Moving into the Zone of Feasible Innovation – towards meaningful science teaching

A draft not to be quoted

Auður Pálsdóttir and Allyson Macdonald
University of Iceland, School of Education

Abstract
Science teaching and learning is considered a complicated challenge both by teachers and pupils. This paper addresses the question of how much change is appropriate in a given context of science teaching and school development. By analysing science teacher motivation and identity and identifying teacher potential to implement the national science curriculum can help us find ideas on activities which might help to change some of the constraints experienced in science teaching. The main findings of the study so far are that by using Roth’s (2007) ideas and Macdonald’s (2008) framework to analyse teachers’ motivation and identity a deeper understanding of some of the constraints on developing science teaching in schools. Also, the results indicate that the theory of the Zone of Feasible Innovation (ZFI) developed by Rogan and Grayson (2007) is a useful idea when evaluating the level of implementation. When the main constructs of the ZFI are adapted and applied to the national science curriculum in Iceland and the capacity of teachers of science, teachers and school administrators can find new ways to identify possible next steps in developing science teaching in their schools.

Aims of the study
In school development, the decisions of what to do next and how to do it are always difficult questions to answer. The advent of a new science curriculum in 1999 for Icelandic schools, and a revised version in 2007, with slight changes in emphasis, has encouraged discussions about science teaching. The capacity of teachers to implement the curriculum differ as well as their competence to evaluate what and how much change is appropriate.

The aim of this study is to assess the current capacity of science teachers to implement the national science curriculum and context within which teachers work. In order to do so we focused on understanding situations in which teachers find themselves and the opportunities and challenges to be found in these situations. It forms part of a larger study on the status of science education in Icelandic schools.1

Since 1996 all schools have been obliged by law to carry out self-evaluation and the Ministry of Education, Science and Culture is required to inspect self-evaluation methods being used in schools at five year intervals. Most schools have already been through two inspections. The ministry provides guidelines for schools of what aspects of the work of schools must be considered (Sjálfsmat skóla : leikskólar, grunnskólar og framhaldsskólar, 1997) but schools choose how they collect the information (Aðalnámskrá grunnskóla, almennur hluti, 2006). However, the capacity of schools to carry out self-evaluation are very uneven (Úttektir á sjálfsmatsaðferðum grunnskóla:

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1 The Intentions and reality project on science and technology education is being carried out by a team of researchers from the Iceland University of Education and was funded by the national Research Fund in Iceland from 2005-2007. This study also received funding from the Research Fund of the Iceland University of Education in 2007.
Today, science education in Iceland faces many serious challenges. National science tests at the end of compulsory school were reintroduced from 2002 until 2008, according to the 1999 curriculum, and have been withdrawn from 2009 in accordance with a new law from 2008 on compulsory education. In future the tests will only be held in Icelandic, mathematics and English. The 2007 revised curriculum for compulsory schools is less detailed than the former one and should be fully implemented in schools by year 2010. Also, the textbooks used for the last decade in the 8th-10th grade will not be reprinted. Many teachers are insecure of what to do next. Most teachers teaching science in compulsory schools are not science specialists and if you are not a science specialist – how will you deal with education through science?

This paper reports on some approaches used in the assessment.

1. First, we collected and analysed information through an electronic questionnaire and interviews on the way in which science teachers understand and interpret the demands of the national curriculum for science lessons.

2. Second, we explored the motivation and identity of science teachers in three urban schools using Roth’s (2007) ideas on emotion at work and a framework developed by Macdonald (2008) based on Roth’s ideas.

3. Third, the framework of the Zone of Feasible Innovation (Rogan & Grayson, 2003) was used to identify areas which might change some of the constraints on science teaching in these schools.

**Background**

Rogan and Grayson (2003) and Rogan (2007) have developed a theory of curriculum implementation based on three major constructs:

- A. Profile of implementation (in the classroom),
- B. Capacity to support innovation and
- C. Support from outside agencies.

Rogan and Grayson (2003) defined six propositions with regard to the theory of curriculum implementation. These are:

- Innovation should be just ahead of existing practice. Implementation should occur in manageable steps
- Capacity to support innovation should be concurrent with efforts to enrich the profile of implementation.
- Outside support should be informed by the other two constructs, matching outside support with capacity, and capacity with desired implementation
- All role players need to reconceptualise the intended changes in their own terms and context.
- Changing teaching and learning is a change of culture not a technical matter.
- There should be alignment between the three constructs and the primary level (e.g. the learning experience).

