Introduction

It all started far beyond the City limits, in a small town called Villiersdorp, a young school girl sat worrying about her Maths lesson. She practiced her sums diligently at home, each time getting them wrong and becoming more anxious about the maths lesson. It seemed as if the other students in her class understood the sums while she was the exception.

Her class teacher, tried over and over again to explain the same multiplication method to her without any luck. The young girl started to get the sums correct. Once she had memorised the rules she could do the method until the teacher threw her a curve ball, this method had not helped her understand what she got to the answer.

It was only later in school that this young girl knew which questions to ask to help herself understand. At this point she realised that there were many more students just like her, who couldn’t explain what they were doing in mathematics. She went on to help others understand, and she loved Maths. This was where her passion for teaching came from.

This little girl is me. I went on to finish school with a distinction in Mathematics and later to study pure mathematics at university. The skills I learnt in maths once I understood, have helped me solve many problems in Mathematics and in life.

I am going to use this example from my life and focus on multiplication to explain my idea today.

I would like to start by defining the two key concepts outlining my presentation:

1. Critical thinking
2. Problem solving

I believe these two concepts are very closely linked and overlap on occasion.

Critical thinking:

Critical thinking is being able to make meaningful, unbiased decisions or judgments. Students need to be able to interpret, analyse, evaluate and understand the evidence that relates to a particular discipline. A 21st century critical thinker will be unique in their way of thinking, as they will each have their own interpretations and allow them to think for themselves instead of learning information parrot fashion.

Problem solving:

Problem solving is the logical interpretation of a problem and the approach of solving the problem or finding a solution to a problem. There are many challenges in everyday tasks which are difficult to complete. Arnout Brombacher, a mathematics teacher and leader in the South African mathematics education community, would say that problem solving is knowing what to do when you don’t know what do to...
**Similarities between Critical thinking and Problem solving:**

Critical thinking and problem solving are similar because they both encourage students to think about how they approach a problem or challenge and how to tackle the problem.

The following procedure can be applied by critical thinkers while solving a problem:

1. Identify the problem (which computational skill they need to use)
2. Conduct research (engaging with the information given)
3. Generate ideas (use previous knowledge to develop their understanding)
4. Develop possible solutions (apply your understanding)
5. Check solutions (have they used sounds reasoning)
What is critical thinking in mathematics?

Mathematics is about thinking critically to solve a problem. We need to keep this in mind when we are teaching mathematics. For example instead of introducing multiplication by saying “alright class today we are going to look at multiplication” and then start by showing them how to do solve a multiplication sum.

\[ 56 \times 5 \]

You could set them a problem, or ask them a question and allow them to use practical tools to find the answer which would help to guide the students to the method you have in mind. For example:

Problem 1: If I have four groups of 5 marbles, how many marbles do I have altogether?

Problem 2: What if I have 4 groups of twelve marbles, how could I work this out?

This problem could not just be any old one, you would need to think carefully about what you wanted the students to learn in that lesson and therefore what question you would ask. You can see in my example, the first time they would probably count in fives until they get to the answer. The second example would be more difficult to do this so we could talk about how to add twelve up in a simpler way. You would not want to tell them what to do but rather work together with them to develop a strategy or set of criteria for deciding which method would be the most helpful.

By approaching a problem like this you are expecting the student to use his/her previous knowledge and reasoning to solve the problem. When a student is thinking about the reason for using a particular method and then deciding on an appropriate method to use, he/she is far more likely to understand it and then remember it. In other words the student needs to consider the reason and criteria behind the decision to use a method and does not just guess or follow a rule which has been memorised from class without understanding or assessing its use.

When we are teaching mathematics in primary school we need to make sure that we are not teaching each concept on its own. For example, addition, subtraction, multiplication and division are all very closely linked and one cannot be taught without the others. This means it is important to draw on their previous knowledge and understanding and not to teach each separately.
I have a video to show you how I introduced multiplication to a group of nine year old boys, who find mathematics very difficult. Please notice that I did not ever show them a method. But rather just asked them carefully thought out questions to help them develop their own method.

*VIDEO*

https://drive.google.com/file/d/0B1x3rbLUE7VkMXYwcGU5UmV2Vnc/view?usp=sharing

Mathematics is more than just curriculum or textbook based formulas focusing on the final answer. Students need to understand these formulas.

We need to shift our focus in teaching from teaching learnt facts to thinking about thinking. If they learn to think they could think to learn.

I will show you an example of someone teaching the soldier multiplication method. I have added questions to the video to remind you of some of the questions a child might ask or be wondering while you were teaching this method.

