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USING INNOVATIVE TEACHING STRATEGIES IN MATHS CLASSROOMS

REPORT ON THE ADDED VALUE PROJECT CONCERNING ALTERNATIVE TEACHING METHODS
RUN BY THE SCHOOL WITH CLASS FOUNDATION TOGETHER WITH NHL STENDEN,
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1. Maths as a demanding subject

Maths is perceived as one of the most difficult school subjects. Several factors contribute to such an opinion. First, it is a common practice to divide students into those who are good at maths and those who are good at humanities. The second group, once labelled in this way, starts to feel that there is no reason to study maths. Both teachers and parents use the same grouping mechanism (Baczko-Dombi, 2017). As a consequence, there is some sort of a generalised acceptance of lack of mathematical skills. Also, girls are assigned to the “humanities” group more often than boys, which can lead to decreased interest in science in the future (Bedyńska & Rycielski, 2016; Eccles & Jacobs, 1986). It is also a common opinion among students that maths is of no use in everyday life. Thus, there is a great need to change the stereotypes concerning maths as a “difficult and useless” subject in Polish schools.

The second factor that makes people reluctant to study maths is the attitude of the teacher. The teacher's role is key in determining the student's success or failure at maths. Students emphasise that their motivation is much greater whenever they are instructed by a good teacher who knows how to explain mathematical concepts and does not mock them in front of the blackboard (Baczko-Dombi, 2017). It is commonplace to think of maths teachers as stricter and more unjust than the rest of the school staff, however.

The third factor influencing maths performance is the teaching method. Although the school curriculum emphasises the importance of reasoning, argumentation and problem-solving strategies, school lessons in Poland are usually limited to teaching basic instrumental skills and using traditional methods of instruction. There is no attempt at developing curiosity and creativity. Besides, the need to prepare students for final exams that mark subsequent educational stages discourages teachers from trying out more diverse teaching methods. According to the teachers, the syllabus is overloaded with material and the number of hours to be devoted to teaching a given subject matter is insufficient. School lessons do not go beyond what is proposed in textbooks. Some of the teachers try to incorporate real-life examples in their

lessons, use game theory or organise escape rooms with mathematical enigmas to activate students. Others use the available internet tools such as Geogebra that facilitate the understanding of solid shapes. The use of physical aids is fairly uncommon. Teachers say there are practically no such materials in Polish schools (survey conducted by the School with Class Foundation).

The current educational system does not encourage holistic teaching. Teachers of different subjects rarely cooperate beyond additional undertakings or extra-curricular activities, such as organising a school science festival. We seldom see the same issue discussed from more than one perspective, e.g. at a maths, Polish language and/or biology class.

2. The Added Value programme

In June 2019, we ran a project that focused on innovative maths teaching methods. As a part of the initiative, teachers were offered a range of tools – lesson plans using the design thinking method in problem-solving. Over 200 teachers from more than 260 schools took part in the project. Maths teachers applied for participation on their own initiative¹. 193 teachers participated in two surveys whose results are presented below. The goal of the project was to show the practical dimension of maths. Another objective was to show both teachers and students that there are interesting ways of learning mathematical concepts that go beyond solving math problems on paper. The materials used in the project were accompanied by incentives to work with teachers of other subjects so that students could see the generalisability of maths and mathematical thinking.

Factors that constitute the basis of the Added Value programme include fighting negative stereotypes about maths as a “difficult” subject, using mathematical skills in everyday life, endowing students with enthusiasm and excitement about learning maths and related scientific methods.

