Electromagnetic phenomena and prospective primary teachers

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Abstract

Even if magnetism and electromagnetism are generally not addressed during the formative courses in Italy, they are part of the curricular programs in primary schools. A formative learning intervention concerning electromagnetism was conducted in the context of the physics course for Prospective Primary Teachers (PPT) held at the University of Udine. In this paper are analysed how PPT address the analysis of the electromagnetic phenomena while they are facing an experimental learning path for pupils, looking to what conceptual nuclei and the learning knots are identified and re-used by them in the design of their own learning path.

Keywords: University education, prospective primary teachers, magnetism and electromagnetism

Introduction

Due to the diffusion of magnetic toys in everyday life, pupils have a larger experiential background on this magnetism than their teachers and they come to school having already well-established spontaneous interpretative models for the magnetic interaction [2,3,6]. In fact, electromagnetism is not a usual taught subject during the formation of Prospective Primary Teachers (PPT) even if magnetic and electric phenomena are part of the curricular topics addressed in the primary school in Italy. This situation creates the paradox of having in class pupils that have more practical experience with magnetic phenomena than their teachers [7]. As emblematic example, in Figure 3, is reported the comparison between pupils' [5,7] and teachers' predictions of the behaviour of two magnets approaching with the same pole when only one of the magnets is constrained.

In particular, previous researches [4,9] highlighted the presence of learning problems in prospective teachers knowledge. It is therefore necessary to produce Design Based Research (DBR) for PPT aimed to find recommendations for the effective implementation of Modules of Formative Intervention (MFI) [4]. The critical improvement of teachers' experience is necessary in order to allow PPT understanding of the roots of the pupils' naïve interpretative models [4].

Rationale and Research Questions

The implementation and the design of a MFI aimed to cover this gap with the pupils developing PPT's competences concerning both contents (CK) and pedagogical aspects (PK) in an interlaced way (PCK) [1,8] was therefore necessary. In this view, the framework offered by an experiential activity related to the development of an inquiry based learning path designed for a particular age group of students, could provide an effective context for an in depth discussion of the learning knots and the core nuclei of the subject [4,9] was designed and implemented to investigate:

RQ1. What are the conceptual referents that PPT use to analyse simple electromagnetic phenomena? (i.e. local vision)

RQ.2 How do the teachers identify learning knots and the conceptual nuclei faced during the proposed learning path?

RQ3. How do the PPT design their own learning path on the light of the conceptual nuclei and the learning knots identified? (i.e. global vision)

Strategies instruments and methods

A significant contribution in the foundation of conceptual nuclei and the identification of the milestones and the stumbling blocks of the subject is proposed by activities based on an experiential model centred on the personal involvement of PPT.

The formative activity proposed was structured in three main phases (Figure 1):

1) a MFI in which the content knowledge is offered by means of an experiential model in which PPT face the pupils' learning path;

2) the analysis of the subject in which PPT individuate the conceptual nuclei and the learning knots with the aim to compare and to discuss their individual choices in groups;

3) the group work phase in which PPT, working in small group, develop a proposal of learning path describing it by means the use of a conceptual map and a list of questions and actions aimed to be adopted in class with pupils.

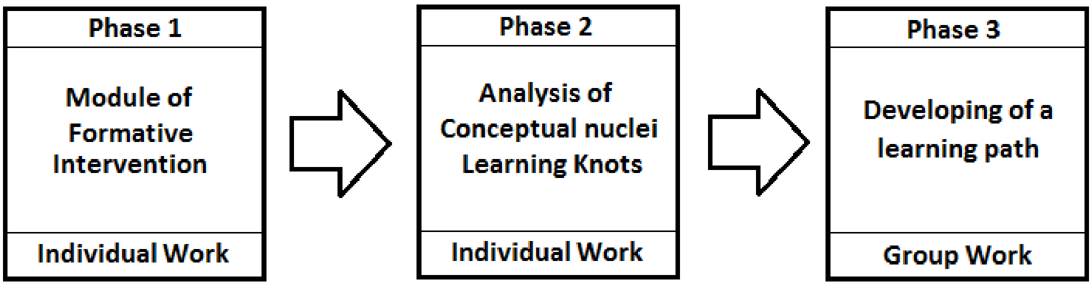

Figure 1. Flow diagram representing the structure of the formative activity

In particular, PPT carried out a well-experimented inquiry based learning path for primary pupils concerning magnetic and electromagnetic phenomena [7]. During the proposed activity, the PPT addresses interactive lecture demonstration, filing personal and group inquiry based worksheets.

The personal worksheet is used during the analysis of the phenomena proposed in the MFI the structured investigation of the conceptual nuclei and learning knots and the individuation of the critical questions. The group worksheet is used during the comparison phase between small groups of PPT to improve, on the basis constructed from the previous analysis, their individual learning path aimed to introduce magnetic and electromagnetic phenomena to pupils.

In Figure 2 are reported the activities and the key questions proposed by the researcher to the teachers during the MFI.

To the PPT formation course participated 120 PPT students, mainly female, in the second year of university (grade 15th, mainly 20 years old).

