation is accurate to 1 degree. In Figure 6 a video containing the drawing of the result of the created trajectory by Photon Robot can be observed.

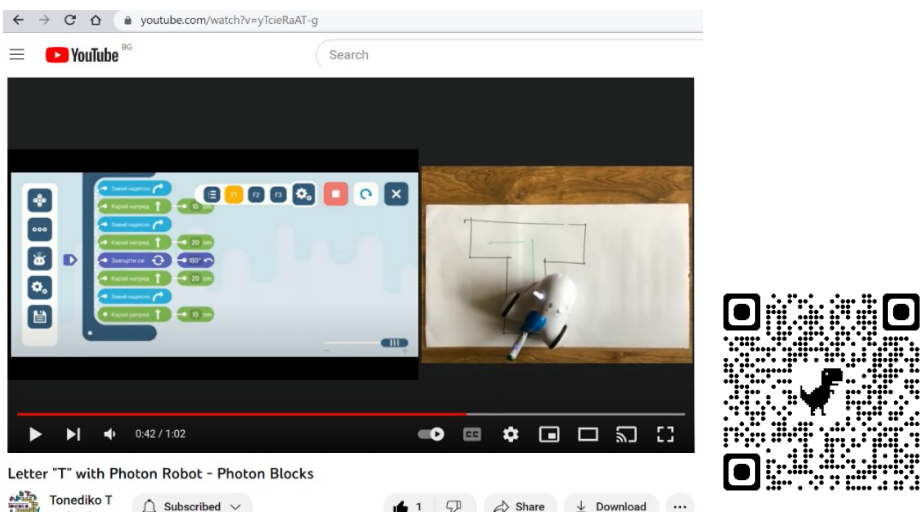

Figure 6: Video of Photon Robot Drawing Letter 'T' Using Photon Blocks (Expert Level) https://www.youtube.com/watch?v=yTcieRaAT-g .

The last level of difficulty - Photon Code (Master Level) is very similar in design and buttons to Photon Blocks (Figure 7). For the purposes of the study, we chose to present

again the printed version of the letter "T", which was already shown at the beginning of Figure 2 with Photon Draw level.

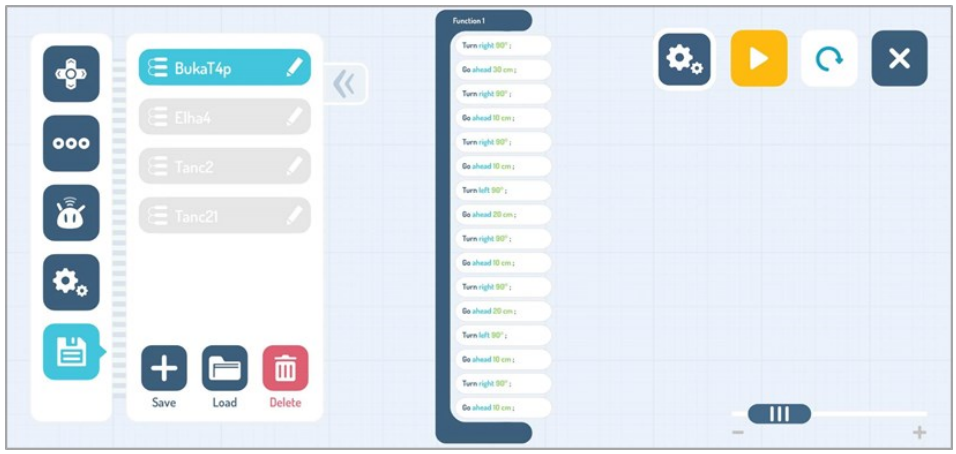

Figure 7: Variant of letter "T" via Photon Code (Master level).

In Figure 8, a video of the result of the block programming through its execution by the robot and its drawing can be observed.

