

# **Basic Mathematical Calculations and Number Conversion in different bases using Empirical Modelling**

**University ID No: 0751796**

## **Abstract**

Basic methods of teaching are evaluated and compared and a detailed discussion on ways of teaching is elaborated with an overview of constructivist method of teaching. Problems related to the current scenario of uses of technology is discussed and the need for technology in education is analysed and evaluated. Learning on a whole is discussed in detail to support the idea of using technology in education. The salient features of Empirical Modelling (EM) with respect to the field of educational technology are discussed and the advantages of using EM are proposed. A detailed description of the tool developed for basic mathematical calculations and conversion of numbers into different bases is provided and also its development with relation to educational technology is discussed. An overall understanding of the tool proposed is evaluated and a brief conclusion of the ideas of using EM in educational technology and thus the developed tool is summarized.

## **1 Introduction**

The paper starts with a discussion on various methods of teaching and then explains the idea of constructivism mode of teaching. The concept of learning is explained from different perspectives and the understanding of learning with respect to age is depicted. The need for technology in education is then discussed with support from relevant sources.

The next section deals with the role of technology in education and most importantly how EM can be used effectively for teaching. Significant features and properties of EM are then discussed in detail. The third section explains the working of the tool developed for basic mathematical calculations and number conversion into different bases. This section gives a detailed

explanation of the development of this tool. The paper concludes by briefing the benefits of the developed tool and whatever little role it could play in this vast area of using EM in educational technology and the conclusion of the above discussion.

## **2 Educational Technology**

Educational technology in a very primitive way refers to all the computer aided or computer related technologies which support teaching or learning. These include a wide range of components like CD-ROMs, web-based teaching material, e-mail, wikis, computer aided assessment software, educational animations, intelligent tutoring systems, simulations, mobile learning, etc. Thus educational technology on a whole is a wide range of activities

which help in learning. Technology plays a major role in the improvement of education. However, many people and philosophers do not agree upon the point that use of technology in the field of education is beneficial. They contradict this point by saying that learning using technology is confined only to a defined space and cannot substitute learning in real world which allows a person to think openly and use his brains to the fullest to learn about reality of the world outside the formally defined system. [Harfield,2007]

### 3 Learning

The two basic types of learning are: mere learning by not understanding the logic behind something which is 'memorisation' or learning by knowing how and what is happening which is called 'understanding'. However, only memorising things for the sake of doing it is meaningless and not fruitful. For example, just memorising the formulae for trigonometry will not be helpful unless you know how to solve a problem and similarly just knowing trigonometry is useless unless you know how to use it and where to apply them. Its very important from the learning perspective that you actually understand the logic and concept behind things happening.

This concept gives rise to two thoughts: 'instructionism' where in it's the teacher's role to supply knowledge to students and the other is 'constructionism' where in the student himself makes an effort to learn things conceptually. Information gained by this mode is

always very helpful and remains permanent for its use in practical applications in the real world. [Roe,2003]

Antony James Harfield, 2007 defines the following Eight significant characteristics of learning :

**Experimental** - Learning occurs when constructing artefacts in the world, Learning involves an active construction of understanding, Learning results from realising the unknown.

**Flexible** - Learning need not follow a preconceived path, Learning can occur without a prescribed outcome.  
**Meaningful** - Learning is motivated by personal interest, Learning is a situated experience, Learning is a continuous experience. [Harfield,2007]

#### 3.1 Experiential Learning

Experiential learning is learning from experience and is based on the constructivist mechanism. The Experiential Framework for Learning (EFL) was first described in [Beynon,1997] and was then formalised by [Roe,2003]. EFL classifies learning activities on a spectrum between the 'private' and 'public' domain. The idea behind this framework was not to describe learning as a linear transition from empirical to formal, but to show how different learning activities can promote each other.

private experience / empirical / concrete interaction with artefacts: identification of persistent features and contexts practical knowledge: correlations between artefacts, acquisition of skills identification of dependencies and postulation of
independent agency identification of generic patterns of interaction and stimulus-response mechanisms non-verbal communication through interaction in a common environment directly situated uses of language identification of common experience and objective knowledge symbolic representations and formal languages: public conventions for interpretation public knowledge / theoretical / formal

Figure : The EFL - from Roe (2003)

The movement between activities in EFL can be in both directions but is most effective when in both directions. Roe describes the movement from empirical to theoretical as 'abstraction' – formalisation of learning and that from theoretical to empirical as 'concretisation' – gaining familiarity with the practical uses of theory. [Roe,2003]

### 3.2 Constructionism

Constructionism mode of learning is a method in which the learner plays a very important role in learning unlike the instructionism mechanism in which the teacher play the major role of supplying knowledge to the students. In the constructionism mode, the learner tries to understand the concept behind things after he has been given the basic knowledge. The

learner here uses his brains to the maximum possible extent in order to solve problems. This mode makes the user think logically with an open mind. This mode of learning is much beneficial than instructionism as the knowledge here is retained by the learner for a very long time and which he can use effectively to solve practical issues in the real world.

