Abacus and Empirical Modelling

Abstract

Abacus as a calculated tool has been used in schools and other areas for many years. Throughout this paper it is going to be examined how to use an abacus can be taught, how easy or difficult that can be and also how some aspects of Empirical Modelling (EM) can be used in order to help learning how to use the abacus without actually knowing in advance how it works.

1. Introduction

For many centuries abacus has been used as a calculating tool for performing arithmetic processes in many parts of the world. That was a fact until the modern numerical system was adopted by many countries worldwide. Despite that though, abacus is still widely used mostly in Asia by merchants, traders and clerks.

This paper has been divided into two main sections that contain a few subsections of their own. The first main part is about the history of the abacus, what are the differences between the different versions of the abacus that have been created throughout the years and finally it is going to be explained how the modern version of the abacus works. The second part of this paper is going to be focused on how some aspects of Empirical Modelling have been applied in order to help with learning how to use the abacus without having to know in advance how it works or even how you can perform actions on it.

2. Abacus

The word abacus is originated even before 1387 AD. Its origins are from the Greek word abax which means "board strewn with sand or dust used for drawing geometric figures or calculating". From the Greek word abax came the Latin word abacus which was used from a middle English work in order to describe a sandboard. And from that is how the word abacus was establish (Huehnergard 2011).
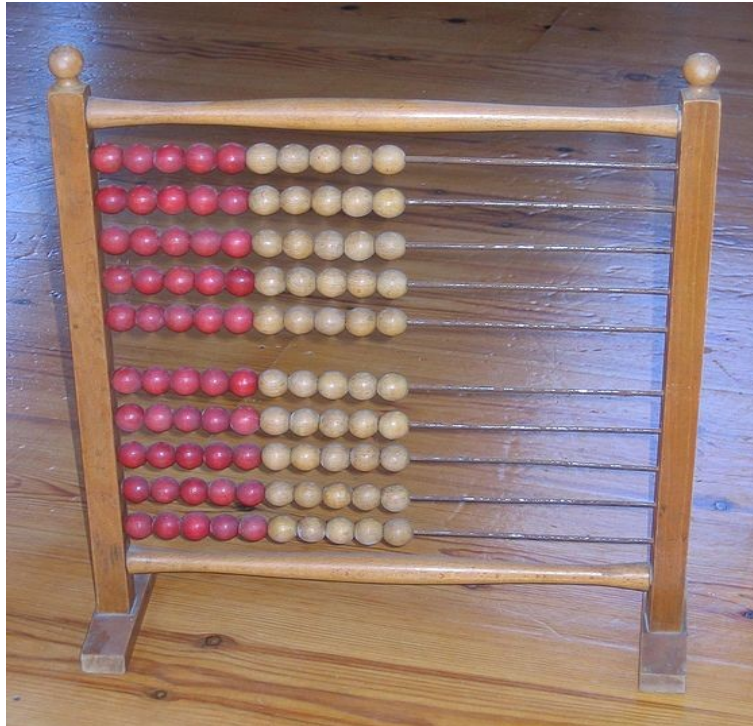
Throughout the centuries the abacus was used in order for people to perform arithmetic calculations. Due to the fact that the abacus was widely used in different countries throughout the world, many versions of the abacus where developed, with most of them being very similar and easy to understand. In the next few sections it is going to be described a few different versions of the abacus and how somebody uses them. The Chinese abacus is going to be explained in more detail since the model that was created was based on it.

2.1 History

As it was mentioned above the abacus has been used by different countries for many years. The first appearance of the abacus was registered in Mesopotamia and it was based on the sexagesimal number system (Crump 1992). The oldest counting board that has been found so far is the Greek abacus that was used in the 5th century BC. It was represented by a table of wood or marble with small counters in wood or metal for mathematical calculations. The calculations were performed from the left side to the right (Ifrah 2001). In the contrast of the general abacus was the Egyptian abacus. In the Egyptian abacus the calculations were performed form right to left instead from the left to right like it was in the Greek abacus from

where the Egyptian generated theirs (Smith 1958). Furthermore there is the Roman abacus which was very similar to the Greek abacus. In the original roman abacus the counters were moved on a smooth table but later jetons were manufactured. The marked lines indicated the numbers as in the Roman numerical system. The Roman abacus was widely used until the 9th century and again during the 11th century which has spread in the rest of the Europe too (Pullan 1968).

