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INTERDISCIPLINÁRNE VYUČOVANIE MATEMATIKY A PRÍRODOVEDNÝCH PREDMETOV NA SLOVENSKU – PILOTNÁ ŠTÚDIA

INTERDISCIPLINARY TEACHING OF MATHEMATICS AND SCIENCE IN SLOVAKIA – PILOT STUDY

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ABSTRAKT. *V príspevku sa zaoberáme výsledkami pilotnej štúdie zameranej na prácu učiteľov po prijatí štátneho vzdelávacieho programu so zameraním na interdiciplinárne vyučovanie. Na základe prác Nikitina (2006) a Chevallard (2002, 2004) hľadáme v slovenských triedach hlavné prekážky a naopak, podmienky, ktoré môžu pomôcť rozšíreniu interdisciplinárneho vyučovania matematiky a prírodovedných predmetov do slovenských škôl.*

KĽÚČOVÉ SLOVÁ*: interdisciplinárne vyučovanie, práca učiteľov*

ABSTRACT. *In the article we present results of the pilot study interpreting teachers practice within the new school settings using interdisciplinary teaching. Based on Nikitina (2006), and Chevallard (2002, 2004) we define main limitation and concerns in Slovak classroom as well as formulate some possible approaches which can help broader integration of interdisciplinary teaching of mathematics and science in Slovakia*.

KEY WORDS: *interdisciplinary teaching, in-service teachers' practice*

CLASSIFICATION: *M13*

1 Introduction

The word interdisciplinary means integrating two or more disciplines. On the very beginning there was no separation into scientific fields at all. The growing human knowledge caused the rising of separate research/knowledge fields. But the complexity of the word and society required particular cooperation. There are plenty of examples in the history where the development in one discipline was caused by development of another mathematical discipline and vice versa. In contrast with the complexity of the word is the simplistic way of understanding the word as is dealt by media. Even people who conceive the reality as something complex sometimes accept simplistic arguments (Garcia & Abril, 2009). In the effort to grow up and educate critical and active citizens, the complex thinking should be introduced to schools. Interdisciplinary teaching is not new idea. It was one of the concepts of Progressive Education Movement in USA in late 1920's (Vars, 1969). In 1949 Tyler listed integration of subjects as one of criteria for effective organization of school.

2 Theoretical considerations

Integrating of two or more disciplines can be done in three main approaches according the level of cooperation of teachers (Spelt et al., 2009): multi-disciplinary teaching, interdisciplinary teaching and integrating curricula. Within multi-disciplinary teaching there is one shared topic, but the teachers do not cooperate. Within interdisciplinary is one shared topic taught by several teachers across different subjects, but the teachers

collaborate. Students' knowledge from one discipline is enriched by other one. Integrated curricula are presented by one teacher in one subject.

Nikitina (2006) divided successful strategies of interdisciplinary teaching into three groups: (1) contextualizing, (2) conceptualizing and (3) problem-centering.

The first of the strategies, contextualizing, sets the discipline content in the broader context of history, ethics, society, culture or personal experience. Typical example of this approach is the history of mathematics which sets the discovery in the matter of time. Main advantage of contextualizing strategy is offering the student to gain the 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.

The second defined strategy is conceptualizing. Conceptualizing means to identify 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 rather philosophical issues characteristic for contextualizing, the conceptualizing connections need strong standard of verification, replication and mathematical expression. These links in practice usually need particular effort, they are not intuitive, students usually do not see the connections. The role of the teacher in this kind of approach is really crucial.

The last described strategy is problem-centering, it 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 previous two strategies, its aim is not to build coherence between different ideas, but to create tangible outcome or product. 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.

