# *STUDENT GRAPHICAL INFORMATION LITERACY IN MATHEMATICS AND SCIENCE*

Skolēnu prasmes darbā ar grafisku informāciju matemātikā un dabaszinātnēs

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VPP 2014 – 2017 **“New pedagogy for deep learning”**

# Introduction & background

- In Latvia and 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

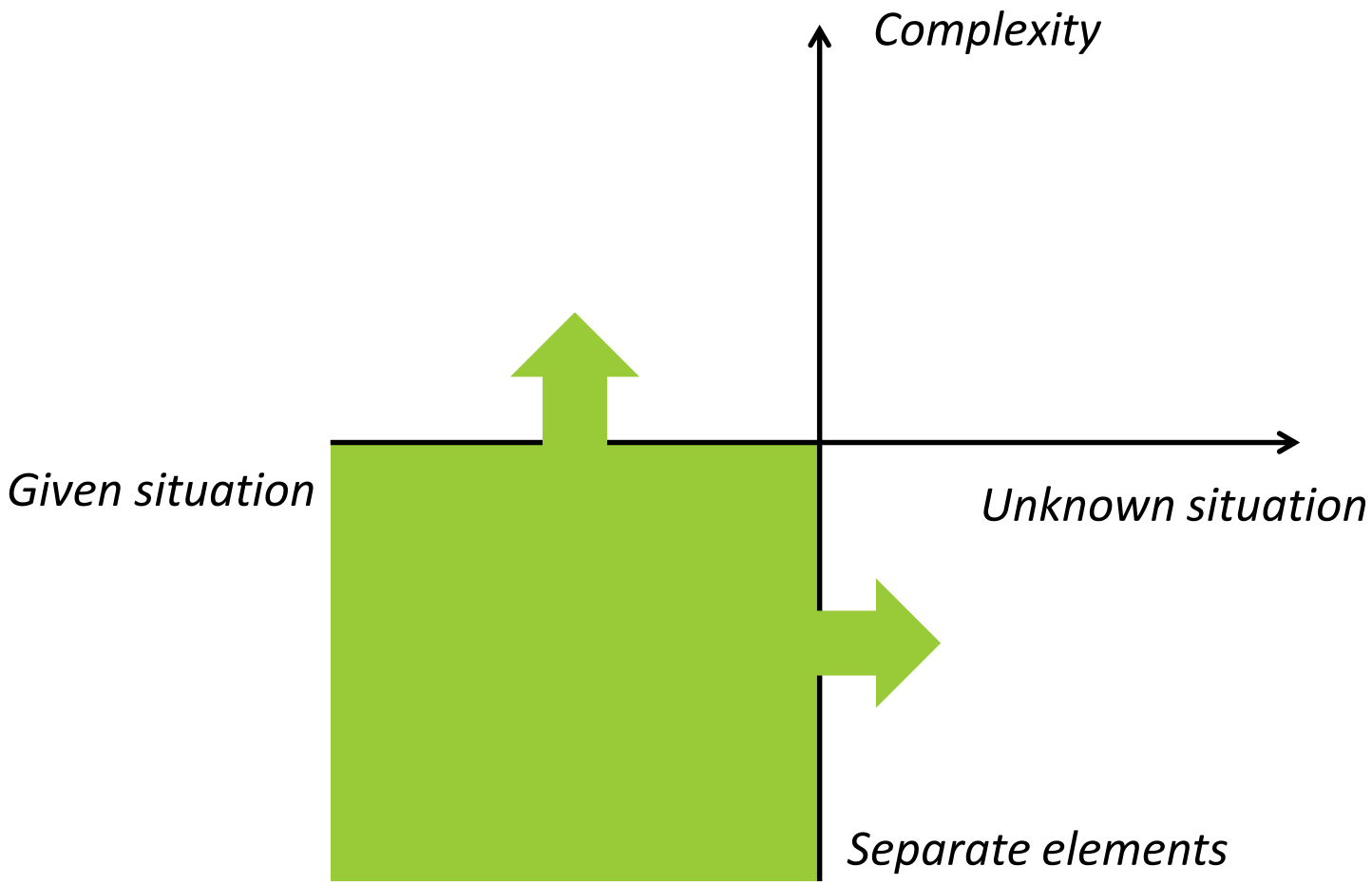
- In Latvia implementation of deep learning approach has been started in 1998, putting an emphasis on analytical and critical thinking, creativity and self-expression, communication, collaboration and learning skills

# Introduction & background

**Framework of categories and criteria**

| Continuity of reform documents (categories) | | Criteria |
|---|---|---|
| Aspects of study content (2006) | Transversal competencies (2016) | |
| Analytical and Critical thinking | Cognitive activity including critical thinking | Depth of cognitive activity |

# Elements and complexity of assignements



# Introduction & background

## Research questions:

- What is the performance of 9th grade students doing assignements where skills for applying graphical information in science (and real life) context is measured ?
- What is the cognitive depth of the 2016 national test assignements in science and mathematics?
- How is the methodic of learning how to work with graphical information literacy viewed in science and mathematics study materials ?

