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Interdisciplinary approach to technical education

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Abstract

The authors introduce a realistic concept of innovation in teaching technical subjects at primary schools with regard to sustainable development of industrial society. The concept is based on the published results of an institutional survey carried within six organizations which are concerned with teaching the educational area of Man and the World of Work and preparing teachers for the area. The survey was conducted as a part of the project Erasmus +Activity 1, action strategic partnerships for school education no. 2015-1-SK01-KA201-008942 and as a training of the institute of informal way of teaching at Techmania Technology Center. The innovation is seen especially in interdisciplinary connections between subjects, implementation of new modern technologies in teaching and support of informal education.

Key words: informal education, technical education, new technology, 3D print, creativity, STEM.

Introduction

In the context of the coming fourth industrial revolution known as Industry 4.0, there is a high probability that some of our traditional fields and job positions will vanish. In 2016, the company ABB Elektro-Praga integrated a cooperative robot named YuMI into their assembly-line production. The robot solves part of the tasks of his human co-worker who may be soon substituted by it [tyden.cz]. Technical education at primary schools must be innovated to be able to prepare graduates for the modern world. It is more necessary to focus on the development of creative thinking than on gaining other knowledge or skills, which may be barely applicable [Deloite 2015]. For the teachers of technical subjects are basic questions to solve following: How to prepare pupils for the modern world? How to change the negative perception of technical subjects? How to change the embedded prejudices about the technical education? How to motivate pupils to study technical subjects and natural sciences? One possibility is to support the areas of:

– interdisciplinary connections between subjects,
– new modern technologies in education,
– informal education and free time activities of pupils.

Interdisciplinary connections between subjects

The educating area Man and the world of work is in the Czech and the Slovak Republic from its big part solved by subjects such as Technical education or Technology. The subject is taught for the most by qualified teachers, but also by professionally non-qualified teachers. The lessons are carried in a traditional way at most of the schools (that means mainly instrumental conception of teaching). The workshops and specialized classrooms are equipped with basic hand-operated tools, in the best case with electrical or construction boxes. According to a research, new tools are acquired primarily on commercial principles, regardless of children and their ergonomic requirements. The research was conducted within the questionnaire institutional survey of the Czech-Slovak-German project called World of Work [Mach, Simbartl, Krotký 2015]. Furthermore, it can be concluded that passivity of teachers predominates in the area of the technical education, in terms of their unwillingness to use methods supporting the creativity development [ceskaskola.cz; Naiman 2012].

In general, the biggest issue of the field can be seen in a low amount of lessons dedicated to this, which is set up like this by educational programmes and also by underestimation of the area Man and the World of Work by individual primary schools. A teacher of technical education says directly: “My conclusion is, the biggest problem of gaining and developing technical skills lies in the low amount of lessons of technical education at primary schools. Speaking from my own experience of teaching technical education at a primary school, I must say that there is much knowledge and skills which are supposed to be passed on by teachers, but there is too little time to do so” [Draxal 2016].

On the other hand, the area of technology is relatively large and opens possibilities for integrating into other disciplines or subjects. Therefore the low time allocation may be solved by interdisciplinary approach, connection between subjects, suitable selection of projects and teaching material rather than by increasing the scheduled amount of lessons. Our society can detect various “threats” brought about by the development of civilization, where children do little sports, use more computers, financial literacy is low and so on. Again, there may not be the only solution to increase the amount of lessons or even to implement new subjects. The day only has 24 hours and schools should not cut down the time which is necessary for the important family interaction.

As a reaction to the issue with interdisciplinarity at schools, there are currently being prepared teaching materials for the area of Man and the World of Work, The materials are created as a product of the above mentioned Czech-

Slovak-German project World of Work granted by the publishing house Raabe. Their primary task is to integrate interdisciplinary teaching materials of the Man and the World of Work area into realistic and practical application [world-of-work.eu]. The analysis of the area Man and the World of Work in Czech, Slovak and German school educational plans shows the share of Mathematics up to 20%, Physics 16% or 10% share of Chemistry, Computing or Communication Technology etc. The educational plans or programmes were compared partially in primary and secondary schools and in the case of German in its equivalent called Realschule [Mach, Simbartl, Krotký 2015].

New modern technologies in education

Another issue of teaching technical subjects at primary schools in the Czech and the Slovak republic (the above mentioned research confirmed that Germany is not affected) is low use of modern technologies, which are nowadays much more corresponding to the real concept of practical research and development. By implementing these modern technologies into the lessons, pupils of primary schools get much better understanding of the process starting with an idea, going through a product design and finishing with its physical implementation and practical verification. We refer especially to the implementation of computer-control system of machine tools or prototype machines, which are adapted for their use in primary schools. The implementation has already brought its positive results in the form of executed educational projects at 31st Primary School in Pilsen or at Primary School Pilsen Černice. The focus in this case was on the implementation of 3D printing in teaching [Fuchsová 2015].

There was a project of implementing 3D printers into teaching at primary schools to support STEM (Science, Technology, Engineering and Mathematics). The project was executed in Britain in 2012 and its results showed the following findings and recommendations [Department for Education 2013]:

1) The modern technologies bring no extra burden for the pupils like new teaching materials. (ed. Pupils work with prototyping and auto-controlled machine tools like with a usual computer printer).
2) The right use of technologies supports team work between pupils.
3) Computer-controlled machines, 4D printers etc. have the positive effect on interdisciplinary connection and support connections between subjects and their links to their practice.

We can add from our own experience that the interdisciplinary approach is not supported only by the subjects belonging to the STEM area or the mentioned design subjects, but also for example the subjects like Music (designing and producing the own musical instrument) or Environmental Education or Geography (a part of the equipment for measuring the directions or speed of wind etc.) [Krotký 2014].

