

5-14 Mathematics in Scotland: The relevance of intensive quantities

Project grant holders: Christine Howe, Terezinha Nunes and Peter Bryant

Aims:

- To provide researchers, policy makers, teachers, and trainers of teachers with information about the extent to which intensive quantities are grasped by primary school pupils in Scotland, and about particular areas of difficulty
- To develop a whole-class plus small-group approach to the teaching of intensive quantities, and to make controlled comparisons with alternative methods
- To contrast the efficacy of ratio and fractional approaches to the teaching of intensive quantities
- To explore how base-line knowledge of intensive quantities, and responses to teaching intervention, vary with pupil age, sex, and mathematical ability
- To develop an impact strategy, and to implement this with policy makers, trainee teachers, and relevant academic staff

Significance:

In mathematics and science education, there is an important distinction to be made between two types of quantity: extensive (e.g. height, weight, volume) and intensive (e.g. speed, density, temperature). This distinction is recognised elsewhere in the world, but it has been neglected throughout the UK, where teaching concentrates on extensive quantities.

There has been little psychological analysis of the contrasts between intensive and extensive quantities, of what pupils should learn in order to avoid confusion, and of how they should be taught. However, previous TLRP work in England by two of the investigators demonstrates difficulties that vary with the logical moves required by the problem, the language used in problem description, and the specific type of intensive quantity.

In view of the above, this two-year Scottish extension aims: a) to document the ways in which primary school pupils in Scotland learn about intensive quantities, and the difficulties that they have with this learning; b) identify modes of teaching that are both effective and sensitive to the Scottish context; to ensure that the results have maximal impact upon policy and practice.

Framework for enquiry:

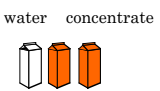
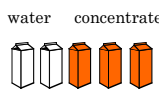
The project will document Scottish children's understanding of intensive quantities in the absence of formal tuition, and, anticipating difficulties, will seek to establish effective modes of teaching and optimal approaches to curriculum development.

The project will build on the ESRC-TLRP research that Peter Bryant and Terezinha Nunes have been conducting in Oxford.

It will capitalise on Christine Howe's experience of educationally relevant research in Scottish contexts, including work that addresses intensive quantities.

Extensive vs. intensive quantities:

- Extensive quantities are based on the logic of co-variation. If you add orange juice from a first jug that has 20 decilitres in it to juice from a second jug with 60 decilitres of orange juice, you have 80 decilitres. Volume is an extensive quantity, and the whole is the sum of the parts. In contrast, the concentration, and therefore the taste, of the orange juice is an intensive quantity.

<p>Jasmine's orange juice mixture</p> 	<p>Julia's orange juice mixture</p> 
<input type="checkbox"/> Jasmine's juice tasted more orangey. <input type="checkbox"/> Julia's juice tasted more orangey. <input type="checkbox"/> The two juices were as orangey as each other.	
<input type="checkbox"/> of Julia's drink is made of water.	

The concentration is directly proportional to the amount of orange concentrate used, and inversely proportional to the amount of water. Thus two variables need to be considered, orange concentrate and water. If the concentration in one jug is 20% orange concentrate and the concentration in the second jug is 60%, mixing the two does not lead to a concentration of 80% orange concentrate.

- Measuring extensive and measuring intensive quantities are different processes. An extensive quantity is measured by the scalar value of a unit of the same nature: length is measured in units of length, and time in units of time. An intensive quantity is measured by the relation between two other measures, e.g. speed is measured by a relation between distance and time.
- Extensive quantities are expressed numerically by one value; intensive quantities are expressed numerically by two values. The two values can be expressed in a ratio form, e.g. one cup of orange concentrate for two cups of water - or in a fraction form - e.g. one third concentrate and two thirds water. The language of fractions can only be used when the intensive quantity is a mixture of the two variables involved in the situation.

An example of an intensive quantities problem presented to children (the child ticks the correct answer and writes the appropriate fraction in the lower box).



Example of a child doing the practical version of an intensive quantities problem.

The programme of work:

- The project will begin with a base-line survey to establish how much primary school pupils in Scotland currently understand about intensive quantities. Around 1000 pupils will be surveyed with roughly equal numbers from P3, P4, P5, P6 and P7. The survey will be conducted by presenting c.40 intensive quantity problems by PowerPoint demonstration to whole classes. Pupils will then be asked to solve the problems, and write their answers in booklets.
- The survey will be followed by an intervention study, which will contrast alternative approaches to the teaching of intensive quantities. Around 600 primary school pupils will be involved. They will be from two age levels within the P3-P7 range, with the base-line survey clarifying which are the best levels to target.
- The intervention will involve four thirty-minute lessons and will contrast 1) whole-class vs. whole-class plus small group teaching 2) representation of intensive quantities in fraction or ratio forms.
- To evaluate the outcome, appropriate controls will be used, and all pupils will be pre- and post-tested using a subset of the base-line survey problems.

Research team:

Prof. Christine Howe
(University of Strathclyde)

Prof. Terezinha Nunes
(Oxford Brookes University)

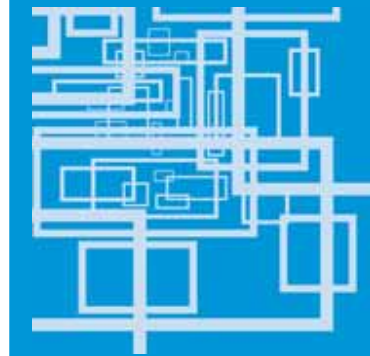
Prof. Peter Bryant
(University of Oxford)

Contact details:

Prof. Christine Howe
Department of Psychology
Graham Hills Building
40 George Street
Glasgow G1 1QE

Tel: 0141 5482575
Fax: 0141 548 4001
E-mail: c.j.howe@strath.ac.uk

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Professor Andrew Pollard | Cambridge
Dr Mary James | Cambridge
Dr Kathryn Ecclestone | Exeter
Dr Alan Brown | Warwick
John Siraj-Blatchford | Cambridge

TLRP Programme Office

Dr Lynne Blanchfield | Lsb32@cam.ac.uk
Suzanne Fletcher | sf207@cam.ac.uk

TLRP
University of Cambridge
Faculty of Education
Shaftesbury Road
Cambridge CB2 2BX UK



Tel: +44 (0)1223 369631