

## METHODICAL SUPPORT FOR TEACHERS OF ROBOTICS IN THE CZECH EDUCATIONAL SYSTEM

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**Key words:** robotic kit, primary education, programming, primary school, methodical support.

**Abstract:** The aim of this work is to describe the possibilities and extent of the methodical support of teachers of robotics and robotic programming in the Czech primary education system and to find and describe the deficiencies as well as possible ways to improve the educational support of teachers in this field.

To map the current situation in the robotics education in the Czech Republic, we implemented a questionnaire survey by means of a structural online questionnaire which took place in November and December 2016 and was aimed to teachers of primary schools and appropriate school years of multi-year grammar schools. 3911 schools were asked to fill in the questionnaire. We received 360 responses. Afterwards we mapped the available methodical materials primarily focused on robotic kits LEGO in Czech and foreign market with the aim to describe the possibilities of teacher support in the robotics education.

The result of the survey of available materials in the market was the finding that there are a lot of Czech and foreign materials which use various approaches in the education. It is evident that teachers do not use foreign materials very much and that they rely mainly on the materials being included in the kit or on freely accessible materials provided on specialized webpages and blogs. As for the foreign materials, teachers miss mostly the translation into Czech language and its usage in the Czech education system.

The results of this study could help to map the extent of methodical support of teachers in the specific field of robotics education as well as teachers' requirements and needs which could help with the future improvement. Strategy of Digital Education until Year 2020 should also contribute. In the strategy, there is also included the methodical support of teachers to integrate new technologies in education.

### Introduction

The sharp increase in the number of new technical and teaching resources leads to the transformation of Czech education environment. New digital tools are being delivered into technically-oriented subjects to all types of schools, which makes it necessary to revise the content and methods used in teaching and to search for new and up-to-date methodological approaches. One of the areas that is currently undergoing this process in the elementary and high school curriculums is robotics. The word robot is defined in various ways. Robot (McKerrow 1986) is most commonly referred to as a machine that can be programmed to perform various activities and tasks. Robotics as a discipline then comprises its design, creation, management, programming and its use in solving various problems (McKerrow 1986). All of these activities can be applied and used also in education, which leads to the concept of educational robotics (Tocháček, Lapeš 2012), which uses robots to accomplish educational goals. It is characterized by the utilization of robots when acquiring knowledge and skills in the field of technical subjects. Students discover technical and mechanical principles by solving and completing robotic projects and activities.

However, the concept of educational robotics cannot be generalized. In lessons, we can use a number of robots whose primary function is to only respond to specific student's commands, either in the form of input data or a created program. In this article, we will focus on robotic kits, which are specific, because the robot has to be assembled either by the students themselves or it has to be prepared by the teacher before beginning the actual task. Therefore, working with these robots also involves designing them and

the actual construction. The kit then becomes a means of understanding the various design mechanisms and elements. The finished model can then be revived by a programmable control unit and with a range of input and output modules and sensors.

Since robotics and robot programming are not currently included in the curriculum for elementary and high schools, only enthusiasts who want to enrich their lessons beyond their obligatory and recommended content include robotics into teaching. Because of the lack of information on how to teach robotics and how to use the robotic kit in lessons, the teachers mostly gather information from available sources. However, methodical support for teachers is planned for the future as well as the use of new digital technologies in schools. This concept will be included in the Digital Education Strategy 2020, which plans to ensure open, non-discriminatory access to information and also a sufficient degree of methodical support for teachers. The planned changes include updating the curriculum focusing on technical education (MŠMT 2014). Then the question is, whether robotics will become part of the curriculum as its popularity grows. The Centre of Robotics in Pilsen, which is widely supported by the city aims to educate a new generation of students interested in technical education. This can be a sign of this growing trend.

Up to this time, changes have not yet been made, so teachers need to look for other ways to get quality information and materials focused on teaching robotics. There are a lot of methodical materials to be bought. They could be divided into several groups. To the first group belong products which are published directly by the producer of robotic kit. The manual which is provided together with kit can be also included here. The materials are either general or thematically oriented. To the next group belong materials published by other educational institutions or specialists. The last group contains various tips and exercises which are available on specialized educational websites and blogs.

