Having fun with

When we hear 'function', memories of symbolic manipulation of abstract equations in secondary school such as f(x)=3x+5 come to mind. If primary teachers were to teach algebraic concepts in a formal notational manner the results would be potentially disastrous.

You may wonder why we are writing this article given that there is no mention of 'functions' in the PSMC (1999). While not mentioned explicitly within the PSMC (1999), the algebra strand unit of 'Rules and Properties' requires that 3rd and 4th class pupils "… should be enabled to explore, extend and describe sequences". It also recommends that children in the senior classes "… should be enabled to identify and record verbal and simple symbolic rules of number patterns".

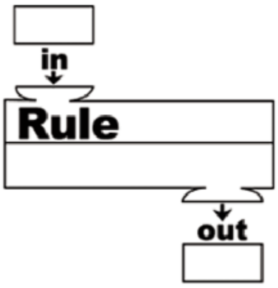

Figure 1:Traditional function machine illustration

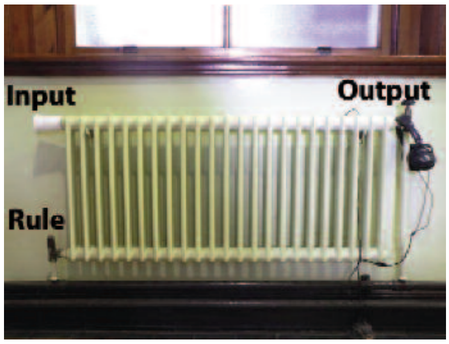

Figure 3.

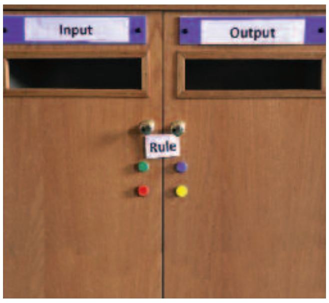

Figure 2.

Figure 4.

Figure 5.

Teaching functions with understanding: the function machine concept

In the primary school, a function should be seen as a rule (e.g. adding, squaring). The use of a function machine is an effective strategy that makes the concept of 'function' accessible to young children (Reeves, 2005/06; Suh, 2007). The ideas we present here have been successfully used in primary classrooms in Limerick City and in other countries (Reeves, 2005/06; Suh, 2007; Leavy et al, 2010).

It is possible to use a variety of function machines in primary classrooms. Traditionally, illustrations of function machines have been used (see figure 1). In recent years, physical models have been promoted as enjoyable ways to introduce functions (Reeves, 2005/06). A 'real' function machine provides a physical embodiment of the mechanics of function thus promoting the development of conceptual understanding. Children can relate to the concept through comparisons with a 'cloning machine' and quickly realise the benefits of placing items such as treats and money in the machine. To heighten curiosity and interest, leave the machine in the classroom for a few days prior to its introduction. Function machines may be made from old machines such as radios or heaters. It is important that the function machine has a definite place for the 'input' and 'output' as well as a dial which facilitates the rule to be applied to the input (see fig 2).

When using function machines, children uncover the 'function' (rule) by examining the various inputs and outputs presented. If using the physical function machine above (see figure 3) the process requires the imagination of the teacher and/or pupils as they must pretend to input a number into the machine (through the beaker/funnel), twist the radiator knob to apply the rule and receive an output (through the ear phones). In order for this approach to work, the person in charge of the function machine must possess efficient mental mathematics strategies. While it is possible to apply a new function/rule once the 'dial' is reset, rotating the 'dial' anticlockwise allows pupils to take on the challenge of working from 'output' to 'input'.

> The use of a function machine is an effective strategy that makes the concept of function accessible to young children

In some cases, function machines can facilitate a more concrete experience, where it is possible to see and touch the 'input' materials as well as the 'output' e.g. cubes or digit cards. One such function machine, the step-in physical model, was developed by creating holes for input/output as well as a rule button on an old wardrobe box (see figure 2) (Reeves, 2005/06). This function machine facilitates a person (teacher/child) to enter and become 'the brains' (accepting inputs and presenting outputs).