Informal education and free time activities

The implementation of computer-controlled machines into lessons requests no little financial initial investment. Schools are not able, neither are able the grants, to equip all primary schools with adequate facilities. Some technologies also cause technical problems or need special approach [Krotký, Honzíková, Moc 2016]. The current trends of the informal education area are directed to sharing work space and ideas. One of the solutions is to create a shared space in the form of "workshop" with proper equipment like an alternative to the innovation of technical education at primary schools. A common space like this may serve to schools especially for their educational area Man and the World of Work. All the schools would get the possibility to use the shared space for their lessons with no investing in their own facilities. In general, common or shared spaces are very popular "trends" in this area and also in the commercial sector (e.g. prototyping stands in Japan etc.) Shared spaces for creative activities like workshops form a part of most of Science Centers [Krotký 2012] or creative platforms [Plzeňské DEPO 2015].

A problem of the use of this kind of shared space is its location, respectively the transport of pupils into the education institute – shared space. Another complication is the fact that teaching materials are at primary schools divided into individual subjects and each subject (each pupil) is evaluated individually and separately and there is just a little interdisciplinary interference or cooperation between teachers in the primary school. The time allocation for Technical Education (based on the educational programme 1 lesson per week or 2 lessons in two weeks) makes it impossible to use such areas. That means the prepared educational programmes for this kind of spaces should be in a form of projects with large interdisciplinary overlap. The interdisciplinary overlapping is a relevant reason for the school management to accept the offer of this kind of prepared lesson. It is not necessary to strictly think about substitution for "the missed" lessons of other subjects as they are partially involved in the project carried on in the shared space.

The projects should be prepared as the-whole-day projects or more precisely they should cover the usual amount of the lessons per day (5 lessons) at higher grades of primary schools. The projects should also be executed by all the class (pupils are usually split into two groups for the technical education lessons in the Czech Republic).

The very important aspect is the different aspect or concept of the technical education. The prepared programmes should involve also teachers not only his pupils. The methodology of the prepared projects should count with actions of edutainers (Science Center employees) as well as with actions of teacher or more teachers. The implementation of the "custom-made" project without involving

teachers into the performed activities will not bring the wanted effect of innovation into the process of education.

The project should also work with talents and disadvantaged pupils (particularly with socially and in lesser extend with health handicapped pupils). The realization project team formed by edutainers and teachers allows to work with the mentioned specific groups more effectively than during standard lessons performed in their school areas (more numerous staffing to support individual work etc.). While preparing the activities, it is necessary to check the current trends in the area of modern teaching, to concentrate on team working of pupils and problem solving tasks in the process type "problem-idea-solution--implementation-verification".

The different approach to pupils between formal and informal education is also visible while watching them during practical work – watching their physical products. Luboš Draxal [2016] carried on a research in 2015 where he measured the exactness of product processing. He compared products of two groups of pupils from the 9th grade in primary schools. The first group (5 pupils) attended a free time activity – model making. The second group (5 pupils) did not attend that free time activity. All pupils made their products according to the same documentation. Several selected parts of each product were analysed to show deviations from ideal measurements given by the drawings. The measurements of each group were averaged and when comparing the two groups the result was evident. The pupils attending the model making activity are able to work much more precisely. The researches also point out that students which are led this way are also more creative [Honzíková 2015; Scott, Leritz, Mumford 2004].

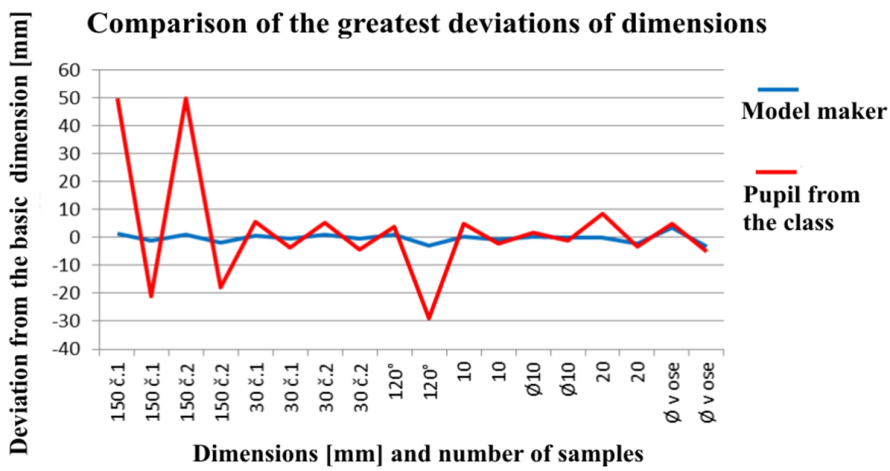

Figure 1. Comparison of the largest deviations from the individual measurements [Draxal 2016]

Conclusion

Dr. Heidi Hayes Jacobs, the famous populariser and leader in the area of education, said: "Teachers need to integrate technology seamlessly into the curriculum instead of viewing it as an add-on, an afterthought, or an event" [Gupta 2015]. Technologies are available here so we should accept them as the part of our environment and work with them. Traditional manual activities will never disappear from the technical education. The professionality, that implies fundamental technical and technological knowledge, and skills are one of three elements of creativity. There is no creative process or creative product without professionality, thinking and motivation. Today companies have already troubles with finding qualified employees, because schools are not flexible and do not react to the market demand quickly enough. It should be noted that schools are not alone in this process of changes. The well-timed innovation of the technical education at all levels starting with primary schools could save us from serious future problems.

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