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Polytechnic Education and Its Possible Use at Non-Technical Secondary School

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Abstract

Technological and polytechnic education in the field of computer aided design (drafting) in 2D and 3D at non-technical secondary schools represents a new and relatively unexplored area. It is therefore necessary to deal with questions concerning the necessity of such training, and its potential influence and/or impact on students` further development. The answers were sought via an investigative research, the outcomes of which are presented by the submitted paper.

Keywords: polytechnic education, computer aided design, secondary school

Introduction

Technology is an internal part of our life, it is all around us. Nowadays, a person without necessary basic technical knowledge and skills would not be able to perform their social function properly, and, consequently, would not live a full life (Zubata, Plishke, Kropáč, 2011). Therefore, elementary technical knowledge and skills should be mediated to the general public, not just to the students of technical secondary schools, by the educational system. In terms of advanced educational systems, elementary technology training represents an integral part of the general curriculum taught at elementary and secondary schools. It is transferred to pupils and students via a school subject, different not only in name (practical training, practical activities, technical training, technical practice, technique, practice, technology etc.), but also in scope and content.

Over the recent years, the term "subjects of technical character" has been used in professional literature (Idrus, Mond, Abdullah, 2010). By means of this subject, pupils acquire not only theoretical knowledge, but also elementary work skills. The emphasis is usually placed on technical creativity, depending on students` fields of interest, and the training is carried out mostly within the framework of ooptional subjects. Despite the rapid development of computer technology in all developed countries` education systems, elementary manual activities of technical nature such as woodworking, metalworking, working with tools and

simple machines, electrical work etc.), remain a part of the curriculum. A combination of the two aforementioned is more and more common. The aim of the technology or polytechnic education is to develop the skills of the learners in manipulating working tools and machines, adopting work culture, and to acquaint them with the scientific principles of contemporary production, safety rules, etc. (Mojžíšek, 1981).

At present, these objectives are further developed by the supportive role of ICT, as information technology today covers or supports a significant part of industrial production. The aforementioned goals shall be well achieved in technically oriented subjects, which are based on the combination of the two stated goal segments, and the content and process side of which are close to a number of professions, not only these called technical today (Manullang, Kons, 2012).

Even though teaching at primary and secondary schools is primarily focused on general training, preparation for the use of computer technology and technology in general grows in importance as a component of education (Granath, 2003, p. 129). These efforts have not only been declared, but also embedded in a wide range of curricular and policy documents, and in many cases they have also been financially supported by various grants. The above stated facts indicate that education systems clearly aim to promote polytechnic education. Unfortunately, at least in terms of the Czech education system, it is not always the case. During 2006 and 2007, the Faculty of Informatics and Statistics of the University of Economics in Prague in cooperation with the company CACIO-CSSI-SPIS conducted a complex research to analyze students' of grammar schools readiness for academic studies at technical universities.

The study involved 53 faculties all over the country. The conclusions of the study were alarming, as they revealed a lack of experts in technical fields, as well as the absence of expertise among teaching staff, and an inadequate level of education at grammar schools in technical disciplines, based on the rudiments of drawing documentation, as one of the most important prerequisites for successful studies at technical universities. Moreover, according to the conducted study, only a small percentage of grammar schools` students proceed with their studies at technical universities. They prefer fields of study more related to humanities, though their dispositions to study at technical universities might be very good (mathematics, chemistry, physics, etc.). Following the results of the aforementioned study, the author of this paper conducted a similar research in 2013 (Klement, Kubrický, 2013), a part of which was carried out at six 8 and 6 year grammar schools. Among others, a question concerning the reason why so few students of these grammar schools apply for technically oriented universities was asked. The most frequent answer received from the students was a claim that they were unable to assess the benefits of technology studies, because their high school`s curriculum did not involve any subject which would at least partially expound technology and technical issues to them.

Based on these results, we started to prepare in 2015 and implemented in 2016 an experiment, based on the inclusion to the set of ICT subjects taught at 8 and 6 year grammar schools of a thematic unit "Application of mathematics and chemistry in computer-aided technical drawing", which integrated both the technical area of technical drawing and drawing documentation, and the area of specialized CAD software tools used in these activities (Klement, 2001). The experiment thus consisted in the introduction of a new thematic unit to the established curriculum, and in the evaluation of the impact of thus conceived education on the students.

