## Informal Training of Primary School Teachers on Magnetic Phenomena

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### Introduction

Society's demands upon the individual imply a capacity to make choices according to themes, requiring specific scientific knowledge within a basic culture of wide spectra [1, 2, 3]. In this context we address the issue of basic cultural formation within a scientific field [4] and, as a consequence, we suggest radical change in didactic content and strategy, revealed to date as being incapable of providing this grounding [5,6]. Various studies have highlighted the importance of an operative and active role of children in exploring phenomenological contexts in order to build this awareness [3-8]. Primary school teachers are required to possess new skills, for example: preparing and carrying out simple experiments; the use of active and colloborative strategies in teaching-learning; the use of new technologies in order to utilise their didactic-methodological fruits [4]. The main problems, faced in particular by teachers in open teaching activities, concern either poor or non-existent scientific training, cronic difficulties with regard to formalization and changes in the development and consolidation of methodologies used in teaching [5, 6, 9, 10].
Literature differentiates three models of teacher formation: metaculturale, experience-based; on-site [11]. It defines the different role and the limitations of each, and moves toward a blending of the three in order to overcome the problems above [12-13]. A metacultural reflection allows us to develop an organic frame of the theme in question, both on a disciplinary level and on that of a related didactic proposal. Didactic laboratory activities with experience-based methods enable us to deal with the disciplinary and methodological challenges of a particular path. In addition they provide fundamental expertise for didactic planning [14-16]. On-site experiments taking place in class provide concrete evidence, rather than real innovation. [17-19]. They may reveal details and problems hidden in the planning phase. Taking this unintentional or unconscious learning path is what characterises informal learning [20-21].
The objective of this study has been the role of the experimentation carried out in school as an informal learning in for primary school teachers formation. For this scope, during 2003/04, a collaboration between the University of Udine and two Schools in the surrounding is activated in the context of action-research study of magnetic and elettromagnetic phenomena (1). The principal results are documented in this paper.

### The characteristics of the training programme and materials utilised

The four phases of the training course for teachers are presented in table 1.
These were developed over the two years of the project (1). The first phase was completed in the first year. The second and third phases were carried out over the two years. Phase 4 took place entirely in the second year.
The first phase began with a review of the available research relating to the principal learning problems involved in the study of magnetic and electro-magnetic phenomena [22-23]. This

was integrated with an analysis of a didactic proposal, developed in response to these problems [24].
In experience-based activities in the didactic laboratory, teachers carried out simple experiments of phenonmenological exploration, similar to those that would be proposed to the children in the following areas in the third phase: orientation of a suspended magnet or compass; interaction between magnets; interaction between a magnet and other systems (ferromagnetic and non-ferromagnetic); the concept of field; simple electromagnetic phenomena and applications (electro-magnet). Materials of the phenomena section of the GEI exhibit [25] were used, of which three examples are represented in fig. 1 [24]. Such materials are simply assembled and easily available, given that they are everyday objects or components of magnetic toys.

| *Phase* | *W.S.* | *Activities* | *Teachers involved* |
|---|---|---|---|
| ***1*** | 8 | - Review (Metacultural) of learning problems concerning magnetic phenomena and presentation of educational proposal<br>- experience-based didactic laboratory concerning educational proposal | 4 teachers → 6-7 year old children<br>4 teachers → 9-10 year old children |
| ***2*** | 3 | Didactic planning and preparation of methods and materials for monitoring | 2 teachers → 6-7 year old children,<br>2 teachers →9-10 year old children |
| ***3*** | 1 | On-site training in class experimentation and counseling via email | 4 teachers → 6-7 year old children,<br>2 teachers →9-10 year old children |
| ***4*** | 2 | Analysis of data from class experimentation | 3 teachers (*) |

**Table 1**: Project phases; number of meetings in which teachers and researchers were involved; activities and number of teachers involved (* - not foreseen for project). Two teachers did not complete and second and third phases as they were transferred to other schools.

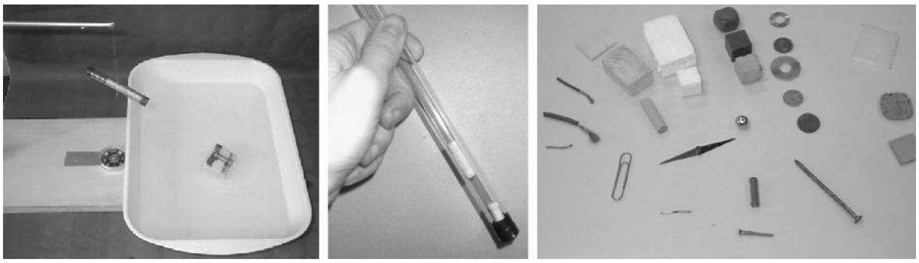

**Figure 1**: Basic experimental apparatus to explore: a) suspended or floating magnets and compasses; b) repelling magnets enclosed in a tube of plexiglas; c) different materials objects interacting with magnets.