Besides those types of the abacus there were the Korean abacus which is the same with the Chinese one, Native American abaci, the India abacus and the Japanese abacus or soroban which means counting tray. This type of the abacus is suited to decimal calculations since the Japanese had abandoned the hexadecimal weight calculations. Still until these days this abacus is used in the primary schools of Japan, as a part of mathematics, in order to help the students perform faster mental calculations. There is also the Russian abacus or schoty which is fairly different from the others. In this style of the abacus there is usually a single slanted deck with ten beads in each wire, where in the other ones there were two sides with five beads in one and 2 in the other (Hudgins 2004). The Russian abacus is often used vertically with the beads moving from left to right in the manner of a book. After the rise of the decimal notation in the sixteenth century this abacus has fallen out of use in western Europe (Bud & Warner 1998). In addition to all these types there is also the binary abacus.

A similar abacus to the Russian abacus is used
in primary schools until today.

2.2 Chinese Abacus

The earliest version of the Chinese abacus is dated up to the 2nd century BC. Here there are usually two beads in the upper deck each of the ten rods that there are and five in each on the bottom deck for both decimal and hexadecimal computations. The beads here are usually counted by moving the beads up and down towards the beam, when the bead is moved in the direction of the beam the its value is counted while when it is moved away from the beam its not counted. In contrast with the simple counting boards that are used in schools this type of abacus is very efficient and can be used for square root, cube root, division and other operations (Fernandes 2003).

3. Abacus and Empirical Modeling

Empirical Modelling is a new approach of developing models based on observables, dependencies and agents. When developing a model that is based on Empirical Modelling techniques, one thing that is going to be sure of is that "human computing" is going to be a factor in the approach of the development of that model, as well as how some techniques from Empirical Modelling can help from the educational aspect in users learning how to use the abacus.

First of all the user that is going to use the abacus model that was developed using Empirical Modelling does not necessarily have to know how the abacus is used, for example the user might not know which rod represents which number or how to perform calculations with it. The reason for this is that the model it self helps the user to understand the way the abacus works after having many interactions with the model. The fact that Empirical Modelling uses observables and dependencies has an enormous part in that.

By using dependencies when developing the abacus model can produce a very user friendly model for the user. The dependencies that exist between the beards of the abacus model help the user understand how the beads are connect with one another, for example if all the five beads of the bottom rod are move towards the beam by the user then because of the dependencies that exist between the beads one bead from the upper rod will move towards the beam while the other five beads will be moved down. In this way the user will begin to understand how the beads interact with one another. This continues further for the rest of the beads as well and not only for the bottom rod of the deck but also for the upper one too. Based on that, after many interactions with the model the user most probably will start and

notice what number is represented in each rod of the abacus. So this will have as a result that the user will start and understand how the abacus works which is the main goal of the developed model.

In addition to all that when the user interacts with the abacus model, due to the nature of the model, it has the impression that the model is learning how to use the abacus as well, in other words it has the illusion that model is thinking and acting as a human while at the same time is a computer based model. This happens because in this model the user cannot input a number that wants to see how it is represented in the abacus style but the user has to figure out how to represent that number in the abacus by moving the beads around and seeing in the text box next to the model if the number has appeared.

The use of EM techniques when developing models for educational purposes can be very useful as it was tried to shown from the use of the abacus model. By applying Empirical Modelling aspects in the abacus model it had as a result to help the user learn how to use the abacus without having previous knowledge about the abacus or any experience with it before. Even though the model could be improved in many aspects, by using even more Empirical Modelling techniques and make it even more user friendly, the outcome of this has shown that with further research and better understanding of the Empirical Modelling approach of developing models it can be very useful when it comes to education.

4. Conclusion

Abacus had been used as a mean of performing arithmetic calculations for many centuries in many parts of the world. That changed in most parts of the world as the years have pass, since

the numeric system of calculating has emerged. Even though the numeric system was adapted in most countries of the world the abacus is still widely used in Asia and Africa. The abacus is an interesting tool to use and easy to learn how to use it if the user starts interacting with it multiple times. Empirical Modelling due to its way of combining the human interaction with the system can be very useful in helping users to understand how the abacus works without having interacted with an abacus before and also helping them learn how it works. This approach can be a very interesting way of teaching how to use an abacus through practicing on it.

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