# Research Methodology

- Analysis of national test results. Diagnostic work with science subjects from year 2015 in grade 9 (14600 students), and from year 2016 (15340 students)
- Selected assignements with graphical information – 6 test elements (2015) and 5 testelements (2016)
- For data analysis WinStep programm was used and IRT RASCH model applied
- Analysis of student work, in-depth analysis of 300 student works (2015) un 270 students works (2016) from 8 schools

# Research Methodology

- For national test analysis assignements from 2016 test and diagnostic assignements in science and mathematics was selected (10 sets of assignements)

- For determining cognitive depth, performance indicators and criteria where used (SOLO taxanomy)

- The evaluation of cognitive level can be compared to the OECD PISA framework

# Research Methodology

***Comparison of cognitive depth among different instruments***

| Level of cognitive demand | PISA proficiency level | PISA cognitive level | National testing | Lesson observation | SOLO taxonomy |
|---|---|---|---|---|---|
| High | 5, 6 | High | High | 3 | Extended abstract |
| Medium | 4, 3 | Medium | Medium | 2 | Relational |
| Low | 2 | Low | Low | 1 | Multi-structural |
| | 1a | | | 0 | Uni-structural |
| Under low | 1b | | | | Pre-structural |

# Research Methodology

**Analysis of study materials was done accordingly to the following criteria:**

- Selected assignements with graphical information
- What is the level of cognitive depth in these assignements
- What are the possibilities of students to learn skills independently through using learning materials

**Study materials selected:**

- 14 study books in mathematics grades 4 to 9
- 17 study books in science, physics, chemistry, biology till grade 9

# Results & Discussion

***Student performance in testelements with graphical information (2015)***

| Assign. Nr. | Performance indicator | Difficulty level(p) |
|---|---|---|
| 6 | Reads numbers and other information from a graphic | 0,77 |
| 29 | | 0,71 |
| 7 | Recognize non-linear graphic among other types of graphical info | 0,68 |
| 28 | Visualize data graphically from a given table | 0,51 |
| 16 | Analyze complex information about a given situation in written text (also in visual and graphical materials) | 0,29 |
| 22 | Creates links between the complex textual and graphical information, analysis graphics and shows data literacy | 0,26 |

# Results & Discussion

***Student performance in testelements with graphical information (2016)***

| Assig. | Student performance indicator | Difficulty level (p) |
|---|---|---|
| 7.3. | Reads simple info from a graphic | 0,80 |
| 9.2. | Reads simple info from a graphic by using also textual and visual information | 0,72 |
| 6.4. | Reads complex textual and graphical information to reason, make conclusion through analysisng a given situation | 0,49 |
| 11.2. | Analyze textual, graphical and other visual information about a new real life situation | 0,36 |
| 11.1. | Analyze complex textual and graphical information about new real life situation | 0,25 |