Teachers had 8 lesson plans to choose from. All of them combined maths with other subjects:

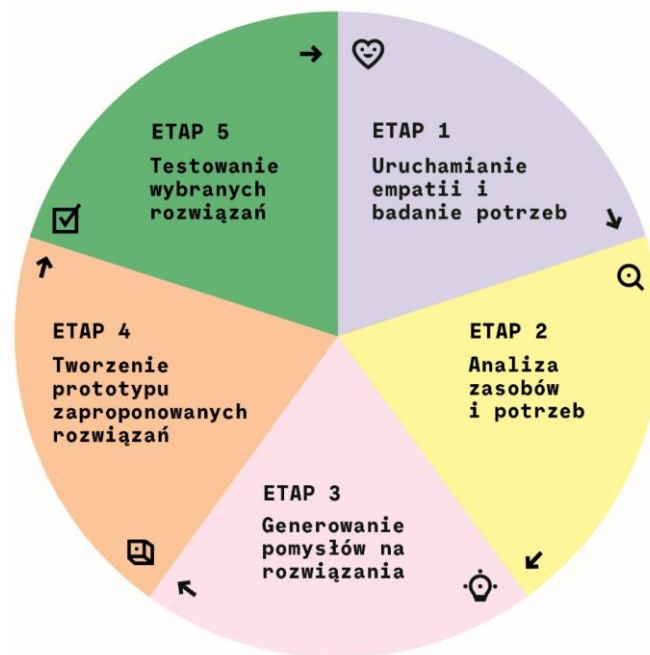
- designing a dream classroom (offered as the first, obligatory option, and hence implemented by 93% of the teachers),
- organising a school trip (implemented by 11% of the teachers)²,
- baking muffins (11%),
- preparing a salad (11%),

¹ As teachers participated in the programme on their own initiative, we cannot make any statistical inferences on the whole teacher population. The sample is not representative. Teachers from both big and small towns and villages took part in the project. They represented small schools and bigger school complexes.

² The percentages do not sum up to 100 because the teachers were free to use more than one lesson plan. The percentage points indicate how popular a given option was.

- boosting physical activity in class (8%),
- planning a local sight-seeing trip (7%),
- lowering sugar intake (6%),
- less plastics in the waste bin (4%)³.

The teachers were asked to choose any lesson plan they wanted and use it with the class of their choice. Most of the projects were undertaken with 4th and 5th grade students. The average number of students taking part in the lessons was 20. The lesson plans were based on the design thinking method which consists in identifying the needs of a given target group and then preparing and testing solutions.



Stage 1. Using empathy and identifying needs. Stage 2. Analysing needs and resources. Stage 3. Generating ideas. Stage 4. Making prototypes of the proposed solutions. Stage 5. Testing selected solutions.

An overwhelming majority of teachers (97%) were satisfied with the project and the materials prepared by the School with Class Foundation. The teachers were also surprised by the positive feedback they got from students. Only 3% of the teachers said that their students were not very engaged in the task. Below, we present the main conclusions from the survey, adding some of the teachers' comments (in italics). Survey participants used the provided materials to summarise the concepts introduced earlier in class. 58% of the teachers deemed the provided materials (lesson plans, posters) very good, and 35% – good. The teachers pointed out that they were interesting, practical, concrete, content-based, well-prepared, and that they foster

³ All the materials from the Added Value project, including lesson plans, are available at: <https://www.szkolazklasa.org.pl/programy/wartosc-dodana/>.

students' social and scientific development. Only 7% of the teachers deemed the materials mediocre (e.g. they said that the first instruction telling student to divide themselves into groups was unclear). 97% of the teachers plan to use the materials and the associated design thinking method in the future.

The aim of this report is to show how the project addresses the main factors that discourage students from studying maths and what changes it proposes to improve the situation.

3. Students' attitudes towards maths

3.1 Converting negative attitudes into active engagement

Low levels of student motivation, in and beyond math classes, is a common problem at Polish schools. The proposed method helped change students' attitudes. Some of the teachers decided to ask their students which lesson plan they wanted to use, which boosted their engagement. Many teachers were asking for the students' opinion for the very first time. While working on the challenges offered by the School with Class, students were happy that they could put forward their own ideas and had an influence on their implementation (especially in the dream classroom case). Engaging students in the decision-making process and empowering them had very important consequences in terms of motivation. Students happily took part in class activities and expressed readiness to take up new challenges when their teachers gave them some part of the initiative.

