Computational Thinking and Mathematical Problem Solving, an Analytics Based Learning Environment

Newsletter 5

October 2024

Dear Readers,

In this 5th Newsletter, we will inform you about the progress made in the project, about piloting interactive tasks in Gedminai Progymnasium and the workshop in Klaipeda, Lithuania, September 28 – October 2, 2024.

CONTENT

1. Briefly about CT&MathABLE

The Vilnius University Institute of Educational Sciences continues its significant work on the *Computational Thinking and Mathematical Problem Solving, an Analytics-Based Learning Environment* (CT&MathABLE) project. This Erasmus project involves six universities: Ankara University, Eötvös Loránd University, the University of the Basque Country, the University of Turku, Vilnius University, and KTH Royal Institute of Technology, along with two schools: Klaipėda Gedminai Progymnasium and Mamak Özkent Akbilek Primary School.

The main goal of the CT&MathABLE project is to support students' digital transformation in multiple areas. This involves boosting their digital skills and self-awareness using learning analytics, enhancing computational thinking (CT) and algebraic thinking (AT) through interactive activities, applying the STEM approach to task-based learning, and creating assessment tools for CT backed by learning analytics. Additionally, the project aims to provide interactive tasks and assessment tools compatible with various learning management systems. By developing a learning-analytics framework, the project supports personalized learning paths for students aged 9 to 14 across Europe. The core aim is to empower children within this age group to strengthen their computational and algebraic thinking skills through engagement with Computer Science and problem-solving activities, which are essential for success in the 21st century.

The project partners meet virtually every month to discuss progress, allocate tasks, and coordinate their work. In-person meetings, though rare, have played a vital role in advancing the project. After gathering in Budapest, Hungary in June 2023 and Muğla, Turkey in April 2024, earlier this year, the latest meeting took place in Klaipėda, Lithuania between 28 September – 2 October 2024.

A key focus of this collaboration has been preparing for the second pilot test of computational and algebraic thinking assessment instruments: COMATH1, COMATH2, and COMATH3. These tools are fully integrated into ViLLE, an interactive, visually engaging learning platform designed for ease of use by students and efficiency in collecting and analyzing data for researchers. During the meeting in Klaipėda, the team delved into discussions on how best to analyze the results using appropriate statistical methods, the timing and journals and conferences for publishing and presenting scientific papers, and more.

2. Project meeting and workshop in Klaipėda

The project has now entered its third and final year. A vast amount of educational material has already been developed to help teachers guide students in computational thinking and algebraic reasoning. One of the most impressive outcomes thus far has been the creation of 100 interactive tasks related to various informatics concepts, now fully integrated into the ViLLE platform. These tasks are set to be tested by students at Klaipėda Gedminai Progymnasium.

Participants of CT&MathABLE project (left to right, front row first): Asta Jankauskienė, Cansu Guden Tektel, Marika Parviainen, Nilüfer Tan Yenigun, Indra Sudeikienė, Daranee Lehtonen, Valentina Dagienė, Javier Bilbao, Zsuzsa Pluhár, Eugenio Bravo, Tuğba Öztürk, Tolgahan Ayantas.

The project partners had the opportunity to observe lessons at Klaipėda Gedminai Progymnasium, where both primary and secondary school students engaged with the interactive tasks developed for the project. The enthusiasm among the pupils was evident as they worked through a variety of challenges. Students showed particular interest in tasks like Venn diagrams, logical puzzles, and those requiring strategic planning. These tasks not only captured their attention but also encouraged them to think critically and apply computational thinking and algebraic thinking skills in a hands-on, practical way.

It was impressive to see how the students, even first-graders who had just started school a few weeks prior, were highly engaged with the tasks and able to solve many of the problems independently. Their ability to work through the exercises with minimal guidance reflected the accessibility and intuitive design of the ViLLE platform. For the older students, the more advanced tasks provided a stimulating challenge, sparking curiosity and fostering deeper problem-solving skills.

This direct observation provided valuable insights for the project team, as it allowed them to see how students interacted with the material in real-time. The feedback gathered from these sessions will be used to further refine the problem sets, ensuring they are not only user-friendly but also appropriately challenging and effective in developing key computational thinking skills. This iterative process of observation, reflection, and improvement is central to the project's aim of creating meaningful educational tools that can be widely adopted in classrooms.