Another context which facilitates the use of a function machine with concrete materials is that of a 'broken oven'. The next section presents a sequence of possible activities based around the 'broken oven' theme.

The 'broken oven' context

The context of the 'broken oven' can be introduced by telling a story: "Yesterday I made 2 cakes and put them into the oven (see figure 4). When I took them out something strange had happened". The contents of the oven are then presented (see figure 5).

Explanations of what happened ("It added 2 (+2)", "It doubled them (x2)") should be welcomed. Pupils need further examples of the function/rule that the oven is using e.g. "Later I made 5 lasagnes, but when I opened the oven guess what I found?" Guesses will vary depending on the rule selected (e.g. 7 lasagnes (rule: +2), 10 lasagnes (rule: x2 or double)). Children are informed that the teacher's oven is not normal but rather a magic machine called

functions!

Figure 6.

Figure 7a.

Figure 7b.

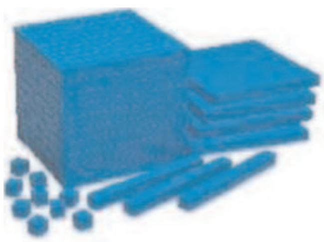

Figure 8.

Blue Button

Input	Output	Rule
7	14	
23	46	

Figure 9a: Teacher/pupil record of input/outputs.

Figure 9b.

a 'function machine'. The physical 'function machine' (a tinfoil covered box with coloured buttons) is then revealed to the class (see figure 6). Children should be introduced to the features of the function machine (input, output) as well as the fact that each coloured button has a different rule (see figure 7a, 7b).

In our Limerick City classrooms, the function machine generated great mystery and excitement. Base ten materials (see figure 8) were prepared in advance (input/output trays) to ensure smooth flow of the activity. Input trays were placed in the line of vision of children, while output trays were hidden (unknown to children) inside the function machine (see figure 7b).

Working the function machine

A child places the pre-prepared tray (e.g. 7 cubes) in the input slot (figure 7a) and presses a coloured (function) button e.g. blue. The teacher then opens the slot at the back of the function machine, quickly and discretely removes the input tray and selects the appropriate output tray e.g. 14 cubes (see figure 7b). Led by the teacher, the class record the inputs and outputs for the selected button on an activity sheet in an effort to predict the rule (see figure 9a and 9b).

Children can be given responsibility for counting and inputting materials, pressing the respective button and counting the output during the above activity. In each case on presenting a number of related inputs and outputs, pupils should be given time to work out the possible rule/function (e.g. blue rule could be +7 or x2 after the first input/output – see figure 9a). In order to promote success, initial rules for the buttons may focus on one-step rules such as 'add 5' or 'double'. In order to facilitate challenge, the final button (yellow in this case) can be a more complex 2-step rule such as 'multiply by 3 and add 1'.

Once the four rules have been identified and explored using the function machine, children can then work in small groups to generate and identify their own rules/functions. Group members take turns to act as the 'function machine'. This involves one child receiving inputs (between 0 and 10) from each group member and reporting the corresponding outputs using a secret rule e.g. +5. Children are encouraged to create a two-step rule if they wish. A hundred square or calculator may be given to each child to support them in their calculations. The recording of all the relevant information promotes prediction and checking (see figure 10). As a concluding activity, groups or individuals may be given opportunities to share a rule with the class.

Generator 1

Input	Output	Rule
		Guess
		Actual

Figure 10: Section of group work activity sheet

Conclusion

Function machines facilitate enjoyment and act as an effective tool in promoting conceptual understanding of function among school children. The creation of a function machine requires effort in sourcing and assembling the component parts. However, once made, the function machine is an invaluable resource across the school and curriculum. Beyond algebra, the function machine can be used to promote understanding of operations and tables. There are also opportunities for links with literature and technology. For example, the Chinese folktale *Two of Everything* (1993) by Lily Toy Hong tells the story of a farmer and his wife who discover a large brass pot which has magic doubling powers (Suh, 2007). Websites also present interactive function machines e.g. www.mathplayground.com/FunctionMachine.html.

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A full length version of this article is available on www.into.ie (InTouch section)