THE CONSTRUCTION ACTIVITY AS A METHOD OF POLYTECHNIC AND SCIENCE LEARNING

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Abstract

The research orientation of the Department of technics, Faculty of Education, University of Hradec Kralove focuses on finding new ways for development of polytechnic and science education. The research is motivated by the fact that children's interest in technical and science subjects is decreasing in recent years in the Czech Republic. The research aims are to prove the applicability and effectiveness of multidisciplinary methods in teaching of technical and science subjects. The research observed the effect of the use of construction activity in teaching of physics in lower secondary school. The results of research confirmed that working and construction activity can develop technical and science thinking of children.
Keywords: *polytechnic education, science education, lower secondary school, construction activity, construction kit.*

Introduction

The issue of polytechnic education is discussed in the Czech Republic. Insufficient number of technically skilled experts is available in the Czech Republic. Young people are not interested in technical fields and technical areas. "The education system of the Czech Republic underestimates in the long-term polytechnic education" (Inovační strategie České republiky 2019–2030, 2019, p. 8). A number of documents, such as the Ministry of Industry and Trade of the Czech Republic "Industry 4.0 Initiative" (Národní iniciativa Průmysl 4.0, 2015, p. 10) or the documents of the Council for Research, "Innovation Strategy of the Czech Republic" (Inovační strategie České republiky 2019–2030, 2019, p. 8) draw attention to the need to improve polytechnic education. The Innovation Strategy of the Czech Republic 2019–2030 (Inovační strategie České republiky 2019–2030, 2019, p. 8) emphasises "There is a lack of a sophisticated STEM system (Science, Technology, Engineering and Mathematics), which is one of the key competencies within the new curriculum concept from nursery schools through primary education to secondary education. There is clear absence of a compulsory subject focused on technology in the lower secondary schools (development of technical thinking, practically applicable skills, fine motoric skills and technical creativity) with a link to new technologies" (Inovační strategie České republiky 2019–2030, 2019, p. 8).

Solution of the problems of current society requires interdisciplinary and multidisciplinary approaches. This approach is neglected in the Czech education system. The education is provided in separate subjects such us Mathematics, Physics, Chemistry, Biology etc.

The research aims of the academic workers of Department of technics, Faculty of Education, University of Hradec Kralove is to design activities for primary school second graders and the development of technical and scientific thinking, kids' practical skills and technical creativity. One of the possibilities is to use construction kits - construction models in lower secondary school education. The construction model approximates real phenomena, events and objects with greater accuracy than, for example, a graphical model. Modelling is a multidisciplinary activity in which knowledge from mathematics, physics and technology is involved.

The research aims were:

1. Design a construction model that the kids at lower secondary school could construct and demonstrate the physical phenomenon;
2. Monitor construction activity and find out whether the construction activity helps to develop physics thinking of the lower secondary school learners.

Research Methodology

Using a structural model, the dependence of centripetal force F_d of a solid in circular motion on other mechanical quantities - mass *m*, radius of circular motion *r*, angular velocity *ω* was demonstrated. For the purpose of the experiment the Fischertechnik kit (https://www.fischertechnik.de/en) was used. Learners constructed a model of carousel according to the instructions in the kit. The carousel was driven by an adjustable speed electric motor by means of gears. Totally 53 (28 girls and 25 boys) kids from the eighth grade of lower secondary schools participated in the experiment. The motivation was as follows: "We all know the chain carousel. Some of you went on it yourself. What happens with the seats on the carousel when the carousel starts to rotate?"

During construction the kids were observing the model. The design skills and ability to navigate the instructions and skills of boys and girls were followed.

After building the model, the kids changed the length of the carousel (radius of circular motion *r*), changed the mass of the weights at the end of the arm (*m*) and the angular velocity of the carousel (*ω*).

The uniform circular motion is the simplest circular motion. Uniform circular motion is characterized by constant angular velocity *ω*. The angular velocity can be expressed as:

$\omega = 2\pi/T$, where *T* is period.

The circular motion is caused by centripetal force. Centripetal force F_d is proportional to centripetal acceleration a_d ($F_d \sim a_d$).

The centripetal acceleration is expressed as:

$a_d = rw^2$, where *r* is the radius of the circular motion.

The centripetal acceleration is therefore proportional to the radius *r* and the square of the angular velocity *ω*.

Presented construction model enabled:

- change the size of the angular velocity ω by changing the rotational speed of the motor that drives the carousel;
- change the radius of the circular motion r by changing the length of the hinge;
- change the weight m of the body by changing the weights.