Seymour Papert explains how constructionism relates to constructivism in the following way :

“Constructionism--the N word as opposed to the V word--shares constructivism's connotation of learning as "building knowledge structures" irrespective of the circumstances of the learning. It then adds the idea that this happens especially felicitously in a context where the learner is consciously engaged in constructing a public entity, whether it's a sand castle on the beach ora theory of the universe.”(Papert, 1991)

Thus constructionism is a method which enables the learners to build knowledge constructively. Papert introduced the idea of allowing learners to construct entities using a software tool LEGO/Logo. The user had to build models using mathematics rather than simply using a pencil or a mouse.

### 3.3 Learning and Age

Age plays a very major role in the ability of a person to learn. Piaget's classification of age into different stages is given below:

Table: **Piaget's stages of Cognitive Development** (from AHERTON J S

(2005))

<b>STAGE</b>	<b>CHARACTERISED BY</b>
<b>Sensorimotor</b> (Birth-2 years)	Differentiates self from objects. Recognises self as agent of action and begins to act intentionally. Achieves object permanence: realises that things continue to exist even when no longer present to the sense
<b>Preoperational</b> (2-7 years)	Learns to use language represent objects by images and words. Thinking still egocentric: has difficulty taking viewpoint of others. Classifies objects by a single feature.
<b>Concrete operational</b> (7-11 years)	Can think logically about objects and events. Achieves conservation of number (age 6), mass (age 7), and weight (age 9). Classifies objects according to several features and can order them in series along a single dimension.
<b>Formal operational</b> (11 years and up)	Can think logically about abstract propositions and test hypotheses systematically. Becomes concerned with the hypothetical, the future, and ideological problems

However, though many people have agreed with the above detailed Piaget's idea, there are still quite a few who have posted their arguments in contradiction to this idea.

### 3.4 Mathematical Calculations and numbers in different bases

This paper aims at helping the learners to learn basic mathematical calculations and conversion of numbers from one base one to the numbers of different bases. Though, mathematics falls under the instructivist mode of teaching, the tool developed here makes it interactive for the learners to learn

these calculations and number conversions. Even without prior knowledge of number conversion, learners can use this tool to learn number conversion as it has been developed very well such that it displays an example for each conversion. Also, the calculator part can be used for very basic calculations of mathematics which should help the user to develop interest in the subject as generally learners do get carried away with the interactive mode of teaching.

### 4 Empirical Modelling (EM) and Learning

EM aims at developing interfaces that can be used even by common users and not necessarily only computer scientists. It aims at developing 'artefacts' that uses the computer technology to the maximum and tries to develop an interactive environment logically instead of mere applications.

"computer-based modeling that is based upon a thesis about learning and cognition broad enough to embrace the role of computer as an artefact and an instrument is potentially good for applications in education because the principles of model construction are bound up with the learning process" [Beynon,1997]

EM follows a completely different perspective of modelling compared to other modeling tools and these differences are listed below: [Beynon,1997]  
-Developing systems in ways that allow flexible adaptation, even by users who are not computer specialists

-Developing techniques that create machine independent software.

-Emphasising the creation of 'artefacts' that exploit computer-based technology, rather than applications to produce predefined functionality based on analysis of users.

-Supporting an open-development rather than closed-world engineering culture.

Thus, EM aims at developing an interactive tool which helps to enhance constructivist learning.

## **5 The TOOL**

### **5.1 Model Building**

The main aim here was to build up a model which could be used for basic mathematical calculations like addition, subtraction, division, multiplication and for conversion of numbers from one base into other like decimal, binary, octal and hexadecimal.

EM has been very different from the other modeling tools as it did not restrict the creator to use a predefined space and rather gave the creator the freedom to work according to his creativity and ideas. It allowed the modeller to create an interactive environment for the final user which was effective and simple to use.

All the above discussed topics have been referred to constantly for building up this model. The building up of this model required a regular study of the above discussion and thus the model was developed.

A detailed study of the model is given below and the description of the specific parts are discussed as well.

## **5.2 The developed tool in detail**

### **5.2.1 An Overview**

The tool designed here is basically useful for the learner to learn about the conversion of numbers into different bases and to provide the user with a basic calculator type model for the primitive operations.

However, this tool does not teach the learner about the conversion of numbers right from the start. It is important that the user has a prior knowledge of number conversion. Also it is useful for those who have studied number conversion but have not come across it for a long time. It can prove to be a very useful refresher for these people. Also this tool is helpful for people who want to use a basic calculator for the arithmetic operations like addition, subtraction, division and multiplication rather than some complicated calculators.

The overall structure of the model is pretty simple. An user can enter a number from the key board or by clicking on the buttons specified with the corresponding digits and then click on one of the buttons provided for that particular operation or conversion. For arithmetic operations the user will have to enter a minimum of two numbers for the calculation.

## 5.2.2 Basic Arithmetic Operations

The model can be used for basic mathematical operations as mentioned above. The user enters an integer and then clicks on one of the operations and then enters another

integer for which the operation is to be performed. Finally, by clicking on the equal to button, the answer is displayed on the lower part of the screen.