I did not expect that so many students would vote for the muffin baking project and although I explained that they do not have to actually bake muffins to get the highest score and we wanted to focus on mathematical solutions, they ended up bringing loads of muffins to school and having other children taste them. They took their respective needs (gluten-free) and preferences (different flavours and toppings) into account. They were really satisfied with their results and other students respectfully tasted the muffins prepared by their peers.

The experience was very positive; it was nice to look at students who willingly measured, calculated and drew their ideas. I could see how they share their tasks, help one another and engage in the activities within their own limits.

The students were more engaged in class activities and did not hesitate to propose their own solutions. They responded to their peers' questions in a comprehensive and factual manner. They actively participated in class.

The proposed method engaged all students and resulted useful also in the case of those who were falling behind. Thanks to this methodology and to the offered lesson plans those who did not excel in maths had a chance to show their strengths.

My students fulfilled the task 100% on their own. The descriptions provided on the worksheet were very well-prepared. I think that the choice they were given at the beginning was crucial. In this way they did not feel that they were doing maths. Rather, they had a good excuse to meet after school and jointly bake muffins. Even average students and those who normally have difficulties with maths were appreciated and showed excellent pastry-making skills and hospitality. Apart from getting maths grades for the task, the students were also praised for organising a muffin-tasting session for their classmates. Our sweet maths holiday lasted the whole week.

I was surprised by how well weaker students did.

3.2 Student independence and class integration

The presented method was also about putting trust in the students. Many teachers did not expect that students can divide themselves into groups and assign tasks in accordance with their possibilities.

Students' proposals were very surprising. I had no idea that a different desk arrangement was so important to them. I really liked the brainstorming session during which the students tried to get to know their expectations. The discussion which took place after student ideas were presented was also interesting. During this type of activities, you get to know your students a lot better than during a traditional lesson.

The task that went beyond textbook examples and student notebooks activated the whole class. Students willingly cooperated and shared their knowledge and skills. They also took their own initiative in proposing additional elements. They liked the way the class was organised and showed willingness to participate in subsequent challenges.

With this method, students do a lot of planning and then test and reject some ideas, choosing the optimal solution. They like it because nobody tells them how they should think. They are the ones who take responsibility for their actions.

The chosen projects also offered a way of getting to know the students and talking about group decision-making and compromise.

It was very interesting, insightful and tasty. Maths resulted to be essential and not as difficult as it might seem.

The method also showed teachers how much they take upon themselves – this includes tasks that might be delegated to students with a little bit of trust.

I would never have thought of it myself. Whenever I change classroom arrangement, I take a few volunteers and we redecorate the class after school. I usually do the rest myself.

3.3 Facing the fear of maths

Using the design thinking method encourages proposing various ideas, including those that are not very feasible. This is an added value for students who can see that mistakes can be made and there is no punishment. They learn that they can err and improve their way of solving a problem. In traditional classrooms, students are usually punished for making a mistake by getting minus points or lower grades. With design thinking, they did not fear failure or criticism.

All students had a chance to show their strengths and aptitudes, which made them more actively engaged in the task and cancelled the fear of failing at the assigned task.

Instead of fear and answering questions in front of the whole class, the students learned the benefits of cooperation. The design thinking method and the real-life value of the maths problems showed them that school does not have to be boring and that they can discover new things together with their teacher. Another advantage of the method is that there are no bad ideas. Everyone, including those who struggle with maths, can participate in the group undertaking.

The lesson was dynamic and at times funny. It allowed everyone to relax and learn a lot.

The chance to show one's strengths is the key to overcoming the fear of maths. During the task, students not only practised their mathematical skills. They also had a chance to integrate and get to know each other better.

The task, divided into five stages, allowed students to get to know their peers from a different angle (their tastes, preferences, expectations). It also showed them the importance of teamwork, communication, argumentation and getting feedback. The task activated the students' imagination. As a result, we had dream classroom projects presented in a variety of different forms (drawings, plans, mock-ups).

4. Usefulness of mathematics

By solving true-to-life problems, students could see that maths skills are important in adult life.

The students played the role of travel agents. They wanted to optimise the route at all cost, made appropriate calculations and showed 150% engagement in the task. They saw the practical aspect of mathematics.

