Translated for Cambridge Mathematics by Aleksei Komarov, a Distribution Assistant in our Group Printing and Operations Team.

Maths is needed to become a self-confident citizen

Education innovators believe, that while studying maths a child not only learns how to count but also how to solve problems logically and creatively .

Lynne McClure – an ex- maths teacher and Director of Cambridge Mathematics is one of them – says science journalist Arko Olesk.

It seems that the whole of education, including mathematics, is trying to re-invent itself. What does this lead to?

The world is moving forward. Kids come to school with highly advanced software such as iPads and smart phones. What do they do in schools then?

We are now 50 years behind the times and you wonder why students do not believe in the importance of education any more. Who can blame them?

Whenever the program of lessons is being developed – in most of the cases there won't be any difference - students still have to learn to multiply , divide etc .

Nobody starts the development of the study program from scratch; everybody relies on what has already been done.

What if we could forget what all the rest are doing, and think of what kind of mathematical education we can offer students in 21st Century, bearing in mind that we are living in the times of a digital revolution and today we know much more about a child's learning process.

If we take all this factors into consideration, do we still want to teach them the same things as we've done before? This is the major theme of the project that is being undertaken by Cambridge University.

What is the purpose? What skills and capabilities should the new graduates, who have passed the program in a new way, obtain?

'In ideal world, we want them to be able to think as mathematicians.'

What does it mean?

'It means that they should be able to find patterns, should be able to search for general conclusions, instead of looking at the single details.'

Math studies contributor, Al Cuoco, speaks about mathematical thinking habits:

According to him, student's desire to describe, hypothise, imagine, invent, design and to dig something out should be highly supported.

’This is what mathematicians usually do and what we usually avoid doing during maths classes, because we focus more on calculations and on copying the solutions for similar exercises. We try to give students an experience that supports and encourages mathematical actions.

We do realise that people learn maths for different reasons.

If we take the whole of maths studies from age three to 18, then we can say that those who want to study general maths at the University of Tartu (Estonia) should learn one part; those who want to become a plumber or hairdresses or a primary school teacher need to learn another part.’

But people do not know in advance want they want to be, do they?

‘The general/basic part is huge. You may not need to use maths at work for something in particular; however, you do need to be able to make vital decisions to be a confident and competent citizen. You need to recognize whether politicians tell the truth or to be able to decide which phone to choose from. In other words, you need to know which part of maths to use in which situations.

As the first program is now in place, we can ask - what kind of professional skills do teachers need to teach these pathways, what kind of resources do both teachers and students need, and finally we need to answer the question - how do we assess students?

In most cases, when developing the study program they take into consideration what knowledge they want students to gain finally. And then, after this final destination point is determined, the rest of the studying chain is developed. Study programs adheres to assessment, we want it to be the other way round - assessment adheres to the study program. In the first place we decide what experience we want students to gain and then after that we decide how to assess it.

You came to Estonia, where, according to PISA studies, we have the world's smartest kids...

‘However they do not like school that much...’

Exactly. This is due to education methods. The whole education structure should be changed in this case.

Of course. The main question is what experience do we want to provide for students and how can we do that. Nowadays we know much more about learning processes and should be able to take it into consideration and implement this knowledge when designing textbooks. Our textbooks are terrible. They are designed as if the teacher is writing something on the board and gives students 25 very similar tasks to complete.

Maths was one of my favorite subjects at school – just because I loved to complete those tasks and solve the puzzles. You just put given information into the right place and receive a beautiful result.

It is a good feeling, isn't it?

Yes, however who will teach me the rest, something more than the ability to complete and solve the tasks?

Maths is being taught in a more instrumental way. In Britain there are many state exams - when children reach the age of 7, 11 and 18. According to the results of these exams, schools are being classified in order of competence and they are being inspected. They have to report on how they are going to improve their results. As a result, the results of the state exams end up being the aim of the studies. Teachers say that they want to make students understand maths; however, they are preparing them to pass exams. The fact that they pass the exam doesn't really mean that students truly understand maths.