If we look for example at the offer of methodical materials of one the biggest robotic kit producer, company LEGO, we will find a variety of materials. LEGO's methodical products are available at <http://www.lego.com>'s official website. Exclusive distributor of this company's products to the Czech Republic is Eduxe ltd. The LEGO products overview can also be found at the company's E-shop.

#### **2005544 EV3 projects**

The first introduced material is the projects primarily for the LEGO Mindstorms EV3. The material is divided into three areas: movement, intelligence and system. The students are guided primarily from the design of the robot to the actual creation. The aim of the material is to develop and improve students' creative thinking and constructive skills. It also helps to improve cooperation and effective communication among children and therefore helping them to solve the problem. The stated material span is 30 hours. The last part is intended for the teacher. This is a set of PDF documents containing recommended ways how to use methodical material, along with tips on solving tasks which are contained in a relatively large amount.

The product is mostly focused on the use of the robotic kit and its modules. This does not prevent it from being used in any technically oriented subjects.

#### **2005574 EV3 Space Challenge**

Compared to the previous material, this one is closely related to the imaginary environment of the Universe. The unpleasant thing in using this kit may be the fact that for the full utilization of this product the users need to buy an extension kit called Space Challenge. Without it, only part of the tasks can be solved. The material is again in English and it includes tasks related to robot movement, calculations and research projects. Its wider use in various technical subjects is very well possible. At the end, the material again contains tips and tricks for teachers that make it easy to use the product to its full potential in the classroom.

There are many foreign language materials available on the market. Their authors are either education experts, educational organizations, universities, but also enthusiasts from the public. These materials are either provided printed or published on websites for free or for certain charge.

#### **Classroom Activities for the Busy Teacher: EV3**

The product is designed for 10 weeks of robotics teaching. Its author is Dr. Damien Kee, an independent expert in technologies who focuses on robotics. The material is based on the LEGO Mindstorms EV3 and is available in English only, both in printed and in electronic form. It contains a total of 24 chapters, each of them is conceived as an individual task or a project with an extensive description, process demonstration with many pictures included and also adding the demonstration of the construction design of the robot. Both the teacher and the student are thus closely involved in solving the task. The material is not narrowly specified and can therefore be widely used in various areas.

#### **Robotics 1 with LEGO® EV3 a Robotics 2: EV3E More**

The publisher of both materials is the Ohio State University. The publications focus on teaching robotics and understanding its basic principle and meaning. Given tasks are solved by using the LEGO Mindstorms EV3. The publications are a collection of worksheets into which students fill out answers to various questions or they describe the process of solving the tasks. On the University's website the supporting videos can be found. The material is completely in English, as well as the videos, and although it is from two publications, it is not as extensive as the previous materials presented.

Plenty of users who work with robotic kits in the Czech Republic and abroad publish their work and projects the most frequently on websites. Only some users create compact methodical materials of higher range.

#### **TFs LEGO Mindstorms**

One such material dating back to 2014 and thus still focusing on the older version of LEGO Mindstorms NXT is by Tomáš Feltl and is available at <http://www.tfsoft.cz>. This is a set of materials

containing work cards, ideas, methodological notes, building guides, and test pads. The biggest advantage of the material is that the user can try out the material for free and if he decides to start using it, he then pays the fee to the author. This fee is very low compared to LEGO's commercial products. The advantage of the Czech material is that it is completely in Czech language and that it contains a lot of robotic tasks and tips for usage.

The aim of our research was to cover and describe the possibilities and the degree of methodical support of a robotics teacher and robotics in the Czech primary education and to find and describe the shortcomings and possible ways to improve the support for the teachers. In order to fulfill this goal, we have set several sub-goals:

- 1) To map and describe the level of using various types of methodical materials by teachers in the Czech Republic.
- 2) To find out and describe what experience teachers have with foreign paid methodical materials.
- 3) To map and describe what properties should and ideal methodical material have and what should it contain according to teachers.

For each sub-goal, we set research questions and then searched for answers:

Ad. 1: What methodical materials for the support of robotic education are used by teachers in the Czech Republic the most frequently and to what extent?

Ad. 2: Are according to teachers foreign paid methodical materials suitable for the education in Czech circumstances? What properties characterize the materials which they have worked with?

Ad. 3: What properties of methodical materials are the most important for teachers? What type of information would they appreciate the most in methodical materials?

