Mācām dabaszinātnēs un matemātikā lietot iepriekš apgūto

Teaching to use in science and mathematics previously acquired skills

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Introduction and background

- In Latvia similarly as in other countries it is planned that the study content will be created with the aim to develop students' competencies, also known as the 21st century key competencies

- Competencies as a student learning result can be achieved through learning process with a pedagogical approach focused at deep learning / deeper learning / visible learning tasks

- In Latvia implementation of deep learning approach has been started in 1998, putting an emphasis on analytical and critical thinking, creativity and self-expression, communication, collaboration and learning skills

Introduction and background

Table 1. Comparison of traditional and contemporary task

Criteria	Traditional	Contemporary
Situation or text + context	The situation of the task is composed of concepts, facts, laws in a narrow scientific context. In some cases it is an everyday context (real but not relevant)	Concepts, facts, laws, theories + interdisciplinary context, real life situations, socially meaningful context
Cognitive level, assignment, solving techniques	When solving standardized tasks students remember procedures, execute routine actions. There are tasks with higher difficulty level – ''hard nuts''	Development of cognitive strategies, reading skills. Procedural (routine) and non-standardized actions, behavior in a new situation

Introduction and background

Research questions:

- What is the performance level of grade 9 students doing tasks with applying mathematical skills in a science context?
- How do grade 9 students apply acquired techniques in mathematics and science subjects when doing tasks?
- How is teaching of fractions and percentage calculation covered in study materials? How is teaching conducted in the classroom?

Research Methodology

- Analysis of national test results. Diagnostic work with science subjects in grade 9 (14600 students)

For data analysis ITEMAN software and IRT RASCH model was applied

- Analysis of student work, in-depth analysis of 300 student works from 8 schools

Research Methodology

- Analysis of study materials

As data subject program examples and study materials in mathematics and chemistry were used. Analysis shows that the materials offer to acquire specific questions and what tasks are included accordingly to selected criteria.

- Analysis of classroom transcripts

Classroom transcripts and analysis in electronical format was done by the center experts by using criteria and level description rubrics, on a scale 0-3

Results and Discussion

- Diagnostic work in sciences in grade 9 are composed of 12 tasks, that breaks down into 40 test-elements
- In total it is possible to get 45 points. Highest score was 42, lowest – 1 point
- Applying IRT RASCH model shows that this work has an average difficulty level
- Students can be categorized in four groups accordingly to their ability to do this work

Results and Discussion

Table 2. Groups of pupils according to the IRT RASCH model

Group	Characteristics of student attainment
III group (15% students)	Students are able to use knowledge and algorithms in unknown and new situations, other contexts; analyze complex information; create solutions
II group (50% students)	Students can explain or use knowledge in familiar standardized situations, they choose appropriate approaches or procedures (with two or more steps) Structure (organize) and interpret simple data
I group and 0 group (35% students)	Students are able to show elementary skills, remember or recognize simple facts and concepts or procedures
	Students are not able to show elementary skills, are not able to remember or recognize simple facts, concepts or procedures

Task that was used for this research

Calculate the needed mass of crystal sodium chloride to make 500g saline solution – 0,9 % NaCl solution. Show your calculations!

Level of difficulty 0,17 (average 0,43)

Results and Discussion

How students apply skills acquired in mathematics and chemistry

Skills acquired in mathematics is mostly applied

- During the solution the value of 1 % is calculated and used further
- Calculation of 0.9 % from the solutions mass is done switching to multiplication
- Proportionality is used during reasoning
- Formulas are used for calculating proportion of the unknown variable

Results and Discussion
Calculating values of fractions and percentage in chemistry teaching materials

- There are various mathematical techniques – fundamental features of techniques, percentage as a hundredth of, expressing the size of a formula etc.

- There is a shift from an analogical reasoning to a use of formulas. For calculating any value there is a given formula, which increases the amount of factual knowledge learned by heart

- Verbal reasoning is used to reveal tasks content meaning and the fact that a percent is a hundredth of. Mathematical calculations are mostly ready-given algorithm.

Results and Discussion

Calculating values of percentage and fractions in mathematics teaching materials

- Formally while teaching mathematics students learn concepts and skills that are needed in science subjects. Solving standardized tasks is predominant
- Analysis of mathematics study materials shows a trend that also in mathematics formal procedures and algorithms are predominanting
- Recording of solutions is prematurely formalized, it does not correspond exactly to the reason
- Previously acquired skills and the use of them in a new situations is missing an underlying continuity
- The concept of percentage interpretation is almost never used which leads to the use of proportions

Results and Discussion

When changing the context a standardized task becomes a problem-based task

- When a task is given a context which the student hasn't experienced before it creates a new situation for the student. A Task based on a standardized algorithm becomes a complex task (problem-based).
- Chemistry study materials from the competencies perspective – the students basically have no opportunities to practice in a new context because the tasks with the slightest differences are presented as particular cases
- Mathematics study materials context is mostly formal and mathematical
- Study materials mostly don't explain context-based task solving, whereas if they are explained – there is a risk of developing misconceptions creating a wrong explanation of concepts

Results and Discussion
How learning is happening in the classroom

While studying there is a need to

- Acquire language and reading strategies
- Acquire various strategies to solve tasks, from which the student can apply the most suitable for him/her self while studying mathematics
- Acquire purpose of the science subjects und the ability to see links between them while studying chemistry

Results and Discussion
How learning is happening in the classroom

A challenge for teachers –

how to realize a practice of using previously acquired skills into a new context

- Students' not to recognize *what*? (this is the same task as that…),
- But to recognize *how*? (we could use … approach).

To teach highest level thinking .

Results and Discussion
How learning is happening in the classroom

Tendencys

- Purposefulness of the classroom and a possibility for students to construct new knowledge (1,6)
- Communication about the results in the classroom (1,7)
- Realization of previously gained skills (1,5)
- Average Learning productivity in analyzed classrooms (1,5)

(scale 0 – 3)

Conclusions

- Science context tasks results where students need to apply mathematical skills are low
- One of the reasons why this inability to apply an algorithm that has been used in the learning process for many years could be that teaching both in mathematics and sciences is mistakenly formalized and is not emphasizing the forming of a deep understanding
- Promotion of collaboration between mathematics and science teachers in schools is needed to jointly analyze teaching strategies and creating links among subjects

Conclusions

Further in-depth research is needed into students' outcomes:

- Doing non-science tasks related to determining percentage;
- Doing tasks with various science context;
- Doing tasks with semantically clearer and abstract formulation

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