What ratio should there be between abstract and applied mathematics, if such a ratio could be meaningful at all?

There are those who say, that you can go through a whole study program using problem solving, experiential learning skills. Certain skills you need to acquire anyway, because without them you will be slower. When nine-year old uses his fingers to add up, it prevents him from the opportunity to think as mathematician. There is definitely a place in education for pure maths and for algorithms; however, there should be an objective. The aim of mathematics is to solve the problem; it doesn't matter whether these problems arise in mathematics itself or in real life.

For example, let’s take the skill of counting the corners in geometric shapes. Unless you are an architect, you won't think that there is any need to possess this skill. For most of us, you won't need to implement this skill when shopping or doing something similar day-to-day tasks. However, this skill requires a logical action, and I believe that it is very important to teach how to think logically.

Another skill that we often need in our lives - in decision-making or while evaluating the results of a survey - is statistics. Is it being taught sufficiently in schools?

In some situations it is up to the child to decide whever he/she wants to gain the skills or knowledge. I believe that statistical literacy is the case here. In the new education process a lot of attention is being placed on how to implement skills in the real life. For example, when analysing an article, think about it's actual meaning. When the information is being passed to the reader, he can be misled by statistics or think to himself - what do these statistics mean?

New mathematical education development project:

- ‘Cambridge Mathematics’ is the educational project being conducted by mathematicians and researchers from Cambridge University, the aim of which is to develop an entirely new **maths education program based on experiential learning**.
- The Wolfram consortium develops computerised training materials. Statistics and probability theory study **materials were first used in Estonian schools.**

What is the role of the computing technology in the new approaches to maths? Can we assert, that we do not have to study maths , since we can find anything in Google or in Alpha Wolfram?

People do not need just the information on its own; they also need the understanding of whether the information is trustworthy. They need to evaluate whether the answer they find on the internet makes sense.

Our reason for coming to Estonia is for the statistical study project that is being tested in Estonia. In statistics, a computer helps to do certain things that cannot be done without it. When you've got just 20 data points then you can easily find the average, mean, median and mode and manually draw a graph. When you've got 20000 data points it would take too much time.

Computers help to do this work for you but we can only use computers to work with large data sets. Calculations themselves are simple; however the computer does not interpret the result. A person should interpret. **P**roject testing ideologist in Tartu, Conrad Wolfram, says that you have to be able to materialise the problem, you let the computer do the work and then you rate the answers. This is an appealing method according to Conrad's theory; with computers you can teach how to find mathematical solutions to problems. For example, we visited one of the lessons where the topic 'Am I the mean?' was discussed. This question can be answered only when the context is understood. We deal with spatial (three dimensional) geometry and one of our questions was: how do you find the lost plane?

In order to ease the understanding, a wonderful three dimensional model was made, however I believe that plenty of things can be better done using a pen and paper. Probably because I've got a technical mind, however, I am not sure that you can teach all the important things when a computer does all the complicated work for you. I believe that is better when there are a number of tools you can use.

We need a considerable number of people who could understand what the computer is doing. It is not enough that the computer does everything. The main thing is that I can interpret the results. We need both - those who use maths and whose who create maths.

If everyone starts using computers this way then who will be doing the complex mathematics that is needed for the future step in progress?

You have visited innovative maths learning projects all over the world.
How do children react to all of this? Do they study in the way we had hoped?

Statistics show that they do come around, they like it, they can explore and discuss it with their friends, however, it seems that they may not be able to make conclusions based on a specific problem or realise what mathematical knowledge they have just acquired. When talking about a problem, they always confined in this one familiar context, they could not bring the maths out of it. **After handling more problems they start to see similarities in the problems and begin to perceive the underlying mathematics in them.**

If we talk about the results of the exams – they asked children who were participating in the new education program and children studying a general program the same questions. One might think that the experimental group did worse. In fact, they performed nearly the same. In this case, what is the point to pass the new educational program if at the end the assessment questions are exactly the same? If you study in a different way, does it mean that assessments should be different as well? What opportunities to think differently does the digital world offer us? Nobody has yet found the answer, and I believe the answer is very important.