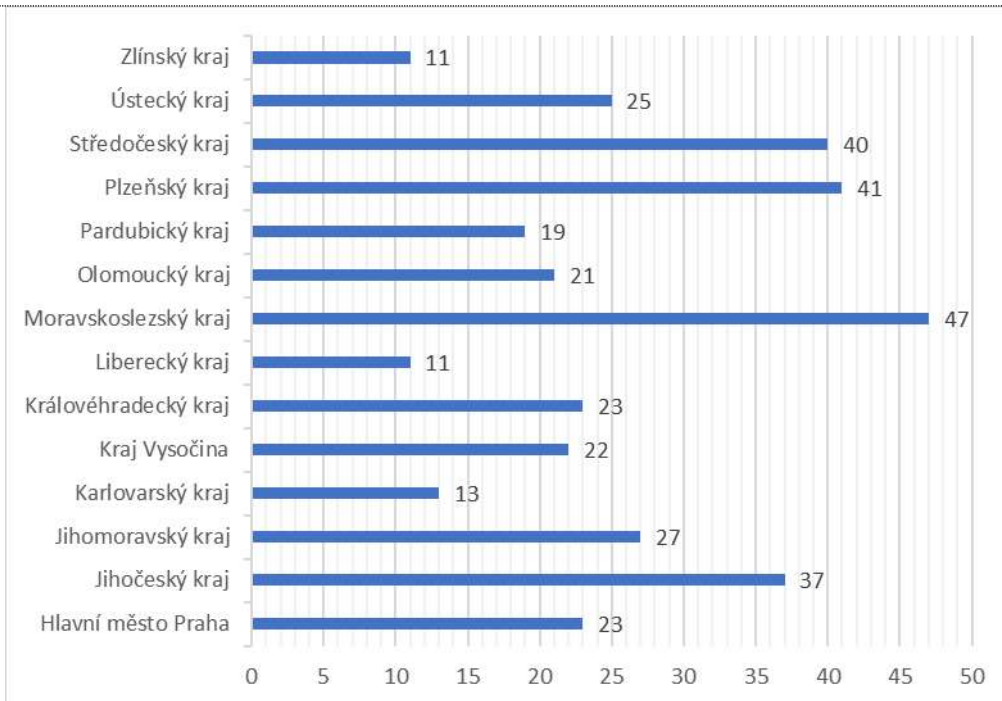
#### **Research methodology**

We carried out a questionnaire aimed at analyzing the current situation in teaching robotics in the Czech Republic. During the research, we contacted 3911 elementary schools and high schools throughout the Czech Republic. The target group of the research was teachers of the upper primary school and the corresponding years of high school. We focused mainly on teachers who actively use robotic kits in their lessons. Among the teachers, we focused on subjects where robotics is used, how to use the robotic kits, how to build and how to program the robots, methodical materials, exercises used in lessons, and the actual schedule of teaching robotics. We also focused on teachers who are not currently using the kits to find out what is the reason for not doing so, and we also asked about the shortcomings which are connected with the usage of robotic kits in lessons.

We received a total of 360 answers from all over the Czech Republic (see Chart 1). 311 of the respondents are not currently using the kit in their lessons from various reasons. The remaining 49

respondents use robotics in diverse subjects. Thus, the percentage of the questionnaire return was 9,2 %. The age variety of all respondents (140 men and 171 women) is shown in Table 1. In this paper, we will present only a part of the obtained results from the questionnaire. The data cover the questions that were focused on methodological support for teaching robotics.

CHART 1. DISTRIBUTION OF RESPONDENTS IN INDIVIDUAL REGIONS OF THE CZECH REPUBLIC



Source: Own

TABLE 1. AGE STRUCTURE OF THE QUESTIONNAIRE RESPONDENTS

Age	Number of the respondents
Up to 26 years	8
From 27 to 40 years	107
From 40 to 50 years	122
Older than 50 years	123
<i>Total</i>	<i>360</i>