There is no detailed explanation provided for this section and the user should have a prior understanding of these operations. However, this part of the model can be used to perform operations on large integers and thus helps the user save time for such lengthy calculations.



Figure 5.2.1 : An Overview

This model thus provides an interactive environment for the user to perform operations on numbers.

## 5.2.3 Number Conversion

This model is very helpful for the users to learn conversion of numbers from decimal to binary to octal to hexadecimal and vice-versa.



Figure 5.2.2 : Basic Arithmetic Operations giving long answers

But it is very important that the user has a prior knowledge of conversion of numbers or even the awareness of the idea of conversion would be helpful. This model is so designed that it allows the user to enter to enter a number in the decimal form and then by clicking on any one of the buttons specified for each number, the desired result is obtained.



Figure 5.2.3 : Conversion into binary

The beauty of this model is that it then allows the user to convert the number back to the decimal form.

Another significant feature of this model is that for the conversion of numbers, it gives an example below the answer explaining the conversion into that particular number system. This feature helps

the user to understand how the conversion takes place and how the desired result is achieved. Also for users who have not come across number conversion for a long time but have a primitive knowledge for the same, it is very useful to clear their concepts again and familiarize them with conversion of numbers. Also, as this model provides an interactive environment for learning, it becomes interesting for the students to learn the conversion of numbers and gets them involved thus promoting constructivist mechanism of learning.



Figure 5.2.4: Conversion into hexadecimal

## 6 Conclusions

Finally to conclude, this paper has given a detailed study of the methods of teaching and learning and logically explained the advantages of constructionism. It gave a detailed discussion of Piaget's stages of cognitive development and the Experiential Framework for Learning by Beynon and Roe.

It then gives a brief description of the model developed to enhance educational technology to some extent. Thus, overall it gives an explanation of how EM is different

to other modelling tools and how it has proved itself to be a very effective tool to aid constructivist learning. The significant features of the tool developed were discussed.

The future work for this tool can be to make it even more interactive for learning and provide an even more user friendly interface.

## Acknowledgement

I would like to acknowledge Dr.Steve Russ for his help in the initial stages with respect to the overall idea of the model and Dr.Meurig Beynon for his precious assistance in the development of the model from time to time.

## References

W.M.Beynon. Definitive notations for interaction. Proc. HCI'85, ed Johnson and Cook, Cambridge University Press, 23-34, 1985.

W.M.Beynon, K.S.H.Halstead and S.B.Russ. Definitions for the specification of educational software. Report for MESU, Dept of Education & Science, University of Warwick, 1988.

W.M.Beynon. Empirical Modelling for Educational Technology. Proc. Cognitive Technology '97, University of Aizu, Japan, IEEE, 54-68, 1997.

Chris Roe and W.M.Beynon. Empirical Modelling principles to support learning in a cultural context. In Proceedings of 1st International Conference on Educational Technology in Cultural Context, University of Joensuu, Finland, 2002, pp 151-172.

W.M.Beynon and Chris Roe. Computer support for constructionism in context. In Proc. of ICALT'04, Joensuu, Finland, August 2004, 216-220.

Meurig Beynon, Antony Harfield. Rethinking Life-long Learning: the Empirical Modelling Approach. In Proc 6th IEEE International Conference on Advanced Learning Technologies (ICALT 2006) Kerkrade, The Netherlands, July 2006, 854-858.

Meurig Beynon. Towards Technology for Learning in a Developing World. In Proc. IEEE 4th International Workshop on Technology for Education in Developing Countries, Iringa, Tanzania, July 2006, 88-92.

Beynon, M. (2007). Computing technology for learning - in need of a radical new conception. *Educational Technology & Society*, 10 (1), 94-106.

Meurig Beynon and Antony Harfield. Lifelong Learning, Empirical Modelling and the Promises of Constructivism. *Journal of Computers*, Volume 2, Issue 3, 43-55.

Despotakis, T. C., Palaigeorgiou, G. E., & Tsoukalas, I. A. (2007). Students' attitudes towards animated demonstrations as computer learning tools. *Educational Technology & Society*, 10 (1), 196-205.

Wake, J. D., Dysthe, O., & Mjelstad, S. (2007). New and Changing Teacher Roles in Higher Education in a Digital Age. *Educational Technology & Society*, 10 (1), 40-51.

Computers for learning: An Empirical Modelling perspective by

Chris Roe -Department of Computer Science ,University of Warwick - November 2003

Empirical Modelling as a new paradigm for educational technology by Antony James Harfield - Department of Computer Science ,University of Warwick October 2007

Steve Russ. Modelling in Mathematics: a common interest for Philosophy and History?. Perspectives in Mathematical Practice, Brussels, March 26-28 2007.

Papert, Seymour & Harel, I (eds.) (1991) *Constructionism* Ablex Publishing Corporation.

ATHERTON J S (2005) Learning and Teaching: Piaget's developmental theory [On-line] UK: Available: <http://www.learningandteaching.info/learning/piaget.htm> Accessed: 5 May 2008

EM for learning to understand numbers in non-decimal bases - WEBEM01- <http://www2.warwick.ac.uk/fac/sci/dcs/research/em/publications/web-em/01/>