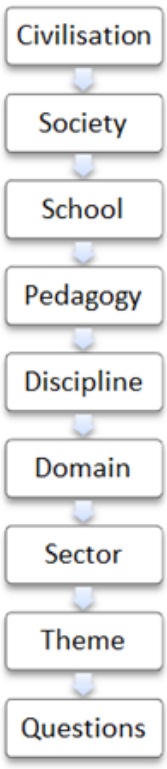

Figure 1 Levels of determination (Bosh & Gascón, 2006)

Each of the three strategies has its own advantages and disadvantages, strength and weak points. Sticking on one of them is almost impossible, but by combining them, students can get coherent knowledge and sense of the world. In the hand of good teachers the reasonable combination of the strategies can be really powerful tool to provide meaningful and exiting nature for the classroom work.

In the effort to follow and understand the process of implementation of interdisciplinary teaching in Slovak schools we used the framework based in the Anthropological Theory of Didactics by Chevallard (1999) where good summary of its main constrict and evolution can be found in Bosh and Gascón (2006). Main tool for our analysis will be the levels of determination proposed by Chevallard (2002, 2004) in an attempt to categorise where this restrictions and constraints are coming from (see Figure 1).

We can divide this hierarchy in two parts: lower and upper levels. Upper levels are characterized by the policy makers and the

organization of the education civilization – society – school – pedagogy. These levels influence what kind of mathematics and how it should be taught in schools. Then the lower levels discipline – domain – sector – theme – question represents the concrete situation how the different topics are taught.

3 The study

Within the European project COMPASS (www.compass-project.eu) were prepared several materials for interdisciplinary teaching at secondary schools. They also contain inquiry-based pedagogy with usage of ICT. The primary strategy for integrating disciplines was problem-centering, but the initial problem was set in the context of European society and particular contents in disciplines were stressed (see Figure 2).

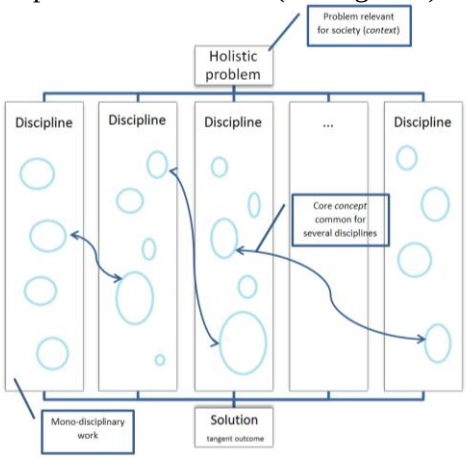

Figure 2 Model of integrating strategy used in project COMPASS

Research questions

What kind of limitation and constrains do the teachers stress in our educational system that prevent interdisciplinary teaching in mathematics and science from being widely incorporate in daily class conditions?

What kind of conditions could help integration of interdisciplinary teaching in mathematics and science at schools in Slovakia?

Methods and data collection

In our pilot study we have two teachers using one of developed materials “Food” in their teaching. The first teacher is specialist in math and physic and second teacher has specialization chemistry and biology. For the first teacher we used pseudonym “Peter“. He is experienced teacher and very active in projects and other activities. For the second teacher we used pseudonym “Olga“. She is a beginning teacher. Both of them teach at one of the best secondary schools in town, with mostly gifted and talented students. The lessons were thought in grade 8th (13 – 14 years old students). They spent nine lessons together with the materials. One introductory lesson, then physic lesson, two biology lessons, two chemistry lessons, two mathematics lessons and preparation of lunch menu for one week.

For data collection we used semi-structured group interview where both teachers had the opportunity to express their opinion and raise new topic. For data analysis we used proposed theoretical framework and focused on the upper levels.

3 Findings

According to theoretical framework we analysed semi-structured group interview with two teachers that experienced the interdisciplinary teaching within new approach that was problem-centered. Our main purpose was to understand the real situation in concrete school based on the teachers' beliefs and opinions, that can served as a key points for further investigation. This down-up approach help us identify main teachers complains and the usage of the material. Based on the identification of constraints we also offer few possible conditions that could help.

Society level

As the main constrains teachers see how the curriculum is set up. But on the other hand the current legislative supports students centered pedagogies and interdisciplinary teaching. "In the educational process it should be emphasized that there are no barriers/boarders between the science subjects and discovering of nature is possible only by the coordinated collaboration of all science fields using mathematics and ICT tools" (Hauser 2008).