Rogan and Grayson (2003) suggest that these constructs and propositions indicate that there is a Zone of Feasible Innovation (ZFI) within which schools and teachers can be encouraged to operate and develop. The ZFI draws on theories of school development, on Vygotsky’s concepts of the zone of proximal development and the importance of social
interaction for development, and on the zone of tolerance i.e. the space given to institutions by communities in the change process.

For each construct it is possible to create a matrix (rubric) of relevant factors and the levels of development schools have reached in working towards the long-term goal of implementing the national curriculum (see Figures 1-3). Schools can find themselves positioned at different levels on different factors, both within and between constructs. The rubrics shown here have been adapted to cover the Icelandic national curriculum guidelines, the capacity of those who participate in the school system and support from outside agencies.

### A. Profile of implementation

<table>
<thead>
<tr>
<th>Ideal</th>
<th>Implementation</th>
<th>Classroom interaction</th>
<th>Practical work (hands on assignments, research)</th>
<th>The nature and role of science in society</th>
<th>Assessment</th>
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<td>4</td>
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Figure 3. Construct A: Profile of implementation

Figure 1  Implementation of the curriculum in the school and classroom (developed from Rogan, 2007)

### B. Capacity to support innovation

<table>
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<tr>
<th>Ideal</th>
<th>Description</th>
<th>Example</th>
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<tbody>
<tr>
<td>4</td>
<td>The teacher has outstanding knowledge in science and excellent teaching skills. He shows willingness to change, is resourceful and cooperative. He has a vision for innovation and shows professional initiative and leadership at times and elsewhere.</td>
<td></td>
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<tr>
<td>3</td>
<td>The teacher is competent with reliable knowledge in science. He takes an active part in professional development by, e.g., consciousness and takes the opportunity to improve his teaching.</td>
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<tr>
<td>2</td>
<td>The teacher has basic knowledge and skills to teach science. He works hard and participates in professional development. He is well connected with students and treats them with fairness and respect.</td>
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<tr>
<td>1</td>
<td>The teacher lacks knowledge in science and is not a qualified teacher.</td>
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Figure 4. Construct B: Capacity to support innovation
Self-evaluation of science provision

In a research project called *Intentions and reality* on the status of science and technology education in compulsory and secondary schools in Iceland, and funded by the national Research Fund and the Research Fund of the Iceland University of Education, a team of researchers collected data from schools in five districts in Iceland 2006-2007 visiting three to five schools in each district. The data on science provision was collected from documents, questionnaires, on-site visits, interviews with principals, teachers, pupils and district leaders.

The capacity of the schools with regard to science teaching was assessed by using the Science Curriculum Implementation Questionnaire (SCIQ) (Lewthwaite 2006; Macdonald, Pálsdóttir and Thórolfsson, 2007). The questionnaire was translated and adapted for use in Icelandic schools, in consultation with Lewthwaite, who developed the questionnaire in his doctoral research (Lewthwaite 2001). Before visiting schools which took part in the research, those teachers who taught science were asked to complete the SCIQ, and the results were available before the visit took place.

The questionnaire calls for self-evaluation by teachers of the actual and preferred capacity of their own school in implementing the science curriculum. Four extrinsic factors (Resource adequacy, Time, Professional support and School ethos and The status of science as a school subject) and one intrinsic factor (Skills, knowledge and professional attitude) are assessed. There are seven questions behind each factor and teachers rate the capacity of their school on a scale of 1 to 5.
In Lewthwaite’s approach, the SCIQ results can form the basis of discussion and further development within schools (Lewthwaite 2001) and the SCIQ-questionnaire has been used in New Zealand and in Canada (Wood & Lewthwaite, 2007; McMillan, Lewthwaite, & Hainnu, 2007).

In Figure 1 the SCIQ-results from 19 schools in Iceland including 105 teachers, showed that there was a clear capacity gap between actual and preferred situations (with average gap close to 1,2). For example, the mean rating of the actual situation with regard to the availability and organisation of professional support for teachers was 3,4 and the preferred rating was 4,5.

In the schools we visited, the biggest gaps were in the area of Resources (1,5) and of Knowledge, skills and attitude of teachers (1,3). Interviews were taken in conjunction with the completion of the SCIQ. A first analysis of the interviews and questionnaire data provides some ideas on activities which might change some of the constraints on science in these schools.

The value of SCIQ to science and self-evaluation consists of a few things. The most important is that it gives a base for discussion with teachers about how they view the strength and weaknesses of their school, and what factors are extrinsic and what is intrinsic to themselves.