The observations and subsequent discussions were essential for refining the tasks, making them even more user-friendly for schools. The goal is to enable teachers to more accurately assess their students' computational thinking and algebraic thinking skills and better support their learning journeys.

The excitement surrounding the CT&MathABLE project is evident among all the partners. There is great satisfaction in designing diverse learning activities, measuring students' progress, and knowing that the work is directly benefiting schools by enhancing the way computational thinking is taught and assessed.

A few moments from the lesson observation: students enthusiastically solving problems in the ViLLE environment, answering questions from guests.





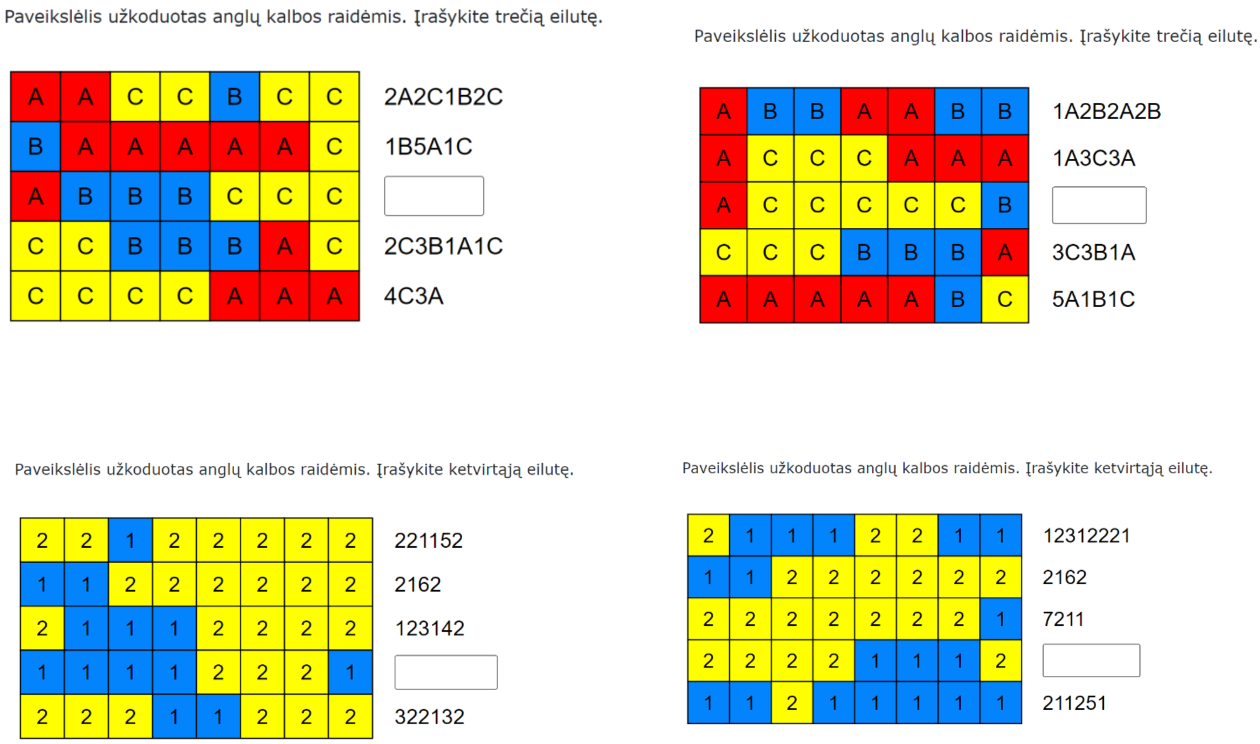
3. Visual learning environment ViLLE and parametrization of tasks

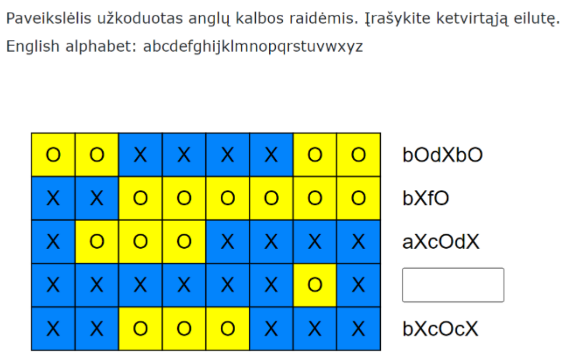
ViLLE's real-time learning analytics provide both teachers and researchers with invaluable information about the suitability of tasks and the progress of student groups. The analytics offer detailed data and also visually represent it, allowing teachers to quickly see, for example, if a student is falling behind. For researchers, one of the most interesting visualizations compares tasks with student performance, showing both accuracy and time spent on each task. When combined with in-person observation, this data helps researchers optimize individual tasks, the overall task set, and the sequence in which they're presented.