Setting conditions for the implementation of the experiment

A necessary precondition for the implementation of the experiment was to create its own concept and content of education, focused on the use of CAD systems, for the purpose of the enrichment of teaching of mathematics and chemistry at 8 or 6 year grammar schools with the practical application based on the use of computer-aided technical drawing. A new training module "*Application of mathematics and chemistry in technical drawing*" was developed, the aim of which was to elaborate interdisciplinary links, interconnect theory and practice via real life examples and practical tasks (Grecmanova, 2000), and last but not least contribute to a substantial development of the competencies of the students in the field of computer-aided technical drawing (Klement, 2003), as one of the important factors facilitating their potential further studies at technically oriented universities.

The aforementioned module enabled a substantial development of interdisciplinary links between math and chemistry, as a consequence of practical use of the students' knowledge of the two subjects during the visualization of objects in 2D and 3D space, elaborated to technical drawing, as one of the basic means of graphic communication. The practical application related mainly to the following fields:

- Plane geometry (parallels, skew lines, etc.).
- Spatial geometry (spatial solids and surfaces, conics, etc.).
- Boolean algebra (operators and, or, or and their graphic visualization).
- Descriptive geometry (traces of planes, intersections between planes, solid edges).
- Visualization of the atomic structure of matter (visualization of the core structure and valence spheres).
- Modelling of element molecules (visualization of molecular structures).
- Modelling of compound molecules (visualization of the molecular bonds).

To be able to implement the aforementioned experiment, a joint project of the Department of Technical Education and Information Technology of the Faculty of Education of Palacký University Olomouc and 6 partner 8 and 6 year

grammar schools from Olomouc region called *CAD – computer-aided technical drawing at schools*, was carried out. The project was aimed at an extension of the subject matter of math and chemistry lessons by practical application of computer-aided technical drawing in the second or third year of a four-year program of study 79-41-K/41, or equivalent years in a six-year program of study 79-41-K/61, and/or eight-year program of study 79-41-K/81 of grammar schools. It was based on an active approach of teachers (methodologists) to the development and implementation of a new learning content and application of subjects, creation of a new learning program, including its verification in live instruction. Moreover, the individual key activities comprised all the basic processes associated with the change in the content of particular subjects` curricula, focused on practical application and use of computer-aided technical drawing in lessons of mathematics and chemistry.

Overall, the thematic unit "Application of mathematics and chemistry in computer-aided technical drawing" was divided into 10 separate training modules, following each other. The time allocation of individual training modules was two lessons. The training modules were introduced into the curriculum and taught in the year 2016 at six 8 or 6 year grammar schools, they were attended by a total of 301 students, and 12 teachers were involved. Upon completion of this conceived training, it was possible to evaluate the impact and the results of the experimental subject matter from the perspective of students and teachers. The following text describes the procedure and the method of the evaluation of the results and of the impact from the students` point of view.

Description of the conditions, the sample, and the method of evaluating the results of the experiment

The actual teaching of the thematic unit "Application of mathematics and chemistry in computer-aided computer drawing" was followed by a research investigation conducted at all involved schools. The investigation was aimed at a determination of opinions and attitudes of the stated schools` students on the instruction realized, and on its real impact on the educational process at these schools. A total of 301 students of the students who had experienced the lessons enriched by the experimental learning content participated in the research.

As the principal tool for obtaining the data necessary for the implementation of the research investigation, a questionnaire was used. Within the framework of research methods classification structure, questionnaire belongs to indirect methods of investigation. According to Ničkovič, a questionnaire can be characterized as "a specific measuring device by means of which opinions of individuals on particular phenomena are explored" (Horak, Chráska, 1983, p. 94–96). From the point of view of the person or respondent questioned, these phenomena can refer either to external phenomena, or to internal processes. That is why

a structured evaluation questionnaire meeting the requirements of the research investigation was created (GAVORA, 2000). It stemmed from personal experience and enabled us to find about the students` views on and attitudes to the teaching of the thematic unit "Application of mathematics and chemistry in computer aided technical drawing".