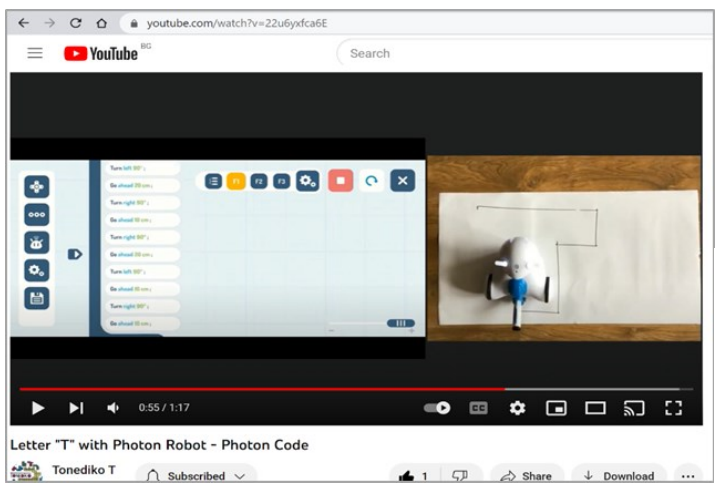

Figure 8: Video of Photon Robot drawing letter 'T' via Photon Code (Master Level)
https://www.youtube.com/watch?v=22u6yxfca6E .

Up to this point, the resulting image can be discussed in terms of the presence of an axis of symmetry, as well as comparing the codes if the drawing starts from the other end

respectively in the other direction when the line is closed). The real challenge is when using two robots to render a figure with an axis of symmetry.

6 LETTER "T" RENDERING WITH 2 ROBOTS

If we plan to use two robots to draw the letter "T" with a 10 cm step of movement, then a variant of their trajectories is shown in Figure 9 via Photon Draw, Figure 10 via Photon Badge, Figure 11 via Photon Blocks and Figure 12 via Photon Code.

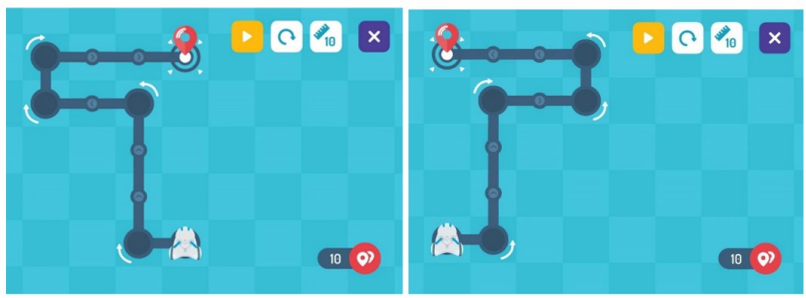

Figure 9: Letter "T" with two Photon Robots starting from the same point, via Photon Draw.

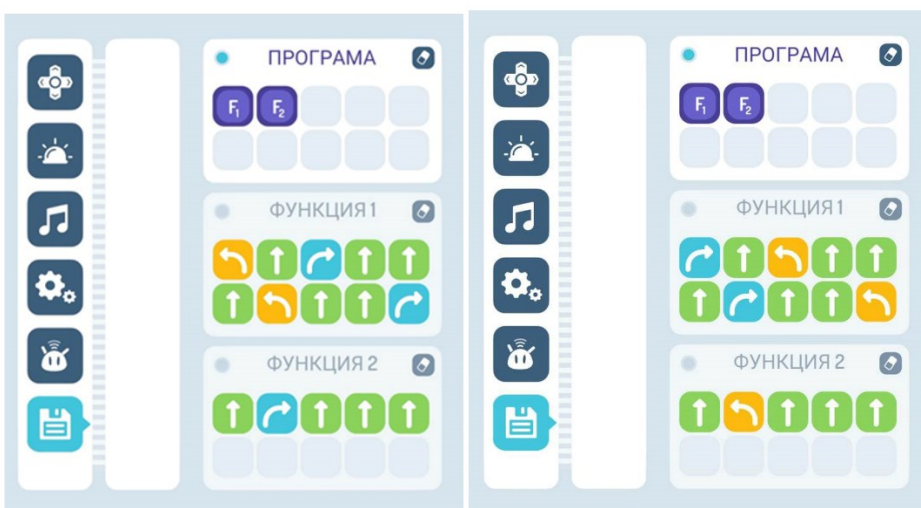

Figure 10: Letter "T" with two Photon Robots starting from the same point, via Photon Badge.

