THE IMPORTANCE OF MATHEMATICS AND PHYSICS FOR THE STUDY OF SAFETY AND PROTECTION OF HEALTH AT WORK

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Abstract: The article deals with the learning results of students in Math and Physics in the period of 6 years. The research sample, consisting of 355 students, analyzed their study results and compared the success of students in the different organization of the inclusion of subjects in teaching. For five years, teaching Math and Physics was done in one subject, and after evaluating the student's learning results, teaching was divided into two separate subjects. After this organizational intervention a survey was conducted of how the results of students changed from the original state and whether this way of teaching subjects reflected in the students' ability to apply acquired knowledge in other subjects of technical focus. The results say that the new concept of teaching Math and Physics has led to more students being successful in these subjects.

Keywords: health and safety at work, mathematics, physics, research.

1 Introduction

Occupational Safety and Health (OSH) is a multidisciplinary department focused on safety, health and well-being at the workplace. Students studying in the field of safety at work learn their skills in areas such as safety legislation, safety behavior, ergonomics, chemical safety, risk management and occupational hygiene (Andersson, Gunnarsson, Rosen, 2015). Applying their knowledge is closely related to other scientific areas such as Math and Physics. In this area, conducted research was done by K. Thanikasalam (2017), who found that the level of exploitation of Math and student logic during their practice in identifying areas of danger, identifying the population at risk, assessing the risk of exposure and prevention and control was very high. The findings showed that students who successfully completed Math during their studies were more successful in solving problems. Thus, Math is an important part of OSH practice with the necessary accuracy in measurement and calculation, in quantifying risks, logical considerations, and conclusions.

Math and its methods provide an apparatus for solving application tasks in various areas of economic practice, e.g. in economics, technology, biology, agriculture, and others. Teaching Math at universities and faculties of vocational training aims to enable students to understand the importance of using mathematics as a means of solving tasks in other specialized subjects (Gregáňová, R., 2012, Neuschlová, M., 2018). The proper joint of information and communication technologies, mathematical theory and solving of applied tasks in the teaching of mathematics and physics improves the quality of university education and from interdisciplinary relationship point of view develops the students' abilities to obtain new complex knowledge (Országhová, 2007).

At Pedagogical faculty Constantine the Philosopher University in Nitra there is the possibility of bachelor study in OSH study program since the academic year 2005/06. Graduates in the field of occupational safety and health can analyze problems and opportunities that open up in different areas of occupational safety, design and implement OSH systems, have the ability to integrate them into other systems or incorporate other systems into it.

During bachelor study, in addition to professional knowledge and skills, students are expected to acquire a broader theoretical background as defined in the core knowledge of the field of study: applied Mathematics and applied Physics. This idea is in line with the principles of curriculum development for technical fields of study and has been used since the year 2009. Therefore, since the academic year 2010/11, the subject of Applied Mathematics and Physics has been included in the OSH bachelor study program.

The inclusion of this subject has raised concerns that the attractiveness of security studies will be reduced from the perspective of students. Science subjects are generally the least interesting and challenging for students. Science education has been (and is) very challenging for universities, as students come to university from different types of schools with varying levels of knowledge in Mathematics and Physics. Interest in studying technical disciplines has decreased. Of the students who report to this study, many consider it only a substitute solution, as they have not reached more attractive subjects. This is also related to the level of Math knowledge, which is very low, as confirmed by researches by several authors (Bezáková, 2000, Serafín, 2016). At the same time students believe mathematics and physics subject matter is difficult (Saleh, 2012, Whitelegg, Parry, 1999), boring and irrelevant to their lives.

Therefore, we have included in the content of the subject Applied Mathematics and Physics topics that we assumed students in secondary schools did not take over, and yet are necessary for the given field. The content of the course consisted of: systems of equations, limits, derivations, integrals, fundamentals of mechanics and basics of kinematics. Since there was no subject with similar content in the study program in the previous period, we were wondering how students would manage it. The course was included in the study plan as a compulsory subject in the winter semester with a 2-hour weekly lecture and a 2-hour seminar. The subject Applied Mathematics and Physics was completed by an examination consisting of a written test. We followed the results of the students in the above-mentioned subjects during the five academic years: 2010/11 - 2014/15 on a total of 238 students. We found that the benefit of students from the subject was significantly influenced by the inclusion of thematic units from physics to the subject, so we proposed to increase the time allocation of the subject or divide the subject into two semesters and thus provide students with enough time to complete the knowledge in this area and master the subject (Lukáčová, Bánesz, 2015).