Students were asked to fill out the questionnaire anonymously and thus present their views on and attitudes to particular questionnaire questions. They were asked to express their opinion by ticking the YES or NO option in compliance with their personal preference. For the description of the research sample, see Table number 1 below.

Table 1. Structure of the research sample

Gender	Number of respondents	Number of respondents in %
Boys	122	40.5%
Girls	179	59.5%
Total	**301**	**100%**

As the main method for the evaluation of the acquired research data we used the chi-square test (Chráska, 1988), which enabled a determination of the dependency of the research outcomes on a significant sign of a group of respondents, that is to say on gender. In order to determine the potency of the particular groups of respondents, whose answers were the same, basic descriptive statistics and their visualization via tables were used. For the purpose of calculating, the statistical system Statistica 11 (Klímek, Stříž, Kasal, 2009) was applied. The following text presents some of the partial results of the realized survey, the aim of which was to find about the opinions and attitudes of students of 6 and 8 year grammar schools on and to the teaching of the topic "Application of mathematics and chemistry in computer- aided technical drawing" and its real impact on the educational process at these schools.

Partial outcomes of the conducted research investigation

In further text, we are presenting the outcomes of the conducted research, organized in six separate areas. Each analysis included the calculation of the pivot table, the calculation of the percentage, and the estimation of the particular outcomes` dependency on the sex of respondents. For the purpose of simplicity and clarity, all three analyzes are comprised in one table.

The first area examined was the level of interest in AutoCAD applications shown by the students. By answering the relevant question, students expressed their opinion on whether teaching supported by AutoCAD 2013 application was interesting for them and whether producing 2D and 3D drawing documentation was to any benefit. A summary of the outcomes based on their responses is illustrated by the Table 3 below.

Table 2. Interest in computer-aided computer drawing teaching

Contingency table for: n = 301 Pearson`s chi square: p = 0,048454 **Was computer aided technical drawing interesting for you?**			
Gender of respondents	**Boys**	**Girls**	**Row totals**
No, it was not – frequency	25	55	80 (27%)
Yes, it was – frequency	97	124	221 (73%)
All groups – frequency	122	179	301 (100%)

According to the findings presented in Table 2, it is possible to state that teaching of AutoCAD 2013 applications caught the interest of almost three quarters of students (73%) of 6 and 8 year grammar schools. The initial presumption that the inclusion of this experimental educational content would be regarded as interesting and beneficial by the students was hereby confirmed.

Furthermore, it is possible to conclude that there is a statistically significant difference (p = 0.048454) between the frequency of responses given by girls and boys. The boys` interest in AutoCAD applications 2013 proved significantly stronger than that of the girls, which, given the fact that technically oriented activities have always been more popular with boys, is not a surprising result and does not defy the average.

Next area of research was focused on whether the students consider teaching of AutoCAD 2013 applications as difficult, or more difficult than other activities aimed at the use of ICT. By answering the relevant questions, students expressed their opinion on whether the learning content of this thematic unit was more difficult for them to understand than the learning content of the other subjects focused on ICT, mathematics and/or chemistry. A summary of the outcomes based on their responses is illustrated by the Table 3 below.

Table 3. The level of difficulty of teaching AutoCAD 2013 applications

Contingency table for: n = 301 Pearson`s chi square: p = 0,070579 **Did you find the lessons of computer-aided drawing difficult?**			
Gender of respondents	**Boys**	**Girls**	**Row totals**
No, I did not – frequency	96	124	220 (73%)
Yes, I did – frequency	26	55	81 (27%)
All groups – frequency	122	179	301 (100%)

Based on the findings presented in Table 3, it is more than obvious that the vast majority of students of 6 and 8 year grammar schools do not consider teaching of AutoCAD 2013 applications as difficult, or more difficult than other thematic units focused on ICT, mathematics, and/or chemistry. This result indicates and confirms, among other things, that the general popularity of the subjects focused on sciences is low and that students therefore welcome every opportunity to enrich the lessons.

Furthermore, it is possible to conclude that there is a statistically significant difference (p = 0.070579) between the frequency of responses given by girls and boys. This time it was the girls who, in comparison to boys, showed a statistically significant enthusiasm for the inclusion of the experimental learning content into teaching, because they regarded it as less difficult.