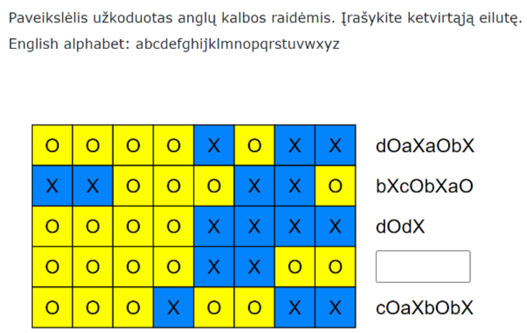
Based on a literature review and classroom observations, our goal is to create a set of tasks that the average student can complete within about 40 minutes during class and 10-30 minutes at home (depending on grade level) to achieve 50% of the points, earning a bronze trophy in the ViLLE system. This system motivates students by encouraging active learning and giving them the freedom to choose the tasks that interest them most. In an ideal lesson, motivation is sparked by initial tasks that grab students' attention, helping them reach a flow state in their learning. Learning is most effective when it occurs within the student's zone of proximal development, but also when students engage in collective knowledge-building with their peers. This leaves the teacher with the challenge of balancing personalization.

A novel aspect of this project is the use of two levels of *task parametrization*. Most tasks have built-in parameters that allow each student to complete a slightly different version of the task. The second level involves adjusting the core concept of the task, for example, by modifying the encoding to suit different grade levels. This approach is especially useful when the same concept is revisited across multiple years of the curriculum.

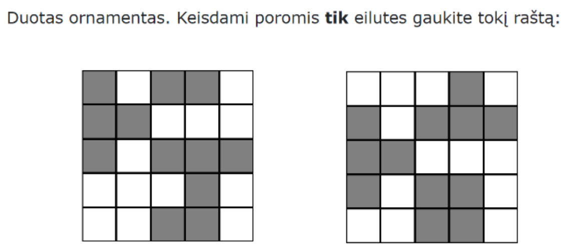
Example 1. Parametrized tasks: encoding (in Lithuanian, as presented for students at Gedminai Progymnasium)

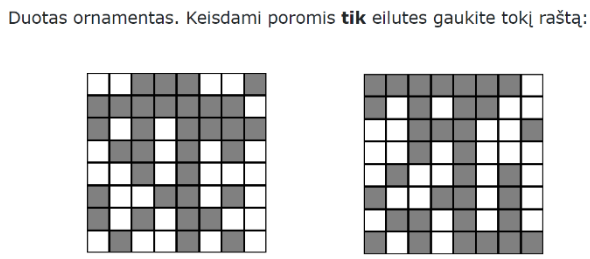




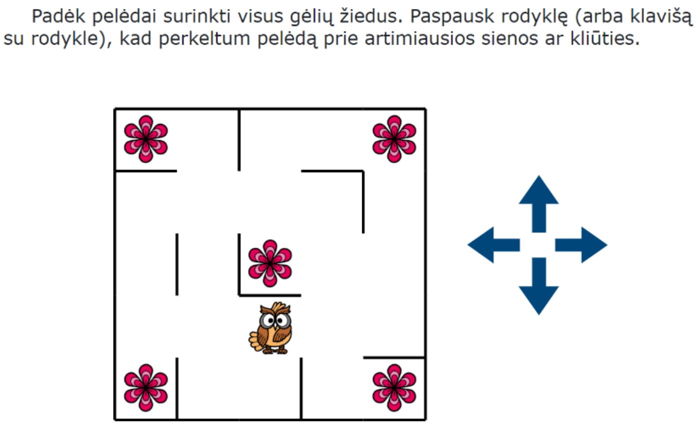


Example 2. Parametrized tasks: shifting rows





Example 3. Parametrized tasks: mevement in the maze



The partners and visiting teachers from other Klaipėda schools observed different classes (1st, 2nd, 4th, 5th, 6th and 8th) using the ViLLE platform and interactive tasks. Below is an example of a 2nd grade lesson from Learning Analytics view.