Expressly prepared work-sheets were provided when the experiments began. These were organised in the following sequence, utilising the PEC (Prevision, Experiment, Comparison) strategy [6]: Situation – a photo and a brief description present the situation teachers have to work with; Prevision – a forecast of the experiment must be presented; Observation – questions are aimed at stimulating the exploration of hypotheses and recognising different aspects involved in the experiment that has taken place; Comparison – an invitation to

discuss differences and analogies between prevision and observation; Conclusion – a re-epilogue phase, activating the interpretative reconstruction of the phenomenon; Transferability – a reflection on the transferability of the activity to the school setting and its didactic role. This experimental phase required the strong participation of teachers both on disciplinary and didactic levels, taking place using didactic tools [3-6].
The second phase of planning was characterised by an intense colloboration between teachers. It produced two shared didactic projects: one for the classes of the first year of the study and one for the classes of the second year. These were discussed on various occasions with researchers, and modified/integrated by teachers on the basis of the observations that emerged. In this phase objectives, tools and monitoring methods were set up.
In the table 2 we see the detail of the experimental groups working during phase 3. They involved six teachers and four classes, and a total of sixty-two children. The teachers carried out the experimentation in class with remarkable autonomy, posing a few questions via email and in the course of one formal meeting.
In the phase 4, the active partecipation of teachers was not foreseen, but three teachers involved in the experimentation wished to be directly involved in the analysis of data.
The following documentation, of the work carried out , provides key data of teacher training:

- Work-sheets, filled in during phase 1, provide indications of the initial ideas of the teachers and of the impact of the experienced-based training;
- Monitoring, carried out by researchers during meetings and providing indications on the problematic contexts arising during training;
- Work-in-progress projects, produced by teachers, providing indications on how the content and didactic proposals evolved through the diverse phases;
- Implemented projects, these highlighted the impact of different training elements in schools in terms of a product;
- School-results, of the implemented projects, providing an indirect view of teacher learning;
- Summary sheets, handed in by teachers at the conclusion of class experiments, providing the teachers' specific ideas following training.

| *Class – School* | *N° children (age)* | *N° teachers* | *Period* | *N° Hours* | *N° Work-sheets* |
|---|---|---|---|---|---|
| Class I - Pagnacco | 21 (6-7 years) | 2 (°) | May 04 | 4 | 12 |
| Class I - Colloredo | 21 (6-7 years) | 2 (°) | May 04 | 4 | 12 |
| Class IV - Treppo Grande | 7 (10-11 years) | 2 | April-May 03-04 | 10 | 3 |
| Classes I e II - Cassacco | 13 (6-8 years) | 2 | April-May 04<br>Oct. 04 - April 05 | 26 | 10 |

**Table 2**: Table of the experiments carried out. Six teachers were involved: 2 (°) worked with the first two classes; four worked in pairs with the other two classes.

**Teacher formation problems and situated activity role**

Here we will discuss the principal contribution that informal activity, carried out on-site in class during the third phase, brought to the formation of teachers, in terms of resolution of problematic aspects not addressed in the previous phases.

With regard to concepts and physics teachers declared on their *summary sheets* that training had helped significantly toward:

- Magnetic interaction and the different aspects describing this and, in particular, ‘property and behaviour of free or fixed magnets’ and ‘reciprocality of interaction’;
- Force as a formal description of interaction and in particular the ‘pair of forces that act upon magnets in the interaction between free rotating magnets’;
- The concept of field.

The first two aspects are to be found in all of the work-in-progress projects. These have borne the major influence of experiencial-based training, as shown by the compiled work-sheets, which have then translated into effective competence with the situated activities. For example, in the case of explorative activity concerning the interaction between suspended magnets, the prevision of attraction between opposite poles and repulsion between similar poles’ had been formed on the basis of prior knowledge. This was completely disproven by the observations carried out. When this was compared with the experiment, it contrasted with fact, as the same teachers observed: ‘while I was expecting it to repulse, in reality the magnet positioned itself, turning around, to attract the other’. The resulting crisis was in part compensated by the investigation of the interaction between fixed magnets. It was recognised that with the interaction between magnets: ‘that distance influences effect’ and ‘when the magnet turned, two forces are called upon’, but the problem of describing the phenomena with a material point model remained unresolved. This problem was overcome initially in the planning phase and eventually in class experiments. With regard to these concerns teachers documented class activities and the learning path of the children in a greatly detailed manner. In the case of situated training, therefore, discliplinary competence transformed into professional competence within the specific and restricted environment under analysis, in order to be able to: translate into effective didactic objectives; work operatively by preparing relevant experiments; work with the children through motivational games and interpretative challenges aimed toward specific objectives.

The third area dealt with by teachers, the concept of field, does not appear in the *work-in-progress projects* and was introduced with a lesser role in the implemented projects. Despite the documentation of the experiments, we see the various specific ways in which the children dealt with this concept. For example the children spontaneously applied a primitive concept of field to explain the repulsion between magnets (‘..because the two similar poles form ‘an invisible ball’’). They recognised and worked with the effects of superimposition of the action of different magnets in the same region of space, and also magnets in a series or parallel magnets. The attainment of this level of understanding with children brought the teachers to include an understanding of the concept of field among the most significant learning of the training session.