**Motivation and identity of science teachers**

Few of the science teachers we met in schools had preservice training in science. The interviews with teachers during the school visits indicated that in many cases teachers had been asked by the principal to take on some science teaching, often because they...
had a background in mathematics or geography. One teacher had been trained as a nurse. Teachers responded to the principal’s request in different ways. Some were very reluctant and felt coerced, as if they had no choice. Others were also reluctant but felt they could make a contribution and so complied with the request. We had one example of a teacher who loved science teaching and who inspired the children, but this teacher was something of a loner and worked in ways which met individual interests in the value and relevance of science but did not necessarily strengthen the capacity of the school to offer science. There was an issue here that needed further exploring.

Thus in order to deepen our understanding of the results of the survey and the views of teachers as expressed in the interviews, we turned our attention to teacher motivation and identity in science teaching and analysed the extent to which collective and individual interests of science teachers were being met in schools.

To do so we built on Roth’s proposition (2007) in which he argues that motivation in the workplace is only high when both individual and collective interests are being met in the same activity (p. xx). Working from this assertion Macdonald (2007) developed a two dimensional framework to map teacher motivation and identity (Figure 4).

![Figure 4](image-url)

**Figure 4** A framework for mapping teacher motivation and identity, based on Roth (2007) and Macdonald (2007).

The vertical axis presents the extent to which individual interests are met in the activity (top is + and bottom is -) and reflect the identity of the teacher as a science teacher. The horizontal axis presents the extent to which collective interests are met (right is + and left is -), i.e. whether the teacher can or does carry out activities which are in the (collective) interest of the school. Competent teachers show high motivation and strong identity but coerced teachers show low motivation and weak identity.

The results for the science teachers in the three urban schools are shown in Figure 5. Teachers P, K and D were assessed competent teachers with high motivation and strong identity. Those teachers are all science specialists with science as a subject in their teacher education or a special degree in science. The other teachers represented in Figure
3 are teaching science without any formal background in the subject area and have even been pressed for doing so since “no one else feels up to it”.

A sentence or two on the value of the framework in identifying the need to work with science teachers in different ways according to their identity and motivation. Science teaching is not only a rational endeavour it is also an activity which depends on emotion.

...  

**The Zone of Feasible Innovation in curriculum implementation**

Further, with teacher response to challenging situations in mind the theory of curriculum implementation (Rogan and Grayson, 2003; Rogan, 2007) was used to discuss with teachers how much curriculum change is appropriate in a given context.

The theory was introduced to and discussed with two focus groups of science teachers. Rogan and Grayson’s idea of identifying the Zone of Feasible Innovation for planning development was used. The ZFI suggests that innovation should not exceed current practice by too large a gap between existing practice and the demands of the innovation.

With the results of the survey and issues of motivation and identity in mind one of us (AP) discussed the ZFI with nineteen science teachers in two focus groups. Those teachers were enrolled in a programme to strengthen their capacity to teach science funded by the Ministry of Education, Science and Culture and implemented by the Inservice Department of the Iceland University of Education.

In the group interviews teachers indicated that the theory of the ZFI is a plausible and useful tool for evaluating the levels of implementation within schools and for identifying...
developmental aspirations and potential contributors and constraints to implementing the national science curriculum. However, they emphasized that they would like to carry out a SCIQ survey in their own schools in order to be able to assess their situation. Also they agreed it would be very useful to be able to compare the survey results with those from other schools in the same municipality, as was done in the SCIQ survey carried out in the main research study. Finally, they felt that the ZFI can be practical to map the landscape and plausible, but that external help could be useful in developing the indicators and guide them in the evaluation process.

Conclusions and Implications
Understanding situations in which science teachers operate, and identifying the opportunities and challenges of those situations can provide information on desirable and necessary steps for professional development and their potential of schools and teachers to implement the curriculum. In the process of evaluating the levels of implementation teachers could identify developmental aspirations for stakeholders and potential contributors and constraints to the achievement of these aspirations.

Our research has revealed that a systemic process of innovation involving policies and practice are needed in science education in Iceland in order to strengthen science education. What happens in the classroom is not the private responsibility of teachers. Teaching materials play an important role and research has shown that Icelandic teachers rely heavily on textbooks in their teaching (Sigurgeirsson, 1992, Macdonald and Pálsdóttir, 2008). Teacher motivation and identity is related to the extent of their education in science and their experiences in teaching science. The support they need to be provided with could be identified by developing Rogan’s and Grayson’s model of Zone of Feasible Innovation.

Bibliography