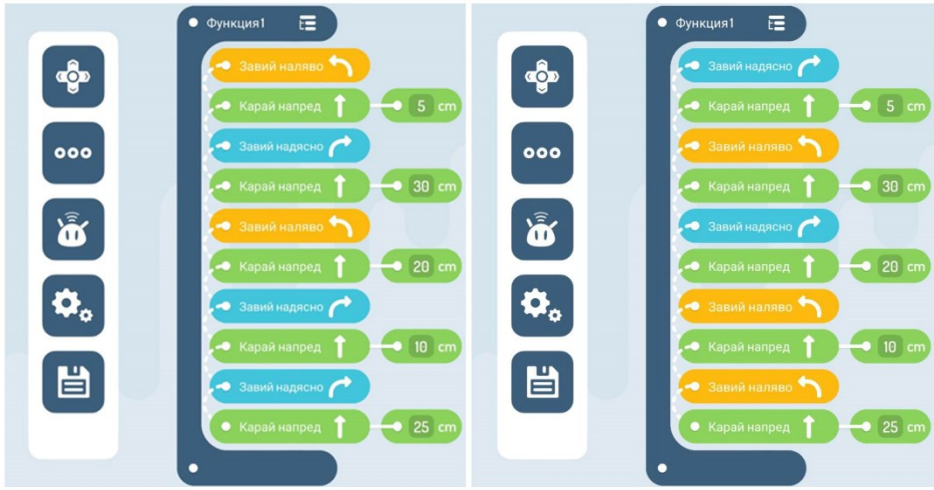

Figure 11: Letter "T" with two Photon Robots starting from the same point, via Photon Blocks.

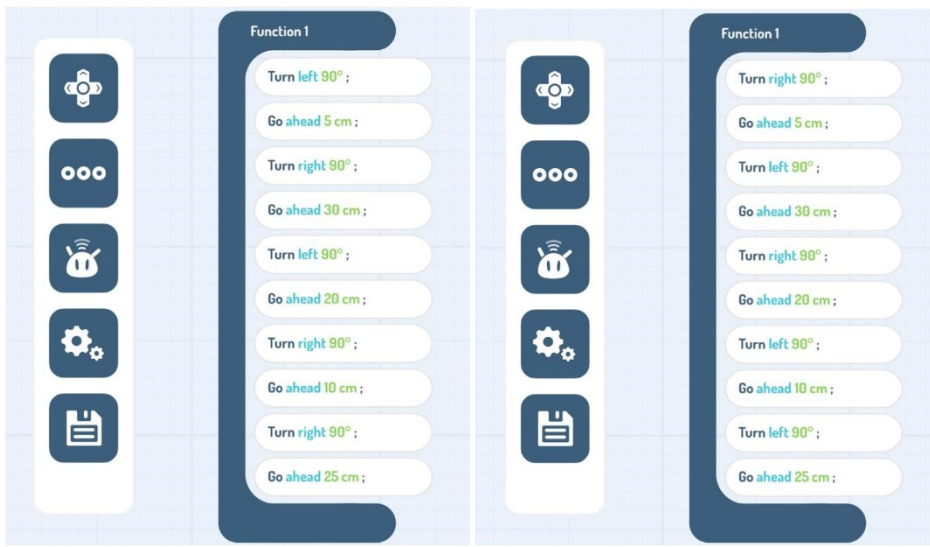

Figure 12: Letter "T" with two Photon Robots starting from the same point, via Photon Code.