The third area investigated was focused on the question whether the students would welcome the opportunity to further educate themselves in the field of 2D and 3D drawing documentation using AutoCAD system in 2013, both controlled and independent. By answering the relevant questions, students expressed their opinion on whether they found these issues as engaging and evolving as to be dealt with further on in the future. A summary of the outcomes based on their responses is illustrated by the Table 4 below.

Table 4. Level of interest in further education in creating drawing documentation supported by the use of AutoCAD system

Contingency table for: n = 301 Pearson`s chi square: p = 0,002095 **Would you like to educate yourself further in the field of computer-aided drawing?**			
Gender of respondents	**Boys**	**Girls**	**Row totals**
No, I would not – frequency	70	133	203 (67%)
Yes, I would – frequency	52	46	98 (33%)
All groups – frequency	122	179	301 (100%)

According to the findings presented in Table 4, it is more than obvious that only less than one third of the students, more specifically 33%, would like to be further educated in the field of the creation of 2D and 3D drawings using AutoCAD 2013 system. Although this result is inconsistent with the first stated analysis relating to the interest in this teaching, it can be explained by the fact that the general level of intentionality in education is currently lower and further education is thus refused by the students.

Furthermore, it is possible to conclude that there is a statistically significant difference (p = 0.002095) between the frequency of responses given by girls and boys, as the girls rejected further education in the field of AutoCAD 2013 applications more often than boys. Even this result is by no means unusual, and can be attributed to the generally lower popularity of technically and biologically oriented subjects among girls.

Yet another area of research was focused on the question whether the students actually apply the knowledge and skills gained in AutoCAD lessons in further education. The assumption was that especially those students who would consider further education in technical fields might show a preference for this need. On the basis of this analysis we can suppose those students might be interested in further technical education. A summary of the outcomes based on their responses is illustrated by the Table 5 below.

Table 5. The use of the outputs of AutoCAD 2013 applications teaching in further education

Contingency table for: n = 301 Pearson`s chi square:p = 0,002431 **Do you think you will use computer-aided drawing in further education?**			
Gender of respondents	**Boys**	**Girls**	**Row totals**
No, I will not – frequency	68	130	198 (66%)
Yes, I will – frequency	54	49	103 (34%)
All groups – frequency	122	179	301 (100%)

Based on the findings presented in Table 5, it is obvious that the vast majority of students do understand the necessity of teaching AutoCAD 2013 applications for creating 2D and 3D drawing documentation, because 34% of them claimed that the subject matter would be necessary for their further education. It is therefore possible to deduce that the level of interest in technical fields, where the use of CAD systems is more than common, is relatively high.

Furthermore, it is possible to conclude that there is a statistically significant difference ($p = 0.002431$) between the frequency of responses given by girls and boys, as the boys perceived the use of CAD systems for further education as more important than girls, which again is a result that could have been be expected.

The fifth area of research was focused on the question whether the students actually apply the knowledge and skills gained in lessons focused on the creation of 2D and 3D drawing documentation in everyday life. Once again, the question is related, though indirectly, to the prospective professional orientation of the students and to their interest in the further career in technical fields. A summary of the outcomes based on their responses is illustrated by the Table 7 below.

Conclusions

The above described experimental educational content focused on an enrichment of the teaching of mathematics and chemistry with a practical application of the computer-aided technical drawing, represents an innovative way of using modern information and communication technologies in education. As it is obvious from the above described research, the experiment and its impacts positively influenced the formation of key educational activities for students in upper secondary education, and at the same time increased the qualifications of teachers of 6 and 8 year grammar schools, where the experimental education was implemented.

The benefits and added value for the teachers was gaining new skills, expansion of professional skills, a significant improvement in the conditions for the preparation and implementation of the teaching of technically oriented graphics systems and, last but not least, a free access to the relevant electronic educational materials.

With respect to students, the experimental educational content offered them an opportunity to learn about and improve in the field of creating 2D and 3D

drawings in AutoCAD 2013 system. They were enabled to develop individual skills in a new way, to solve tasks in a more attractive way and independently, based on the acquired knowledge of work with ICT, to use all means of communication effectively and creatively, and, last but not least, to accept responsibility for their own work. As a whole, all these skills can significantly contribute to the wider adaptability of students in further studies at universities.

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