2 Research questions and methodology of the research

In 2014, when we repeatedly accredited the Health and Safety at Work study program, we changed - applied Mathematics and Physics by two separate subjects: Mathematics, Physics. Mathematics remained in the winter semester of the first year in the range of 1-hour lecture, two hours' seminar and Physics was included in the summer semester of the first year in the same range as Mathematics. After the subjects were taught in the academic year 2015/16, we conducted a survey to find out what changes the change in teaching Mathematics and Physics for the OSH study field brought. In the survey, we tried to answer surveying questions:

How did the average grade of Mathematics and Physics change from the original state?
How did the number of students who did not successfully complete the subject change?
How did the benefits of science students affect their results in the subject Machines and their parts?

The sample for the needs of the survey consisted of 117 students of the first year of the bachelor study and OSH study program. To verify the observed phenomena, we found the average grade of students from the above subjects and graphically displayed the data (Chart 1). Evaluation of subjects at the university is based on a grading scale consisting of six grades: A - excellent (1), B - very good (1.5), C - good (2), D - satisfactory (2.5), E - sufficient (3), FX - insufficient (4). All insufficient evaluations (grade 4) were included in the calculation of the average if the

student repeated the subject exam. The survey was based on statistical data from an academic information system that records student learning outcomes. We compared the data collected with the data in the 2015 survey. The composition of the exploratory sample and basic data is presented in table 1.

Table 1 Survey sample composition

subject	average grade	number of students	number of insufficient (grade 4)
Mathematics	3.12	63	21
Physics	3.41	54	17
Mathematics and Physics Together	3.26	117	38
Applied Mathematics and Physics	3.31	238	37

From the comparison of students' study results, we can conclude that the average grade of students in Mathematics has slightly improved with the average grade of Applied Mathematics and Physics. As expected, the average grade in Physics was worse than in Mathematics as well as in the subject of Applied Mathematics and Physics. The subject of Physics, as shown in table 1 and figure 1, has the worst average grade, while the relative abundance of failed students (grade 4) is high (figure 2).

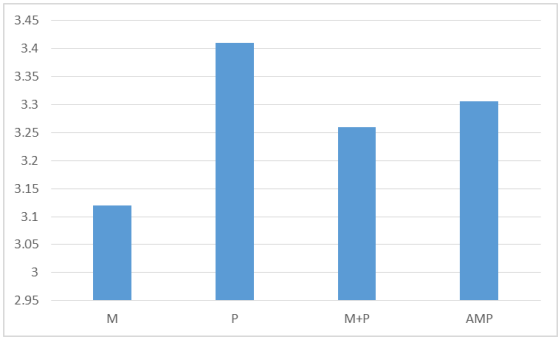

Figure 1: Average grade of students (M-Mathematics, P-Physics, AMP-Applied Mathematics and Physics)

By dividing the original subject of Applied Mathematics and Physics into two separate subjects, we managed to improve the average grade from Mathematics, on the other hand the results from Physics show a worse average grade than previously the subject of Applied Mathematics and Physics. Despite the high relative abundance of unsuccessful students on both subjects (figure 2), by distributing the subject into two subjects, there were fewer students who could not continue their studies because those students who were not successful in Mathematics were not always the same who were not successful in the subject of Physics.

For verification of the second monitored phenomenon, we present a graph of relative abundances (in %) of unsuccessful students in the studied subjects - figure 2.

Figure 2 shows a clear increase in the relative number of students who have not completed the subject after dividing it into two separate subjects. This number rose from 15.55 % to 33.33 % in Mathematics and 31.45 % in Physics. However, when we watched again if there is a correlation between the number of enrolled students and the number of students who do not complete the subject, we found that this relationship exists with a correlation rate of r = 0.67, or moderately high binding. In that year, when we were teaching Mathematics and Physics alone, more students were admitted to the OSH curriculum than in previous years, and there was an increase in failed students.