Thanks to the implemented lesson plans students had a chance to learn how to make both small (shopping lists) and bigger plans (e.g. school or family trips). Teachers who used the school trip lesson plan were also glad that students got to understand how complicated and time-

consuming organising a school trip is. They said that some of the proposed trips will likely be implemented in the next schoolyear.

The students realised that a lot of time has to be devoted to plan a school trip, that it is not done automatically. They were surprised by how much effort it requires, even when the tasks are assigned to different groups and the costs are calculated with the use of Excel. They had to consult prices via internet and learn how to use mathematical formulas.

Some teachers allowed the use of smartphones and then expressed their surprise at the fact that students actually used the devices to find the necessary information. Such a move also showed students that phones and internet can be used for purposes other than entertainment.

The "lowering sugar intake" and "physical activity" challenges sensitised students to topics related to healthy lifestyles. Here, they not only had to make measurements and calculate weights, but also acquired new knowledge about leading a healthy life.

The lesson plans are interesting. Those who do not fare well during "typical" lessons are more engaged. I can see they are happy to be working on the tasks.

The tasks are useful in activating those students who tend to be uninterested. I also discovered organising and leadership skills in some students against my initial expectations.

5. Teacher cooperation

The maths teachers who participated in the project were encouraged to invite other members of the school's teaching staff to join them. 22% of the surveyed persons decided to use this option at their first attempt. With the second challenge, the number of teachers opting for cooperation raised to 53%. Many of them decided to work together with IT teachers. Students made the planning and measurements in maths class and the necessary conversions and calculations were then made in IT class with the use of Excel. Some students would draw solution prototypes using graphics programmes, others used programming. Preparing mock-ups and drawings of a dream classroom was partly implemented in arts class, while scaling was taught in geography class. Sometimes technology teachers were involved in space planning (classroom arrangement).

There were also some non-standard solutions, e.g. cooperation with linguists. In this case students prepared some part of the tables and descriptions in English or German, e.g. put names of products that can substitute those rich in sugars (lowering sugar intake) in the table or made a salad recipe based on an English puzzle set. Thanks to such challenge expansions students could practise several skills at once.

The nature teacher prepared a worksheet based on the provided design thinking worksheet. It was a travel agency offer. The class, divided into groups, had to create a travel

agency that organises trips in the Silesia region. In nature class, the students worked on identifying the needs of the group, analysing needs and resources, and generating ideas. In maths class, they calculated the costs of the trip, looked up information on entrance fees, time needed to get to a given tourist attraction and finished with a detailed description of the trip. During the weekly class meeting, each travel agency had to prepare a poster promoting the trip. At the end of the lesson, each group had 5 minutes to advertise (present) their proposal.

6. Problems with the innovative lesson plans

Some teachers (5%) reported problems related to the challenges and to the design thinking method. They said that the method introduces chaos and confusion. They also pointed out that conflicts arose during the needs identification phase and when generating ideas.

There were some quarrels because boys and girls were in disagreement.

They also noted that some of the challenges are best suited for students from 4th to 6th grade (school trip planning, muffins), while other require more explanation and teacher engagement (ecology).

Ecology is not very interesting for children. I had to modify the tasks so as to make students more active.

Working in teams is difficult and noisy. Students find it difficult to concentrate. I do not teach this class so it was difficult for me to discipline them. They found the materials curious and inspiring.

Some teachers complained that the method, although interesting, takes up too much time (the optimal time for such a lesson is 90 minutes). They therefore declared that they would not use it in the future.

I think the method is too time-consuming and lack of time is the norm in teaching. The method fulfils all the criteria from the school curriculum but the time necessary to teach specific parts of the material and skills in the curriculum is insufficient for frequent use of design thinking.

There were also some teachers who expressed doubt as to whether the conducted lesson involved learning or whether there was enough mathematics in it. It seems that students' enthusiasm, their engagement in making the necessary measurements and conviction that things need to be calculated correctly are all valuable outcomes but are difficult to assess. Presumably, students managed to solve fewer tasks than at a normal lesson, but they solved them thinking that learning percentages, scaling, fractions, areas of geometric shapes, etc. is

essential. 97% of the teachers who participated in the programme said that the project was useful in teaching maths.