The teachers still remain into old settings where the curriculum maps did not change from the time when the topics to teach were centrally given. Even thou Peter and Olga liked the idea, they were very skeptical about the practical usage of materials like this and project based learning in general. They see our school system very rigid as Peter mentioned „*our school system is 150 years old and we cannot change it so easily*".

School level

Peter felt that the school does not support the interdisciplinary teaching and mentioned several limitations to the hinder the implementation in his case. Similar but less explicit are also Olga's believes. Because of implementation of the interdisciplinary material they needed to change current curriculum map and consequently they were in time shortage with other topics. For the question if they could adapt their curriculum maps at the beginning of the school year they were less skeptical, but saw it as one approach how it could be done.

On the other hand, they saw the obstacle of school culture, where it should be more supported by other teachers too. They explicitly expressed that „*we need to have one curriculum map in the school year, but if there are three other teacher teaching in the same year it is not easy to change the plan.*"

Pedagogy level

Both teachers expressed that they did not change their teaching and the lessons were mostly transmisive teaching with interactive questioning. The intended pedagogy wasn't suitable for problem-centered education. The reason for this approach was that Peter thought that 14 years old students are not prepared for inquiry teaching and they are not used to look up for information by themselves. On the other side we observed that both teachers implemented several methods for active learning, but they were not aware of them. Possible explanation is that the implemented material design forced the teachers to use more student-centered pedagogies.

Discipline level

Within the level of discipline we focused on the three different strategies as mentioned in (Nikitina, 2006). Peter presented that he spontaneously built the problems into the

context of every day eating habits of students and was able to adapt the existing material quite easily.

For Peter and Olga the content of discipline was at the first place. They firstly needed to give students all prescribed information and then stress connection between the disciplines. For example pupils got information about saccharides, lipids and proteins and their role in human organism in biology lesson. Afterwards they worked with the **concept** of macronutrients again, in the chemistry lesson, where they learnt about the structure of saccharides, lipids and proteins and conducted several experiments.

In lesson plans we can see strong beliefs that students need wider overview that the **problem-centered** teaching offers. Advantage is that Olga and Peter are used to teach content and they are specialist in their area. On the other side, problem-centering caused the need for teachers to implement new, student-centered pedagogy, teaching strategies that are usually missing in Slovak schools.

4 Discussion and conclusions

Both teachers see interdisciplinary teaching as motivating for students but cannot see its normal usage in practice even thou they mentioned positive effect on students. In the pilot study teachers stressed two main limitations that prevent interdisciplinary teaching from being widely incorporate in daily class conditions: rigid curricular maps and pupils not prepared for inquiry-based learning. As mentioned in the findings, Peter expressed the opinion that his students were not able to work within inquiry based environment. It is in contradiction with research (Brown & Coles, 2008) which shown that 14 years old students were able to work like that and even more their intrinsic motivation to participate in mathematics was higher. We assume that this opinion is caused by lack of experience with student-centered pedagogy. However, design of materials helped both teachers in implementation of methods of active learning and at the end they were surprised by good work of students.

Curriculum concern is connected with the school culture that was another limitation influencing the implementation of interdisciplinary materials. The limitation comes from different views of several teachers within the one year used to teach common content. The new demand of competences arrived after the reform act in 2008 that increased the level of teachers' out-of-the-classroom work. To this situation arose another new competence of interdisciplinary planning of curriculum maps which requires also new way of professional communication between the science and math department.

Slovak teachers are good educated in content of their school subject but they are not experienced in development of common pupils' competencies within several subjects. Well-designed materials can support teachers in development of competences and teachers can prevent existence of blind spots in the disciplinary breadth (Nikitina, 2006) that can bring problem-centering strategy.

The teachers are influenced by their previous beliefs and experience from previous teaching. It is difficult to change their way of work in short period of time. That gives us a reason for longitudinal professional development of in-service teachers that would be focused on interdisciplinary teaching and student centered pedagogies.

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