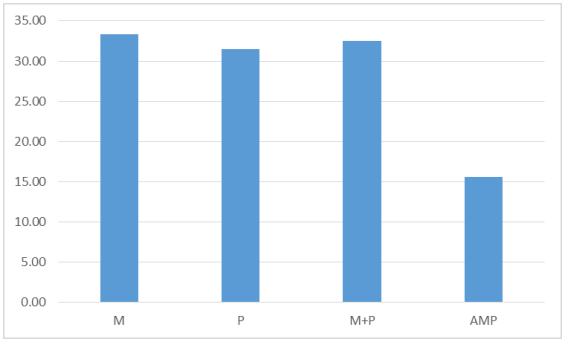

Figure 2: Relative student frequency that failed in the subject

The final examination of the students was slightly more effective, as shown in figure 3, which illustrates the average number of test terms per student. The average number of terms dropped from 1.8 to 1.24 in Mathematics, the average number of terms in Physics remained at 1.74.

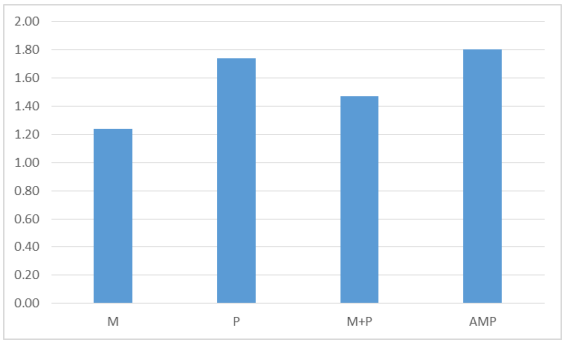

Figure 3: Average number of exam terms in individual subjects

This state illustrates the situation of the final evaluation of students, who were very successful in Mathematics on the first term. These changes had a positive impact on Mathematics teaching.

To answer the latest research question, we evaluated the average student rating in the subject Machines and their parts. In this subject, it was necessary to be able to apply the knowledge of Mathematics and Physics to successfully finish the subject. The course is focused on basic principles of machines and selected types of mechanisms (mechanical, hydraulic, pneumatic) and is taught in the range of 4 hours per week. We investigated whether there were differences in the benefit of students from the subject before and after 2015. The data obtained were processed into table 2.

Table 2: Evaluation of subject Machines and their parts

year	2010/11	2011/12	2012/13	2013/14	2014/15	2015/16
average	2.58	2.83	2.97	3.01	2.96	3.22
Not ended	23	22	28	22	19	21
number of ratings	87	86	91	55	65	87
Not ended (%)	26 %	26 %	31 %	40 %	29 %	24 %

A comparison of the student averages between 2010 and 2016 indicates that the students achieved approximately the same results. When we calculated the total average of students for 2010 to 2015, we got a value of 2.87, in 2016 it was 3.23. Despite improvement in teaching itself, the students worsened on average. On the other hand, the relative numbers of students who have not completed the subject show different results. The percentage of failed students dropped from 30 % to 24 %, which is a significant advance. Overall, we can say that more students

can master subjects that require to apply mathematical and physics knowledge, albeit with a worse overall assessment.

Interesting and comparable findings were obtained by the authors Zvára - Anděl (2001), who examined the connection between the results of the admission procedure and the success of the study at the Faculty of Mathematics and Physics of Charles University in Prague. They have conducted research that shows that the average student is only 50 % likely to go to the third year of study in study programs Physics, Informatics, and Teaching and only 9 % in Mathematics. Therefore, in their contribution, the authors suggest modifying the teaching in the first two years of the study so that it is adapted to the level of incoming students and at the same time suggest modifying the curricula of the mentioned study programs in order to maintain the quality of graduates.

3 Conclusion

According to the results obtained, we can summarize the conclusions and recommendations for the bachelor study of the OSH study program at UKF in Nitra to the following points:
The average grade in Mathematics was slightly improved by creating a separate subject.

The average grade in Physics remained at approximately the same level as the average grade in Applied Mathematics and Physics.