I was glad to see how engaged students were. They willingly took up the challenge. There were lots of ideas. Students were happy to be able to decide on their own. They eagerly investigated, measured and calculated things. They also efficiently used their math knowledge and skills. (And did not really need the teacher's assistance). It turned out that they know and remember a lot from previous lessons. I was very proud to see that they can easily use this knowledge. Interesting ideas and materials help a lot in teaching.

Assessing how much children learn in an innovative classroom can also result difficult. Many teachers like creative teaching strategies but rarely use them, opting for traditional lesson plans and evaluation methods instead (in-class tests with math problems to solve, individual assessment).

I was not sure what to expect from this class, i.e. what educational effects are to be achieved. I would prefer it if the guidelines were more precise.

7. Conclusions

The proposed methodology allowed teachers to conduct interesting lessons that engaged even those students who usually stay away from maths. Both teachers and students were satisfied with the lesson plans. The use of design thinking and making the tasks more true-to-life showed students that maths is useful in many situations. Apart from maths skills, students developed other skills and social competences. Thus, the aim of the project, i.e. motivating students to study maths and showing them its general usefulness in life, was fulfilled.

A lot of other educational effects were achieved thanks to the design thinking method. Students understood that empathy is crucial for effective problem-solving – they had to think about other people's needs. They also learned that it is worth devoting some time to generating multiple solutions. In this way they trained themselves in listening and argumentation skills. Students were also asked to test the proposed solutions, which showed them that making mistakes is not a catastrophe and there will be time and place for corrections if the problem-solving process is well-planned. Students were making joint decisions and taking responsibility for their choices – this is a key competence in adult life that is rarely developed in traditional classrooms.

All of the above are key competences on the rapidly changing labour market. Thus, we can conclude that thanks to the innovative teaching techniques proposed by the School with Class, students had a chance to not only practise their mathematical skills, but also prepare for adult life challenges.

Teachers saw that their students were curious about the world and able to actively implement the assigned tasks. At the same time students, especially those that struggle in the classroom, showed a lot of skills that came as a surprise to their teachers.

The proposed materials complement the learning process, making it more active in accordance with the assumption that people do not learn by listening to lectures but by fulfilling specific tasks. All of the proposed challenges are based on learning by acting. There is no need to explain that maths is useful – students will experience it on their own. Besides, the materials can be used in many ways, adjusted to the age of the students, class dynamics and to the material introduced earlier in class. The proposed method is also suitable for replacement classes and weekly class meetings.

Using the proposed lesson plans on a larger scale by introducing an interdisciplinary, problem-based approach to acquiring knowledge, skills and social competences in the classroom would entail changes in the school curriculum and learning styles reorganisation. Nonetheless, as shown by our surveys, it is also possible to use design thinking within the realm of Polish schools today.

The proposed methodology has many advantages and one main inconvenience: it is time-consuming. Despite this minor flaw, it is worth pursuing given the skills acquired by students in the process.

How to begin:

1. Choose a challenge that best suits your student group.
2. Plan a separate date for explaining the design thinking method (e.g. the weekly class meeting, replacement class).
3. Invite another teacher to cooperate. This will give you more time to implement the task. It will also show students that maths can be combined with other subjects.

Sample teacher cooperation plan: "Organise a school trip" challenge

On a given day, during the first lesson, students are familiarised with the topic, e.g. with a design thinking workshop. During the second lesson, e.g. weekly meeting with the class tutor, they divide themselves into groups and try to identify their expectations (concerning the destination of the trip). In geography class, they can look at the different tourist attractions region by region; in maths class they can calculate transportation and accommodation costs and divide them by the number of participants. In Polish language class, they provide the plan (description) of the trip, while a foreign language class can serve for preparing a short advert of the trip. The biology class can be used to check which animals and plants can be appreciated in the visited area.

Literature:

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