*VIDEO*

Although this method is in actual fact just an extension of some of the methods I might suggest that you teach, it is in my opinion the incorrect method to introduce multiplication with because it is so abstract. If a student did not properly understand this method they could do one of the following:

A nine year old might misinterpret the soldier sum in the following way:

\[
\begin{align*}
56 & \\
\times 3 & \\
\hline
1518 &
\end{align*}
\]

A twelve year old might misinterpret the soldier sum in the following way:

\[
\begin{align*}
2y & \\
\times 8 & \\
\hline
24y &
\end{align*}
\]

Students are not learning to think mathematically when this is the first method we teach them, they are learning to blindly follow directions to manipulate figures and to mindlessly do what they think they’re supposed to do.
Ask “why”

In my opinion the most important part of learning maths is to learn to ask the question “why”. This question encourages us to think critically.

\[12 \times 50 = \]
\[12 \times 5 = \]

Most students just mindlessly follow what they have learnt from a teacher, in a text book or by any digital source. They do not think about why this method was a good one to use, why is it helpful to know how to do this problem, where the concept started, how it links to the previous concept or why the basis for this problem works.

The next video I am about to show you is of a group of 10 and 11 year old boys who really enjoy mathematics. I divided the class into groups and then gave each group a different multiplication sum. They needed to find an easy method to solve the sum. I would like you to notice that the same method is not necessarily the best for every sum.

*VIDEO*

https://drive.google.com/file/d/0B1x3rbLUE7VkRWdDWDkyUDAxboU/view?usp=sharing

In mathematics the critical thinking usually comes when a student asks the question why and does not just take the problem at its face value.

Thinking happens during the method

Physics teacher Gary Stickland said Learning stops at an answer – thinking happens during questioning and “Why” is the question we should be encouraging our students to ask. With this in mind one of my suggestions, especially at a primary school level, is to take the focus off the answer and direct it towards the method. We can do this in many ways but to start we could include the sum and its answer in our questions and then ask the students to use any relevant method to prove that the answer is correct or by allowing the students to check their answers with a calculator and then make the necessary changes if their answer is incorrect.

Why 21st century students need to be critical thinkers and problem solvers?

These days’ students have the world at their fingertips. Most students have access to technological devices, which allow them to connect with others through social media and explore and exchange information. There is a vast amount of information available to them and they certainly do not need to come to school to get this information. Despite all these opportunities and the information available, students are not reaching a higher level of learning. The reason for this is that they have not developed the critical thinking skills needed to be selective in the technologies they use. Being able to think critically would allow them to analyse the “hits” they find on a Google search. There is therefore
very little use in teaching students facts that they could find on social media. A critical, problem solving mind would allow any person the ability to find any information needed via technology.

**Why take the time to promote critical thinking in maths?**

Teachers taking the time to develop critical thinkers will benefit their students and their learning environment. The students have learnt to think and are therefore able to think to learn. Students who are encouraged to think critically and solve problems will be able to:

- Exercise sound reasoning in understanding
- Make complex choices
- Understand the interconnections among systems
- Analyse and solve problems

I have an English example from my classroom. At the start of the year I asked my class to prepare an oral about themselves. I gave them a worksheet with the set of instructions. Most of my students just followed my instructions set for step. However, one student first thought about what he wanted to say and then decided on the best way to say it. He used the image of a tennis racket and compared each part of his life to the strings of the racket.

I have another example where a friend of mine was trying to swap the front wheels on his car with the back wheels. He first jacked up the whole side of the car leaving just two wheels and the jack on the ground and tried to take the other two wheel off. The car was so unstable it almost fell off the jack. If was only after he had thought about what the problem was and come up with a solution that he realised that he could take one wheel off at a time and swap it with the spare one as he went around.

**The solution to this is to shift the focus from method based teaching to teaching through problem solving and guided critical thinking.**

I leave you with these quotes that I found in the Greensboro Handbook, Greensboro Public Schools Reasoning and Writing Project:

“Be aware of the hidden curriculum in all schools. If teachers ask only factual questions that test memory and recall, students assume that this is the most important aspect of learning. If principals spend more time focusing on administrative concerns, discipline or standardized test scores, teachers also assume these aspects of school are the most important.”

“Teachers need time to reflect upon and discuss ideas, they need opportunities to try and practice new strategies, to begin to change their own attitudes and behaviours in order to change those of their students.”
In conclusion children need to THINK to LEARN but are we as teachers stunting this theory by manipulating their learning to satisfy test results?

Some points to think about:

1. Should we be using more technology to encourage students to think critically, such as calculators or Microsoft Excel?
2. Is parent involvement with homework merely a hand down from their own school experience or does it enhance their child’s ability to think critically?