POPULARISATION OF STEM SUBJECTS BY THE MEANS OF STUDY PROGRAMMES FOR UPPER-SECONDARY STUDENTS

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Abstract. *Interdisciplinary teaching is considered as an effective teaching approach. When designing the problems for interdisciplinary investigations the personal relevance for students should be considered. In the poster we present an example of the project presented by two students taking part in the program 'Discover the world of science' for upper-secondary by the university.*

Key words: Mathematics education. Physics education. Interdisciplinary teaching. Mathematical modelling.

INTERDISCIPLINARY TEACHING

It is almost impossible to understand the world around us by the means of only one scientific discipline (Maass et al., 2011). According to (St. Clair and Hough, 1992), interdisciplinary teaching is in line with current research findings on learning styles and students' needs in secondary education and promotes a holistic problem-solving approach and gives students a more comprehensive view of the world. It develops the students' ability to solve the problem by pointing it out from multiple points of view. Nikitina (2006) divided strategies of interdisciplinary teaching into three groups: (1) Contextualization means setting the content of the discipline in the broader context. Main advantage of contextualizing strategy is offering the student to gain theoretical, methodological, epistemological and historical connections among disciplines, to make mathematics and science more accessible. But, we have to be careful while implementing, because it is not aimed to turn the mathematics classroom into philosophical debate. (2) Conceptualization, i.e. working the core concepts which are central for two or more disciplines (e.g. linearity, exponential growth). This strategy aims to understand essential natural laws which are valid without human intervention. It proceeds from the empirical data to more general knowledge. Instead of philosophical issues characteristic for contextualizing, the conceptualizing connections need strong standards of verification, replication and mathematical expression. These links in practice usually need particular effort, they are not intuitive, and students usually do not see the connections. The role of the teacher in this kind of approach is really crucial. (3) Problem-centering is pragmatic, real-life oriented pedagogy. In order to solve (usually) ill-structured problems, the concepts, processes and ideas from different disciplines have to be used. In contrast with the previous two strategies, its aim is not to build coherence between different ideas, but to create tangible outcomes or products. The epistemological goal of this strategy is not so much to advance the knowledge, but to use tools of different disciplines to "fight" with the difficult problem. Disciplines here are used precisely, but only particular parts necessary for attaching the problem. Students in problem-centering classes may acquire specific disciplinary knowledge, but classes like this should be supplemented by broader context and content to obtain the consistent and personally meaningful knowledge of each discipline.

One possible strategy for interdisciplinary teaching is the creation of pupils' projects, i.e. project-based learning (Novotna et al., 2016; Pavlovičová et al., 2011). According to Suryana et al. (2018) STEM/STEAM is learning approach that builds the students not only

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reliable in theory but how to apply the theory to solve the problem. There is some evidence that project-based learning in STEM subjects increases the academic performance of students (Han et al., 2016).

The aim of this paper is to describe the activity focused on popularization of STEAM subject and to provide the narrative about two students taking part in the activity.

THE PROGRAMME FOR STEM POPULARISATION

The program Discover the world of science (DiSci) was aimed at popularization of STEM subjects through out-of-school programmes for students. The summer camp was organized for lower-secondary students. During the week in which they were held, the students were divided into groups and worked on an assigned project. The second activity, an unusual study program Discover the World of Natural Sciences, was designed for upper-secondary school pupils of the Nitra region. There are several similar projects in Slovakia and word-wide. However, curriculum in DiSci programme is specific in several aspects. The curriculum consists of five subjects: mathematics, chemistry, physics, geography and biology. Students of this program attend the university during the lecture period of two semesters. At the beginning of the study the pair of students chose the topic of the final project. During the first semester they were purposefully educated, lectures were more or less related to the topic of their project. The content of the second semester was focused on the development of competencies necessary for the writing and presentation of the final thesis. Students attended a short seminar on statistical methods and mathematical modelling. The real-life context can enhance students' modelling abilities (Plothová, 2017). Students presented their final work at students' conferences held at the end of their two-semester study. After the successful defense of the final thesis, a graduation ceremony took place and they were awarded the title Young Scientist.

EXAMPLE OF THE STUDENTS' PROJECT

One of the final projects connected together mathematics, physics, biology and engineering, the project about ergonomic artificial lighting. Both students participating in this project were students from grade 10, year one of vocational schools. One of the students attended a hotel academy (five-year programme with final high-stake exam) and stayed in the students' dormitory, the second one was a future confectioner (three-year programme without matura).

According to their interest, students chose the two rooms to consider the ergonomics of the artificial lighting, the dormitory room of one of the students and the freshly-renovated kitchen of the house of the second student. In the project they summarized the influence of artificial lightning for human organisms, the fatigue and influence for the human eyes. They also described the basic characteristics of different sources of light, e.g. color rendering index or color temperature. The intensity of light was calculated in the chosen rooms using the formula $E_n = \frac{100.P}{A.P^*} \cdot k$ where P is the light input of sources, A is area of the room and k is the correction factor considering efficiency of particular light source.

They found that the artificial lighting in the kitchen is not satisfactory and the lighting in the dormitory room fulfils the criteria given in the norm. The number of light bulbs needed for the kitchen was estimated by the means of GeoGebra and plotting the intensity of light as the function of the number of the bulbs. The parents of the student bought more lamps according to the calculation of their son.

Even after the presentation of the project the students persisted in verifying whether the different places have an appropriate level of light sources, including kitchens in different restaurants and patisseries where they attended their practical part of the study.

CONCLUSIONS

The project DiSci aimed at popularization of mathematics and science among the students in Nitra region. The presented example illustrates that even students whose carriers are not focused in STEM subjects can be involved in investigations and studying subjects usually out of their interest when they problems are set to the context suitable for students' interest and connected to their everyday life. Even though they lacked deeper knowledge and understanding of mathematics, they were able to solve the mathematical problem using the technology, particularly GeoGebra.