#### Results of the questionnaire

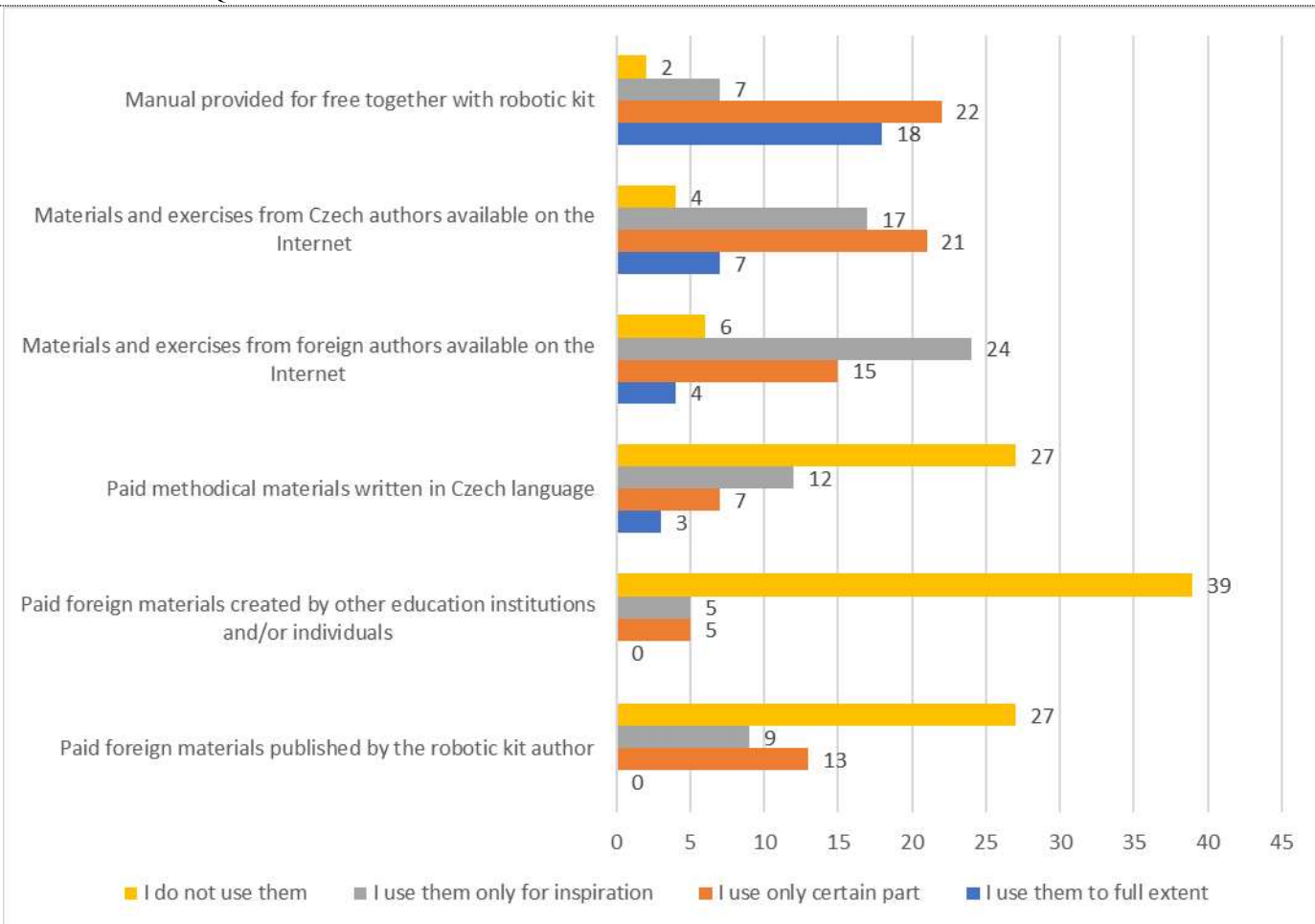
An inexperienced user who buys a LEGO robotic kit does not get any basic set of methodical material that would make it easier to use the product in lessons or at least make it easier for him to integrate the kit into his classes. The kit only includes a manual that is also available for download from the official LEGO websites in PDF format. It contains only the basic instructions on how to use the construction kit and the programming environment. At the end of the manual, in the troubleshooting section, an overview of the

available multimedia elements (images and sounds) contained in the memory of the control unit can be found. There is no other information about programming the unit nor about teaching. First, we were interested in what kind of methodical materials respondents use and to what extent. We divided the materials for the purposes of the questionnaire into the following six groups:

- manual supplied free of charge with a robotic kit (also available for download in PDF format on the manufacturer's official website),
- ideas and examples from Czech creators available on the Internet,
- ideas and examples from foreign creators available on the Internet,
- paid, Czech-written methodical materials,
- paid, foreign-language materials created by other educational institutions,
- paid, foreign-language materials from the manufacturer.

