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Exploring science, mathematics, and computer science education in high schools in selected regions of South Slovakia and Hungary

Introduction

In this paper, we would like to present the research activities realized within project grant VEGA no. 1/0663/19 "*Analysis of science and mathematics education in secondary schools and innovation of the content of vocational didactics*".

The social and theoretical background of the project

Education is an essential response to the urgent need to prepare young people with the ability to apply higher-order thought operations and deal productively with the global crises of the 21st century that affect the economy, the natural environment, and our diverse cultural heritage.

Economic and social development today is constrained by the fact that students' science competencies are not up to par. Science has a significant impact on personal life in global society as well as in its economy. Science has a significant impact on personal life in global society as well as in its economy. Scientific literacy is part of 21st-century skills (Djamahar, R., Ristanto, R. H., Sartono, N., Ichsan, I. Z., & Muhlisin, A., 2018). therefore, students have expected a good level of scientific literacy (Glynn, S. M., & Muth, K. D., 1994), which should be strengthened through nature education (Ristanto, R. H., Zubaidah, S., Amin, M., & Rohman, F., 2018), (Jenisová, 2015).

Andreas Schleicher, director for education and skills and special adviser on education policy to the secretary-general at the OECD, points out that "the world economy no longer pays you for what you know; Google knows everything. The world economy pays you for what you can do with what you know. If you want to learn if someone can think scientifically or translate a real-world problem into a mathematical context, those things are harder to assess. However, they're also more important in today's world. We see a rapid decline in the demand for routine cognitive skills in our world, and the kinds of things that are easy to test and easy to teach are also the kinds of things that are easy to digitize, automate, and outsource" (Robinson, K. & Aronica, L., 2018).

This is why there is an increasing emphasis on 21st-century skills. In one of his reflections, Dylan Wiliam points out that the term '21st-century skills are misleading, as none of the skills commonly referred to in the term is new. On the contrary, they are skills that have always been important. However, the labor market tends to increase the demands on workers, which were previously required of a small number of workers at the top of the management hierarchy (Wiliam, 2013).

They include critical and creative thinking, digital and technological skills, communication skills, and the ability to acquire and apply knowledge to problems and real-life contexts. We often use and interpret numbers, data, and mathematical ideas in everyday life. We do it without noticing or realizing it. When solving everyday problems, we often need to translate the problem situation into a mathematical context. Nevertheless, that is not enough - we also need a mathematical apparatus that we can use purposefully.

We formulate a problem in mathematical terms to solve it using mathematical tools, then interpret solutions to mathematical problems using logic-based thought processes that explore and connect pieces of information in ways that allow us to draw meaningful conclusions.

Most of our everyday problems are linked to the requirement for science competence.

By science competence, we mean the knowledge, abilities, skills, and correct science aptitudes of students to interpret natural phenomena correctly and use the technical resources at our disposal consciously and correctly. Mathematical competence is an integral part of scientific competence; therefore, we have focused on this area in our research. Furthermore, given that the body of knowledge is constantly changing and expanding in the given scientific fields, it is essential to develop lifelong learning in secondary school students.

Despite the significant importance of STEM fields, the younger generation is not interested in these fields, which may lead to a significant shortage of human resources in these spheres. BusinessEurope already highlighted in its 2011 study – *Plugging the Skills Gap the Clock is Ticking* – that the share of graduates in STEM fields in the EU fell from 24.8% to 22.7% in 2005 compared to 1999 (BusinessEurope, 2011). This ratio has stabilized, although there are still significant differences between the EU Member States. Furthermore, it is a well-known finding that the proportion of women graduates in STEM is significantly lower (Caprile, M., Palmén, R., Sanz, P., & Dente, G., 2015).

Interest in pursuing higher education in STEM fields is decided in middle school. However, positive attitudes toward individual subjects are formed in elementary school and continue through high school. This idea inspired us to determine high school students' attitudes towards science, mathematics, and computer science. These were the close regions' grammar school pupils who can be potential applicants to study at our university. We were curious about the level of their logical-inductive-, scientific- and mathematical thinking. We would find out the factors influencing their thinking and attitude towards STEM subjects.

Description of the project

Thanks to the submitted project material, in which we formulated our research interests and innovative intentions, and which was positively assessed within the VEGA grant and funded by the Ministry of Education, Science, Research and Sport of the Slovak Republic, we were able to start the scientific research activities of the project.

Within the project for the four-year project period (2019-2022), activities were planned that focused on meeting the following objectives:

- to examine the main attributes of natural scientific and mathematical thinking, understanding and problem solving;
- to examine the relationship among natural scientific and mathematical thinking and attitudes, socio-economic status of students, their career paths, and learning styles;
- to identify the factors influencing the students' relations to natural science and math subjects;
- to explore the teaching strategies used during the education of these subjects;
- to explore the teachers' view on the learning difficulties of these subjects;
- to formulate recommendations for the methodological renewal of these subjects.

We implemented the project with the formulated goals, which required the design of research activities. To meet the first two objectives mentioned above, we used the theoretical analysis method of domestic and foreign studies and other literature sources.

To meet objective no. 3, we conducted quantitative empirical research. The measurement tool of the research was an online available comprehensive system consisting of questionnaires and tests. The questionnaire survey focused on finding out the socio-economic background of the respondents, mapping the selected aspects influencing the science attitudes of the respondents, and mapping the learning style of the respondents through Kolb's questionnaire. In addition to the questionnaires, the integrated research instrument included a standardized test to map the logical and inductive reasoning of the students and a self-made non-standardized knowledge test consisting of the tasks requiring mathematical and scientific thinking.

The reliability and validity of the measurement tools were checked in pilot research. Subsequently, we redesigned and innovated the didactic test of STEM competencies and refined the investigated competencies. To meet the fourth and fifth goals, we used a questionnaire survey, which we addressed to high school teachers teaching science, mathematics, and computer science.

Our research sample was the age category of pupils in the 1st and 2nd year of grammar schools in Southern Slovakia and Hungary (Komárom-Esztergom and Győr-Moson-Sopron County).

Project results

The pandemic situation due to the spread of the coronavirus had a significant impact on the progress of the project. We could only test pupils on a rolling basis at the start of the 2021/2022 school year. We originally planned to involve 3,600 students from 30 schools in the research. However, due to the short time (September-November 2022), we managed to involve only 1646 students from 25 schools. The processing and analysis of the data are currently underway, and the interpretation of the results of the analyses and their publication is expected soon.

Short time prevented us from conducting research among middle school STEM teachers, classroom lesson visits, and small group interviews with teachers within the defined project period. However, this does not mean our goals will not be met soon.

Conclusions

We see the societal utility and added value of our empirical research in the comparison of results in neighboring regions of two states, which signalize similar societal phenomena related to the unpopularity of the STEM subjects and lack of interest in study programs requiring competency in STEM subjects.

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