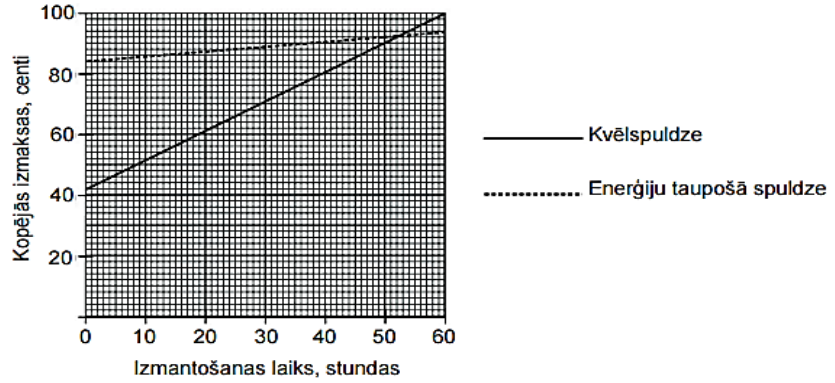
# Results & Discussion

***Cognitive depth in national test assignements in science and mathematics (2016)***

| | Mathematics | | | | Science | | | |
|---|---|---|---|---|---|---|---|---|
| **SOLO level** | 1. | 2. | 3. | 4. | 1. | 2. | 3. | 4. |
| **3rd grade** | 40% | 49% | 11% | 0% | | | | |
| **6th grade** | 23% | 60% | 17% | 0% | 52% | 39% | 9% | 0% |
| **8th grade** | 12% | 56% | 24% | 8% | | | | |
| **9th grade** | 23% | 59% | 18% | 0% | 32% | 60%) | 8% | 5% |
| **12th grade** | 9% | 66% | 17% | 8% | 45% | 42% | 13% | 0% |
| | | | | | **Physics** | | | |
| | | | | | 37% | 61% | 2% | 0% |
| | | | | | **Chemistry** | | | |
| | | | | | 46% | 39% | 15% | 0% |

# p=0,8

7.3. Grafikā attēlotas kopējās izmaksas, pērkot un izmantojot vidēji dārgu kvēlspuldzi un vislētāko enerģiju taupošo spuldzi.

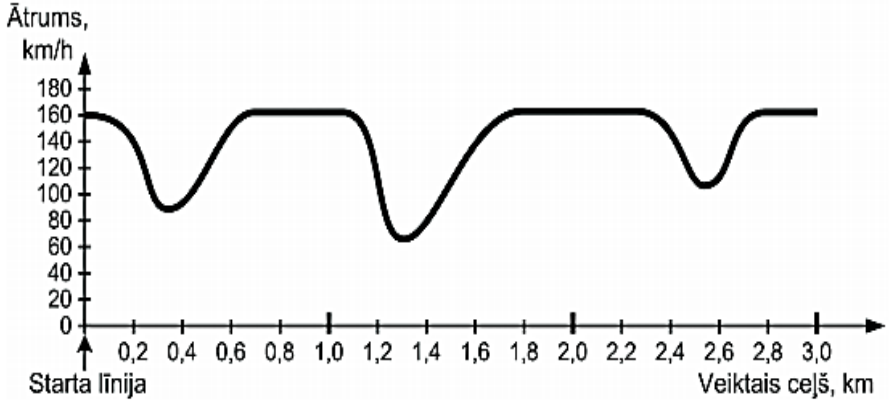



Pēc cik stundām enerģiju taupošās spuldzes iegāde un izmantošana kļūst ekonomiski izdevīgāka, salīdzinot ar kvēlspuldzi? *Atzīmē vienu atbildi!*

**A** pēc 42 stundām
**B** pēc 84 stundām
**C** pēc 93 stundām
**D** pēc 52 stundām

# p=0,25

Grafikā parādīts, kā mainās sacīkšu automašīnas ātrums, braucot pa trīs kilometrus garu horizontālu trasi otrajā aplī.




11.1. Aptuveni cik garu ceļu veic automašīna no starta līnijas līdz trases garākā taisnā posma sākumam? *Atzīmē vienu atbildi!*

**A** 2,6 km
**B** 1,8 km
**C** 1,4 km
**D** 0,5 km

# Results & Discussion

## Reasons for student difficulties and test assignement cognitive depth

- Amount of textual information in some assignements is very large
- Students don’t have enough experience in their learning process with assignements representing new and complex situations
- On average, the performance of students in national test assignements in science and mathematics (2016) is measured in a cognitively low level
- This indicates that teachers in their work tend to use assignements based on the content of national tests (Harlen, 2010)

**This situation indiciates a contradiction between:**

- The need for acquiring 21st century skills (through developing deep learning skills) as proposed in the national development documents of the learning content AND
- The national test assignements in science and mathematics where a surface (reproductive) learning process is generally measured

# Results & Discussion

## Graphical information literacy in science and mathematics study materials

- Students receive diverse set of experience to work with theoretical mathematics models which only approximately describes the real process (in a detailed way)

- Students are practicing through doing assignements with mathematical or real context where it is asked to recognize a specific element or already tested mathematical theoretical knowledge

- Few instances where the student analyzes graphical information in the context of a real life situation and appropriate terminology and linking it with mathematical terminology