The results shown in Graph 2 show that respondents mostly use the free manual from the manufacturer which is a part of the purchased kit. The second largest source of ideas for the respondents is the examples and ideas that the members of the Czech community of robotic kit builders publish on their websites and blogs. On the other side, the ideas from the foreign creators on foreign language websites serve to the respondents rather for inspiration to create their own tasks and projects. The least used type of material are the foreign-language paid materials based on the responses from the questionnaire. It could be further investigated whether the price of the materials or the language barrier is the main factor affecting this behavior.

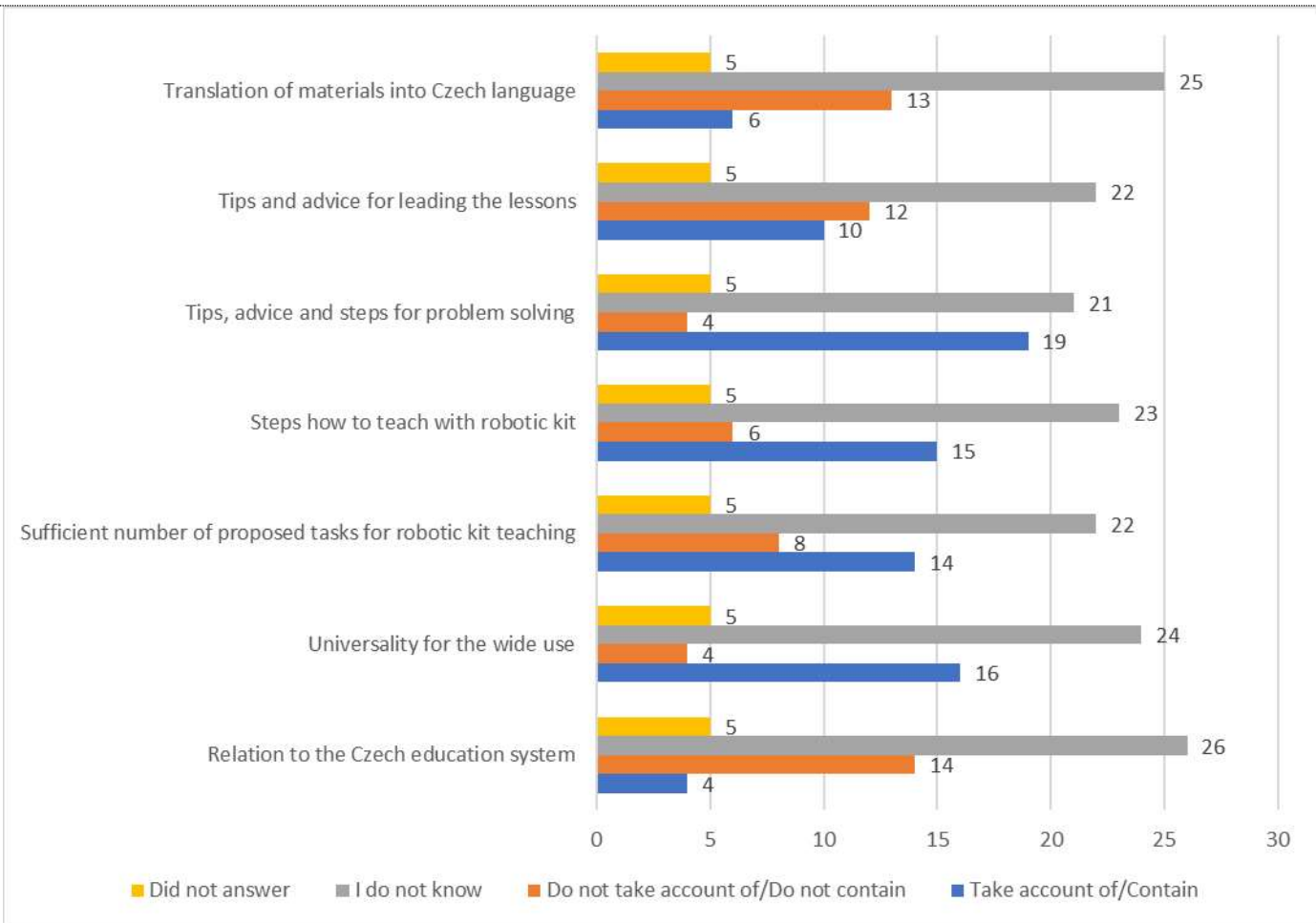
CHART 2. MEASURE OF THE USE OF VARIOUS TYPES OF METHODOLOGICAL MATERIALS FOR THE ROBOTICS EDUCATION SUPPORT ACCORDING TO THE QUESTIONNAIRE RESPONDENTS