When using the programmed files of the four levels, the difference is clearly visible only in the direction of rotation in the two codes.

Figure 13 shows a video of two robots drawing the result of the Photon Blocks level coding from Figure 11.

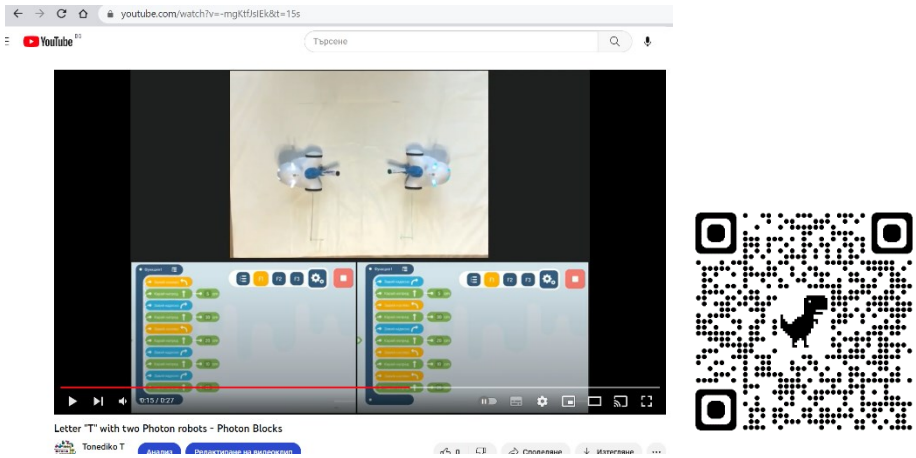

Figure 13: Video of two Photon Robots drawing letter 'T' using Photon Blocks (Expert Level).

For the simultaneous start of two or more robots, it is convenient to use the built-in buttons for starting via sound signal (melody, clapping hands), flashing or turning off lights (light sensors).

7 SOME OBSERVATIONS AND RECOMMENDATIONS

In each of the Photon Draw and Photon Badge levels of the mobile app, there is a limit on both step length (a round number, from 10 to 100 cm) and degree measurement (45^0 or 90^0). These levels are suitable for the initial introduction to working with the robot and the corresponding programming. Photon Blocks and Photon Code levels allow greater maneuverability with accuracy down to one (1 degree, 1 cm). The location and angle at which the marker meets the surface allow an accurate construction of the set trajectory without leaving extra lines when turning. On the other hand, as the robot moves, the position of the marker exerts, albeit a small, resistance with the surface below. The mentioned videos use glossy paper (poster, calendar type). This material was chosen because of its lower resistance. On many drawing surfaces, skidding occurs, and the marker goes under the paper when the robot tries to enter within the paper.

It is appropriate that the starting point is always within the outline. It is recommended to pre-estimate the launch location, direction and size of the space or play the trajectory beforehand without a marker to detect any possible departure from the outline.

When drawing with two or more Photon robots that we plan to launch from the same point, the size of the robots while moving and at rest must be considered. At large distances, the break in the lines is imperceptible, but at small distances, when we want to emphasize symmetry, a noticeable distance remains between the two robots. When working with the robot (even without a drawing tool) in outdoor conditions, it is good to look for smooth and dry surfaces and avoid wet, rough, and uneven places.

8 CONCLUSIONS

The proposed ideas for creating symmetrical figures using Photon Robot support the development of digital competence, critical thinking and creativity, provide propaedeutics of a symmetry concept and help for the formation of a concept of symmetry and the skill of using it. The created materials are suitable for use by teachers during STEAM classes in elementary school, as well as in Mathematics and Computer Modeling classes. Considering that Scratch and Python are studied in Computer Modeling and Information Technology in Bulgaria, students naturally continue their research and creativity with symmetrical figures when learning these programming languages.

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