This chart visualizes student progress during the lesson. The yellow line shows that, on average, all students completed about 12 out of 18 tasks (Figure 1). We can see that two tasks, 9 and 11, resulted in lower marks for most students (as indicated by the short blue bars in Figure 1). Tasks 12 and 16 took more time than the others (highlighted by the taller red line in Figure 1). These observations were also noted during in-class monitoring, and the task design team will improve these specific tasks.

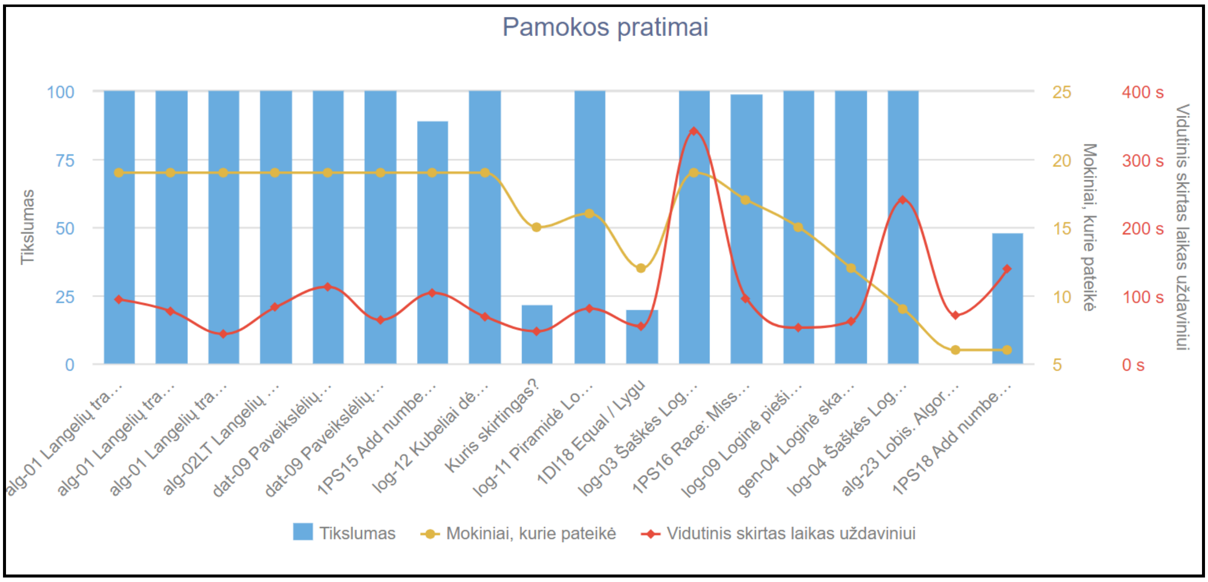


Figure 1. Student progress during the lesson

The "student diligence" view in Figure 2 (for grade 1-2) shows each student as a dot, placed according to their total points and time spent. Vertical lines mark the thresholds for different awards, the trophies. As an anecdote, one student continued working at home immediately after the lesson, which is reflected in the extra time captured here. The general trend is clear: students who spent more time tended to score higher. If any tasks had been poorly designed, this pattern would have been disrupted. This view also acts as an alert system for teachers—if a student is putting in significant effort but consistently scoring lower than their peers, it would be immediately visible. However, in this case, no such issues were observed.