The relative abundance of students who have been unsuccessful in the subject has risen. This is related to the number of students admitted to the field - the higher the number of students admitted, the higher the relative number of unsuccessful students ($r = 0.67$).

Better teaching of Mathematics and Physics has led to more students being successful in the subject. Their evaluation has deteriorated from the past but having more time to master Mathematics and Physics has also been reflected in the subject where they have used their knowledge in applications.

The sense of inability in mathematical problem solving or a lack of talent in math along with feeling of low level of math intelligence may gradually cause negative attitudes towards Mathematics and Physics. The improvement and compensation of students' weaknesses in Mathematics and Physics can have an important role in students' academic motivation (Lotfali, S., Alem, Z. G., 2017).

Regarding the data obtained, we recommend optimizing the number of students admitted to the OSH department during the admission procedure. The acceptance of more students also increases the relative number of students who fail in Mathematics and Physics and cannot continue their studies.

Literature:

1. Andersson, I-M., Gunnarsson, K., Rosen. G.: *Role of Headmasters, Teachers, and Supervisors in Knowledge Transfer about Occupational Health and Safety to Pupils in Vocational Education.* In Safety and Health at Work. N. 6, 2015. p. 317-323.
2. Bezáková, A.: *Postavenie matematiky v inžinierskom vzdelávaní na technických univerzitách*. From: http://pf.ku.sk/katedry/kmat/data/konferenciasub/pdf2000/2cast.pdf
3. Gregáňová, R.: *The Applications of Mathematics in Electronic Education Context at FEM SUA in Nitra.* Journal of Technology and Information Education, Volume 4, Issue 3, 2012. p. 27-30. ISSN 1803-537X
4. Chajdiak, J.: *Štatistika jednoducho*. Bratislava, Statis, 194 s. 2003. ISBN 80-85659-28-X
5. Lotfali, S., Alem, Z. G.: *Effectiveness of Metacognition Training and Short-Term Daily Practice of Mathematics in Academic Achievement and Attitudes Towards Mathematics.* In AD ALTA: Journal of Interdisciplinary Research, vol. 7, issue 1, special issue I. p. 330-334. 2017. ISSN 1804-7890
6. Lukáčová, D. - Bánesz, G.: *Mathematics and Physics as a Part the Occupational Safety and Health Study Programme*. In Proceedings of 2015 International Conference on Interactive Collaborative Learning (ICL), p. 737-741, 2015.
7. Neuschlová, M.: *Implementation and benefits of e-learning project "Immunology - how the immune system works" in an education at Jessenius Faculty of Medicine in Martin.* In: ICERI2018 Conference Proceedings: 11th International Conference of Education, Research and Innovation. Seville/Spain: IATED Academy, 2018. p. 9686-9693. ISBN 978-84-09-05948-5.
8. Országhová, D.: *Integrácia poznatkov z matematiky a fyziky – základ medzipredmetových vzťahov.* In Research and Teaching of Physics in the Context of University Education. Nitra: SPU, 2007. p. 152-157.
9. Saleh, S.: *The effectiveness of brain-based teaching approach in dealing with the problems of students' conceptual understanding and learning motivation towards physics.* In Educational Studies, 2012, vol. 38, issue1, p. 19-29.
10. Serafín, Č.: *Current Access to Innovative Approaches Education in Occupational Safety and Health*. In Journal of Technology and Information Technology Education. 2016, Vol.8, issue 2, p. 93- 104. ISSN 1803-537X.
11. Thanikasalam, Umasenan A. L.: *Utilization of Mathematics Amongst Healthcare Students Towards Problem Solving During Their Occupational Safety Health Internship.* Proceedings of the International Conference on Education, Mathematics and Science 2016. Edited by: Puteh, M; AbdHamid, NZ; Adenan, NH. DOI: 10.1063/1.4983874.
12. Whitelegg, E. - Parry, M.: *Real-life contexts for learning physics: meanings, issues and practice.* In Physics Education, 1999, vol. 34, issue 2, p. 68-72.
13. Zvára, K. – Anděl, J.: *Souvislost výsledků přijímacího řízení s úspěšností studia na MFF*. In Pokroky matematiky, fyziky a astronomie, vol. 46, 2001, No. 4, p. 304 – 312.

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