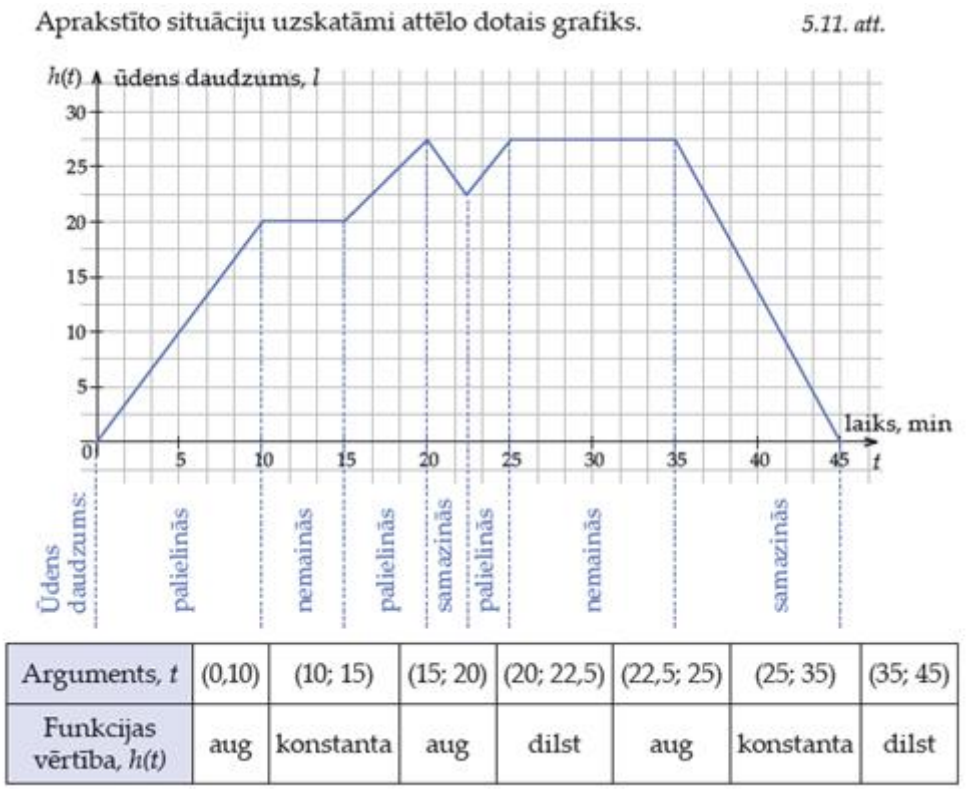
# Results & Discussion

## Graphical information literacy in science and mathematics study materials

Jānis wanted to bath his dog. He started to fill the bath with water but then the phone rang and Jānis stopped the water.

After he finished the phone call, he continued to fill the bath. When it was full, it turned out it is too hot. He took out some of the hot water and filled it with some cold water.

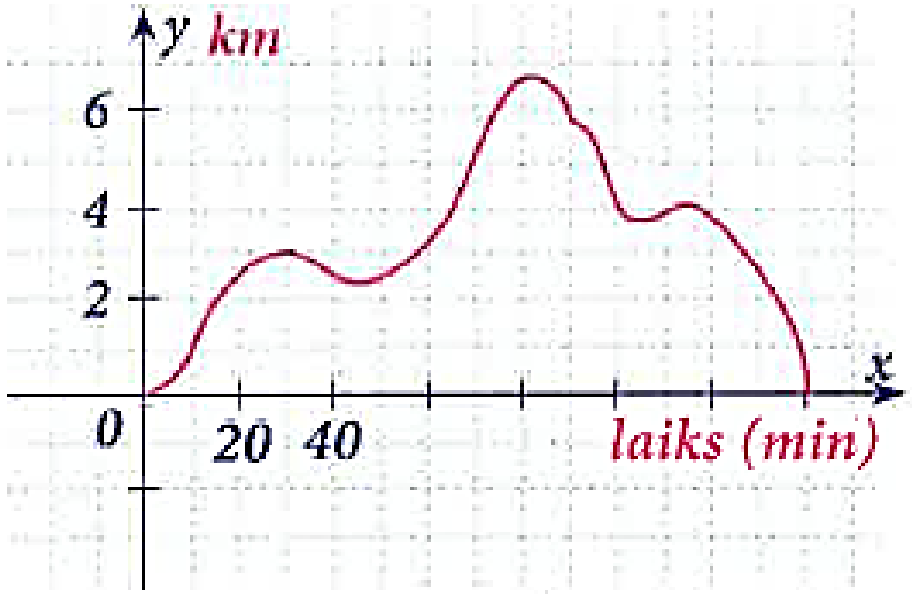
When the dog was finished bathing, Jānis took allt he water out.