Source: Own

As for the foreign paid materials, we also asked the respondents who own them about their experience with these materials. They were provided with selected features that could be crucial for the respondents when selecting the materials that would they use and asked them to evaluate whether or not these features are included in their owned materials. This question was not obligatory as we assumed that not everyone would own these types of materials so they would not be able to answer the question. The results are shown in Graph 3. From 49 responses, the question was not answered 5 times. Most respondents said that foreign paid materials contain tips, hints and procedures on how to solve problems that can be encountered with when working with a robotic kit, they are also universal and therefore can be used for in various lessons, they include robotics teaching guides and a sufficient number of tasks. On the contrary, most of the respondents answered that the biggest issue among these materials is the lack of Czech translation and that these materials are not connected and linked with the Czech education system.

CHART 3. RESPONDENTS' EXPERIENCE WITH FOREIGN PAID MATERIALS – LIST OF PROPERTIES, WHICH MATERIALS TAKE ACCOUNT OF/CONTAIN ACCORDING TO THE RESPONDENTS

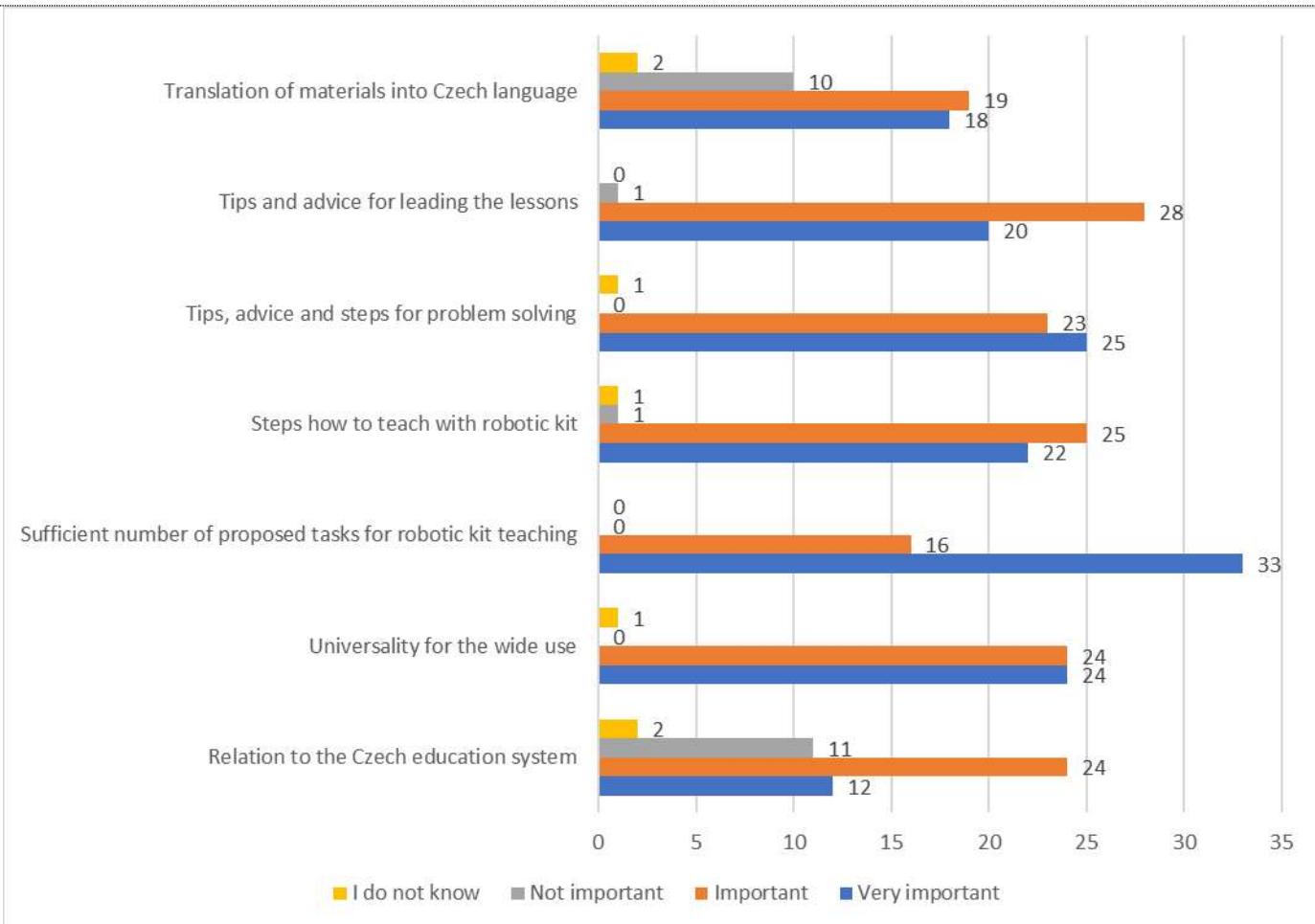


Source: Own

In response to these findings, we asked the respondents what features and criteria would the methodical material have to meet in order to be used in lessons. The results are presented in Graph 4. The most important feature in the methodical material for our respondents is the presence of a sufficient number of tasks and exercises suitable for class. The material should also contain tips, tricks, and procedures on how to solve problems that can be encountered with when working with the kit, it should also be universal for widespread use in lessons, and it would also include the process of teaching. On the other hand, most of the respondents stated that it is not important for them to have a material that is not connected to the Czech educational system and for 10 respondents out of 49 the translation into the Czech language is not important.



CHART 4. THE IMPORTANCE OF METHODOLOGICAL MATERIAL PROPERTIES FOR THE USE IN CZECH EDUCATION ACCORDING TO THE RESPONDENTS WHO USE THE ROBOTIC KIT IN THEIR LESSONS



Source: Own