On the methodological-didactic level, it was specifically recognised that the training was oriented toward a didactic framework of personal operative involvement of the children, and thus a collaborative construction of knowledge. In the *summary sheets*, the teachers agreed that one of the principal contributions of the course ‘Acquisition of a working methodology aimed at internalising concepts’, was ‘valorizing an experimental approach to content and cooperative work’. These assertions find resonance in the implemented projects and in the documentation of classwork and are not thus mere declarations of principle. Rather, they represent the explicit awareness of the formative path taken, which itself may be reconstructed using the detailed documentation materials.

From the first meetings teachers showed an interest in the themes to be dealt with, recognising their importance in basic scientific training. They declared themselves inadequate to deal with the topic at school due to a limited knowledge of the field restricted to what could be found in scholastic texts, and they lamented the lack of documentation of activities carried with children, limited to results research [26]. This combined with an assertive approach to scientific education which is implied in the frequent question: 'How do you explain this detail/concept to children?'

In the *work-in-progress-project* teachers gave priority to an interpretative framework based upon action at a distance, according to the explorative proposals they had evolved. Teachers methodological proposals suggested an indeterminate manipulation, or an assertive strategy, where scientific concepts were outlined by the teacher in a form not related to the phenomenology. Themes and activities had a spontaneous nature, not linked to a coherant didactic path or refined to a precise role.

With the *implemented projects* however, the themes were expressed in terms of well-defined objectives of monitored learning with work-sheets for the children, re-elaborated by the same teachers with a wider scope than that used in training. The activities were collated within a didactic sequence with a definite role. We observed a tendency to 'explain' uncertain concepts, for example that of field. This uncertainty was overcome with the direct experience in the classroom. Discussing the phenomenology with the children and observing how they were able to recognise and manage processes, such as those involved in the interraction between free magnets, and more complex concepts such as that of field, helped them to evolve a disciplinary and didactic competence ahead of the teachers, especially in these areas where the latter had faced problems in the training and planning processes.

The methodological problem of the role played by the documentation of work in training remains unresolved. Teachers judged the work-sheets to be 'too long and structured.. but important in order to specifically explain and recognise problems, acquire new methodologies, to keep in mind conceptual problems and how it is possible to overcome these.. '. They were considered a non-stimulating part of the project and the children thought they were a phase of compilation, of 'recording the experiment that took place and the relative conclusions on the sheet', more a bureacratic duty than a learning activity.

**Conclusions**

This study has been a collaborative project between schools and the university regarding the training of primary school teachers in the teaching of magnetic and electro-magnetic phenomena. In particular, the objective has been to isolate the role of the informal phase in the learning process in class.

The teachers involved in the training programme immediately recognised the importance of practical activity in the learning process of the children. In addition they revealed experience in proposing games, experiments, and imagination in inventing these. By contrast they showed difficulty in recognising the role of learning in the proposed activities, with the exception of those concerning motivational aspects. They did not demonstrate other shortcomings in disciplinary competence, in the scientific field in general and in particular on the specific theme of magnetism, where their experience was limited to shared general knowledge or information recorded in scholastic books.

Experience-based training has been highly important in recognising of the role of hands-on/minds-on activities in the stimulating of ideas, producing analogies and developing formal thinking. Activity carried out in class enabled informal learning and operability to become part of the competence of teachers at least in certain disciplinary fields. It provided an occasion to master concepts and produced a didactic path. It produced the capacity to carry out activities with a cognitive, differentiated objective, able to meet the requirements of children and with a specific role for learning. It made full use of PEC strategies to build the capacity to discuss one's hypotheses in a rigorous manner. This has allowed us to recognise which cognitive paths children follow. We have completed both didactic and disciplinary training, in a way that the learning process of the children has provided proof that the phenomenology of magnetic interaction may be explored and interpreted in macroscopic terms. This may occur within the school environment where teachers have been able to activate the children's capacity to recognise and work through complex processes and concepts, such as those involved in the interaction between free magnets and the concept of field.

The impact upon the children and the ability to activate an operative discussion with them thus became the mode of self-evaluation for teachers to view the efficiency of their own training, particularly concerning the aspects that had been problematic previously, such as the interraction of unfixed magnets and the concept of field. The teachers recognised, however, that the operative approach to the construction of concepts allows children to explore interpretative models and not only areas of experience. Thus they are able to overcome the assertive style of description and transmission of knowledge, which produces a disconnection between everyday experiences and scientific awareness.

In this way informal teacher learning, activated from the moment when one commits to educational action which remains the professional task of all teachers, becomes the key to their training.

**Note**

(1) Collaborative project PRIUS (PRojects of Interest for the linking of University and School) *Formare alle scoperte*, co-financed by two School Institutions (Tricesimo, Pagnacco) and the University of Udine and based on a partnership between university and scholastic research units.

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