| Arguments, $t$ | (0,10) | (10; 15) | (15; 20) | (20; 22,5) | (22,5; 25) | (25; 35) | (35; 45) |
|---|---|---|---|---|---|---|---|
| Funkcijas vērtība, $h(t)$ | aug | konstanta | aug | dilst | aug | konstanta | dilst |

# Results & Discussion

## Graphical information literacy in science and mathematics study materials




443. attēls

*149.1.* Pa ezeru brauc jahta. Tās attālums no piestātnes mainās atkarībā no laika. Šī sakarība (attālums $y$ no laika $x$) parādīta grafikā (*443. att.*). Cik tālu jahta atradās kopš izbraukšanas no piestātnes pēc 20 min; pēc 40 min; pēc 1 h 20 min un pēc 2 h 30 min? Vai ar šo grafiku tiek dota funkcija? Vai tā ir lineāra funkcija? Kāds ir tās definīcijas apgabals un kāds — vērtību apgabals?

# Results & Discussion

## Graphical information literacy in science and mathematics study materials

- Science study materials have relatively few examples where students are asked to work with graphical information

| Number of examples | Number of study books in a subject |
|---|---|
| More than 10 | 2 physics study books |
| 5-9 | 1 chemistry and 1 physics study book |
| 2-4 | 1 zoology and 1 science study book for 6th grade |
| 1 or 0 | 11 science study books |

- Science study books don't have explanations for how students should work with graphics (if they want to learn it independently)

# Results & Discussion

## Graphical information literacy in science and mathematics study materials

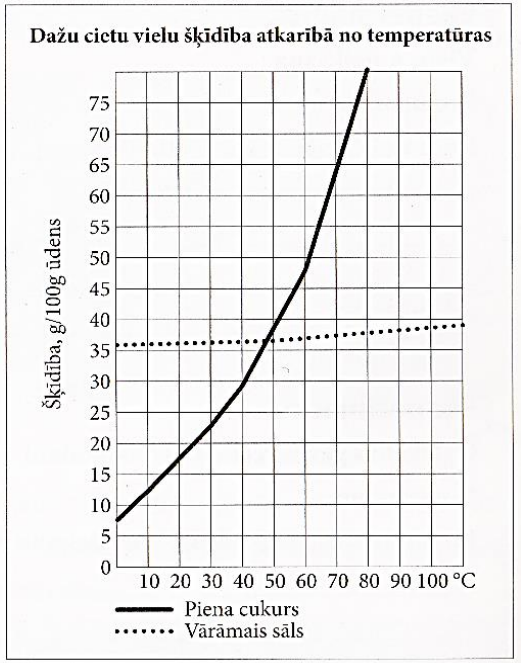
***Example of testelement from Science textbook for grade 6***

**2. uzdevums.**

**Izpēti grafiku!**

**2.1.** Aizpildi tabulu!

| Piena cukura jeb laktozes šķīdība ūdenī atkarībā no temperatūras | |
|---|---|
| **Temperatūra (°C)** | **Izšķīdušās vielas masa 100 g ūdens** |
| 10 °C | |
| 30 °C | |
| 50 °C | |
| 70 °C | |
| 80 °C | |




**2.2.** Vai 100 gramos ūdens iespējams izšķīdināt 50 gramus vārāmā sāls? Atbildi pamato, izmantojot datus no šķīdības līknes!

# Conclusions

- Student performance is relatively high (degree of difficulty 0,6 – 0,8) in selected average difficulty level assignments (in the period of 2015-2016) for measuring students' information literacy skills. In assignments where deeper levels of thinking are required (use of acquired information, transforming it, making judgments, analyzing it in a new situation) student performance varies considerably (difficulty level 0,25 – 0,36)
- Research findings indicate a tendency that the content of science and mathematics national tests in years 2015 and 2016 are dominated with assignments where students are asked to demonstrate relatively low cognitive performance
- Generally students can acomplish assignements with graphical information included in diagnostic work and that are typically found in study materials
- Only is several study materials  (for 1st to 9th grade) complex assignements are included that represent authentic real life situations; these assignemenst give the student a chance to use from mathematics acquired skills for working with graphical information and transfer them to science context

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