#### Final summary

In the final section we will try to summarize the research findings. Robotic kits are a new teaching aid which is to be integrated into teaching due to its potential for teaching algorithm or programming. For a number of teachers, however, robotic kits are still relatively unknown and therefore they will probably try to find adequate methodical support when using them. In our research, we found out that when purchasing a basic kit, the teacher does not get the material that describes how to grasp the lessons and how to proceed with the kit. The teacher must obtain this information from other available sources.

In the Czech Republic, teachers are looking for examples of tasks and projects that they use in lessons mainly on the Internet. They either use these directly or modify them to and make their own. On the contrary, the least used materials are the paid ones which are widely spread over the market. It may be the subject of further investigation to identify the cause of this condition. It may be the high cost of the materials that the schools are unwilling to pay, or the language barrier that will not allow the teachers to use the costly material to their full potential. If teachers were to select a suitable methodical material, the

most important feature when deciding what to use is the sufficient number of tasks and exercises to be used in lessons. In addition, the presence of a troubleshooting section to solve problems that can be encountered with when working with the kit, tips for leading lessons, and the use of the material in different areas and subjects.

We introduced several methodical materials available on the market, which we divided into three groups and from each of them we selected one or more examples that we briefly described. From the description follows that the most of them fulfil the respondents' requirements on the material content. The description shows that most of these materials meet the material content requirements that was set by the respondents. Further research could focus on whether teachers have ever encountered with these materials and whether they are using them and to what extent. This would give us further information about the teacher's needs in the area of methodical support for robotics.

Throughout our research, we have tried to point out the needs that teachers have in the area of methodical support for robotics, pointing out the potential areas of support in the planned activities that are part of the Digital Education Strategy in 2020. At the same time, we also point out to some exemplary commercial products that are being created for this purpose abroad, and which can be an inspiration for Czech creators, because relatively few Czech-language materials are available at the moment. If the new digital teaching aids are to be included in the newly developed curriculum, initial support for teachers should be given a priority in their deployment.

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