Although physics at lower secondary schools does not introduce quantities and relations describing circular motion, children often encounter the movement of the circle in the technique - turning the wheel on the shaft, circular motion of the rotors in the electric motors, moving the grinding wheel on the electric grinder, moving the circular saw, etc.

With regard to the possibility of changes of above-mentioned quantities, the construction model allowed monitoring the dependence of the centripetal force F_d on given quantities qualitatively as well as quantitatively. As already mentioned, the movement of a uniform circle was introduced in the lower secondary school only informatively, without quantities and formulas, the dependence of centripetal force on other quantities can be studied only qualitatively.

During the experiment, the kids wrote in the table the values of the radius of rotation r, the angular velocity ω (given by the speed of the motor), the weight of the mass m on the strings, the value of the hinge length l and the angle of deflection at the movement α. The deflection angle was determined by a video of a moving carousel. The video was stopped at the point where the hinge deflection was the greatest. The angle was measured by a protractor directly on the monitor. The children determined on which quantities the angle of deflection of the carousel hinge depended or did not depend by processing the values of the quantities in the table. The angle α of deflection of the hinge was proportional to centripetal force F_d. Regarding the level of knowledge of lower secondary school learners, the dependency could be determined only qualitatively (Hubálovská, 2018).

Based on the table with measured values, the kids were asked a few questions to find out if they had understood the centripetal force – see Table 1 – Results of a questionnaire

Research Results

The example of the construction model of the carousel created by kids during construction activity is shown in the Figure 1.

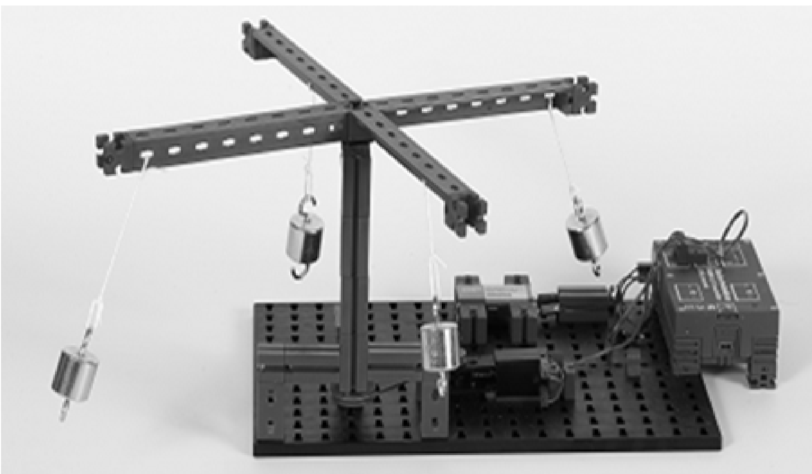

Figure 1. The example of the construction model of the carousel (Hubálovská, 2019).

The differences between girls and boys when working with the construction kit during the construction activity were monitored. The ability of boys and girls to navigate the manual, the ability to work systematically, and to observe the skill of boys and girls were followed. Significant difference between the boys and girls in the monitored areas was not found. Some girls, after studying the manual, first found all the parts to build the model and only then began construction. Almost all kids were able to construct a construction model. Sometimes some of them needed some advice. The biggest problem was with the involvement of the carousel drive.

Results of a questionnaire among children who carried out construction activities and experiments are presented in the Table 1.

Table 1. Results of a questionnaire.

	YES [%]	NO [%]
Does the hinge angle depend on the hinge length?	78	22
Does the hinge angle depend on the mass of the weights?	15	85
Was the largest angle of hinge deflection at the smallest circular speed?	7	93
Do you consider working with the construction kit useful?	89	11
Were you interested in the lesson with the construction kit?	68	32

Conclusions and Implications

The following findings emerged from the pilot educational experiment. Working activities with the construction kit is attracted and entertained for boys as well as girls. There are no significant differences between the girls and boys when working with the construction kit, both of the monitored groups are able to orientate themselves in the instructions and are able to build a model of the carousel. More boys than girls consider the kit to be useful.

Furthermore, the results of the questionnaire discover that experimenting with the created model of the carousel enables the learners to qualitatively understand on what quantities the centripetal force of the circular motion depends.

In this experiment, the kids used both manual dexterity, computer and video technology and naturally acquired physical knowledge. The present time requires a multidisciplinary approach in education. The combination of science and technology curriculum at lower secondary schools seems to be the possible way to develop learners' interest in technical and scientific disciplines.

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