References

Han, S., Capraro, R. M., & Capraro, M. M. (2016). How science, technology, engineering, and mathematics project based learning affects high-need students in the US. *Learning and Individual Differences*, 51, 157-166.

Maass, K. et al. (2011). *Enhancing mathematics and science learning through interdisciplinary enquiry*. Nitra: UKF, 2011. ISBN 978-80-8094-986-0

Nikitina, S. 2006. Three strategies for interdisciplinary teaching: contextualizing, conceptualizing, and problem-centering. *Journal of Curriculum Studies*, 38(3), 251-271

Novotna, J., Jančařik, A., & Rusek, M. (2016). STEM and project-based education. In D. Rychtarikova, D. Szarkova and L. Balko (Eds.), *APLIMAT 2016 - 15th Conference on Applied Mathematics 2016*, Bratislava, SK: STU, pp. 876.

Pavlovičová, G., Švecová, V., Rumanová, L. (2011). Podpora medzipredmetových vzťahov prostredníctvom projektového vyučovania [Supporting interdisciplinarity through project-based learning]. *Cieľom vyučovania matematiky je šťastný človek*. Žilina: EDIS, p. 193-200.

Plothová, L. et al. (2017) An Analysis of Students' Use of Mathematical Models in Solving Tasks with Real-life Context. APLIMAT 2017 : Proceedings from 16th Conference on Applied Mathematics, Bratislava, SK: STU, 2017, p. 1207-1223.

St. Clair, B. & Hough, D.L. (1992). *Interdisciplinary teaching: A review of literature. Information analyses*. ERIC digest. (ED373056)

Suryana, A., Sinaga, P., & Suwarma, I. R. (2018). Analysis of the ability of junior high school students' performance in science in STEM project-based learning. *In Journal of Physics: Conference Series* (Vol. 1013, No. 1, p. 012059). IOP Publishing.

Popularisation of STEM subjects by the means of study programmes for upper-secondary students

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INTERDISCIPLINARY TEACHING

It is almost impossible to understand the world around us by the means of only one scientific discipline (Maass et al., 2011). According to (St. Clair and Hough, 1992) interdisciplinary teaching is in line with current research findings on students' needs in secondary education. It promotes a holistic problem-solving approach and gives students a more comprehensive view. One possible strategy for interdisciplinary teaching is the creation of pupil projects (Pavlovičová et al., 2011).
Nikitina (2006) divided strategies of interdisciplinary teaching into three groups: (1) setting the content of the discipline in the broader **context**, (2) working the core **concepts** which are central for two or more disciplines and
(3) **problem-centering** (in order to solve open, divergent problems, the concepts, processes and ideas from different disciplines have to be used). The reasonable combination of the strategies should be implemented.
According to Suryana et al. (2018) STEM/STEAM is learning approach that builds the students not only reliable in theory but how to apply the theory to solve the problem. There is some evidence that project-based learning in STEM subjects increases the academic performance of students (Han et al., 2016).

THE PROGRAMME FOR STEM POPULARISATION

The program Discover the world of science (DiSci) was aimed at popularization of STEM subjects through out-of-school programmes for students. Study program Discover the World of Natural Sciences, was designed for upper-secondary school pupils of the Nitra region.

The curriculum consists of five subjects: mathematics, chemistry, physics, geography and biology. Students of the program attended the university during the lecture period of two semesters. At the beginning of the study the pair of students chose the topic of the final project. During the first semester they were purposefully educated, lectures were related to the topic of their project. The content of the second semester was focused on the development of competencies necessary for the writing and presentation of the final thesis. Students attended a short seminar on statistical methods and mathematical modelling. Students presented their final work at students' conferences held at the end of their two-semester study. After the successful defense of the final thesis, a graduation ceremony took place and they were awarded the title Young Scientist.

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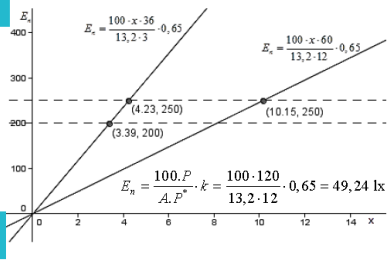

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REFERENCES

Han, S., Capraro, R. M., & Capraro, M. M. (2016). How science, technology, engineering, and mathematics project based learning affects high-need students in the US. *Learning and Individual Differences*, 51, 157-166.
Maass, K. et al. (2011). *Enhancing mathematics and science learning through interdisciplinary enquiry*. Nitra: FPV UKF v Nitre, 2011.
Nikitina, S. 2006. Three strategies for interdisciplinary teaching: contextualizing, conceptualizing, and problem-centering. *Journal of Curriculum Studies*, 38(3), 251-271
Novotna, J., Jančařík, A., & Rusek, M. (2016). STEM and project-based education. In D. Rychtarikova, D. Szarkova and L. Balko (Eds.), *APLIMAT 2016 - 15th Conference on Applied Mathematics 2016*, Bratislava, SK: STU, pp. 876.
Pavlovičová, G., Švecová, V., Rumanová, L. (2011). Podpora medzipredmetových vzťahov prostredníctvom projektového vyučovania [Supporting interdisciplinarity through project-based learning]. *Cieľom vyučovania matematiky je šťastný človek*. Žilina: EDIS, p. 193-200.
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Suryana, A., Sinaga, P., & Suwarma, I. R. (2018). Analysis of the ability of junior high school students' performance in science in STEM project-based learning. *In Journal of Physics: Conference Series* (Vol. 1013, No. 1, p. 012059). IOP Publishing.