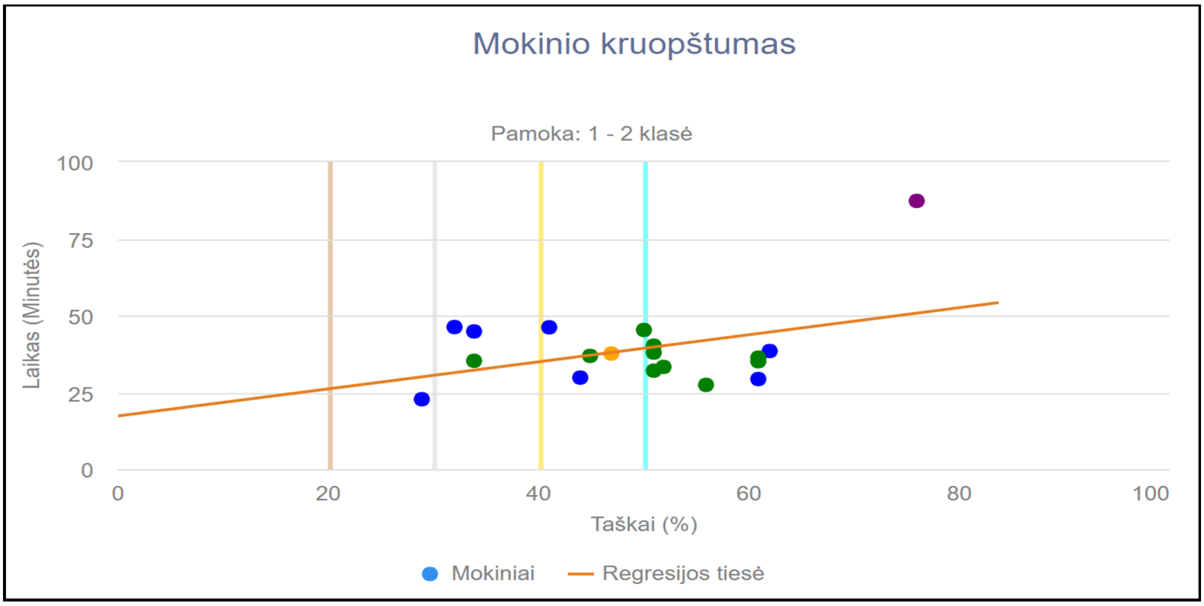


Figure 2. Student diligence view (in Lithuanian *Mokinio kruopštumas*)

Learning analytics, while powerful, should always be complemented by the teacher's knowledge of the class and ideally used over a longer period. These visualizations offer just one perspective on the broader picture of student learning.

Dissemination metrics

Quantitative Indicators:

- 6 white papers distributed to educational service providers and education policy makers. Target, 6 national educational policy officers, and 14 boards of education comprising a minimum of 200 schools across the whole consortium;
- 5 reports distributed to educational stakeholders per partner, 3 articles in national teacher magazines.
- Social media updates, on average 1 per month for each partner;

Cumulative participation in Multiplier/Dissemination events - collective quantitative metrics from project partners (10), external experts (10), teacher educators (20), trainee teachers (50), and in service teachers (50) over the whole consortium. Collected by surveys throughout the project.

Policy focused event (CT&MathABLE Summit) (lead by ELTE and KTH) briefs 50 leaders of Education Providers (Municipalities, School Boards, Heads of Education Depart. etc.) on the outcomes of the project, the learning gains that can be achieved, and why the system and its associated pedagogies should be widely adopted. This event emphasizes the systemic benefits on school system performance and assessments. Measures: 50 people in total attendance, 4 policy makers, and a minimum of 10 representatives of education provider organisations.

VILLE Performance Statistics

- From year 2 minimum 200 students engaging in training CT and Math skills in the online system each year;
- Interactive tasks are assessed as highly relevant and engaging by pupils, assessed by survey;
- Learning analytics in the system show demonstrated learning following the proposed CT&MathABLE learning architecture;

Qualitative Indicators (all surveys have 80% response rate targets):

- Satisfaction of participants attending the multiplier/dissemination events, assessed by quality assurance survey;
- Satisfaction of participants about the Final Summit event, assessed by quality assurance survey;
- Policy maker evaluations of white papers and films, evaluated by interview.

The project advisory board

Partners appointed members to this board from external institutions. Advisory board enable the evaluation of the project activities, ensure quality, maximize impact. This board comprises international and interdisciplinary expertise, from policymakers and local stakeholders: Ágnes Németh (Hungary), Alvida Lozdienė (Lithuania), Filiz Kalelioğlu (Türkiye), Heikki Hyyrö (Finland), Matti Tedre (Finland), Marytė Skakauskienė (Lithuania), Tapio Salakoski (Finland).

CT&MathABLE website:

https://www.fsf.vu.lt/ct-math-able