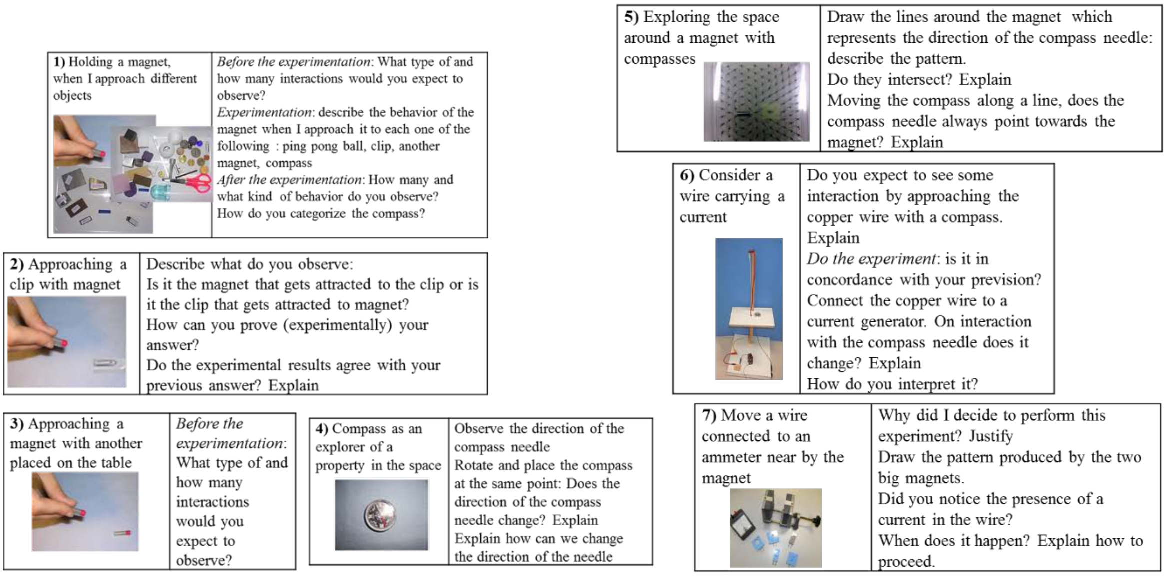

Figure 2. Activities proposed to PPT during the MFI and corresponding key questions

Data and data analysis

PPT worksheets are analysed and, for each item proposed, the PPT answers were categorized in accordance from the categories emerging from the analysis itself.

The analysis of the part related to the MFI gave us a picture of the main PPT alternative conceptions that they use in the interpretation of the phenomena. In particular, concerning situation 1, emerge how PPT focus their attention only on the more noticeable interactions (attraction or repulsion, 73%) and only 24% of them mentioned the possibility to have no (visible) interaction between a magnet and an object. Metals represent also a problem because several of them (64%) do not make a distinction between them, (i.e. “magnets attract metals”).

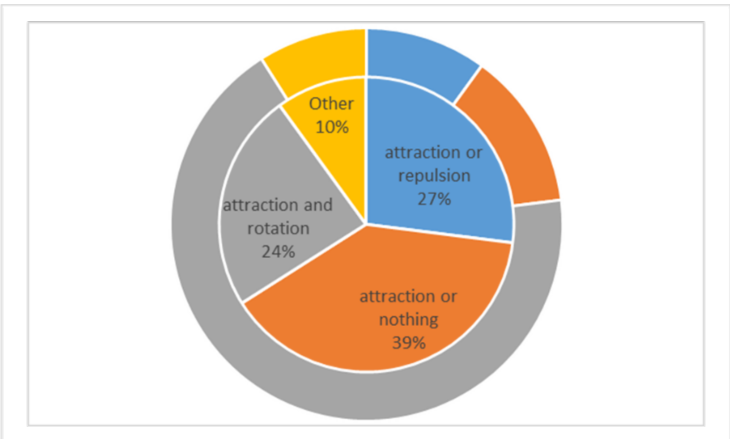

Figure 3. Example of teachers and pupils prediction concerning the behaviour of an unconstrained magnet when it is approached with another magnet in the situation in which two equal poles are faced. The distribution of teachers’ answers is shown in the centre, while pupils’ answers are represented in the circular crown.

In situation 2, the large majority of the students, identifying the magnet as the "active" object in the interaction, assuring that the magnet attracts the clip (93%) without considering the mutuality of the interaction. The PPT replies to situation 3 is reported in Figure 3; PPT, recalling their previous studies, reported what is written in almost all of the textbooks: "two magnets attract or repel each other" (27%) or referred only to the attraction (39%).

In situation 4, the PPT provide four types of drawings that are reported in Figure 4: 17% of the PPT provide a draw in which the field lines do not follow the orientations of the compass needles, 58% provide a draw in which the lines follow almost always the orientation of the compass needles, 12% provide a draw in which the lines follow always the compass needle and 5% provide a draw in which are represented only the filed lines or the compass needles. It means that, with the exception of some PPT (17% + 5%), the majority of the PPT match the correspondence that there is between the field lines representation and the compass needle orientation.

As regard the Ørsted-like experiment proposed in situation 6, is interesting to notice how, even if the first questions referred to the situation in which there is not electric current flowing, 45% of the PPT describe the situation as if it there is. In fact, they forecasted an explicit rotation of the compass forecasting also in 12% of the cases the perpendicularity of the direction of the compass needle and the wire. It is another context in which, as for situation 2, the PPT referred to their school knowledge in a strong way that, in some cases, overcome also the experimental observation of the approaching to new situations.

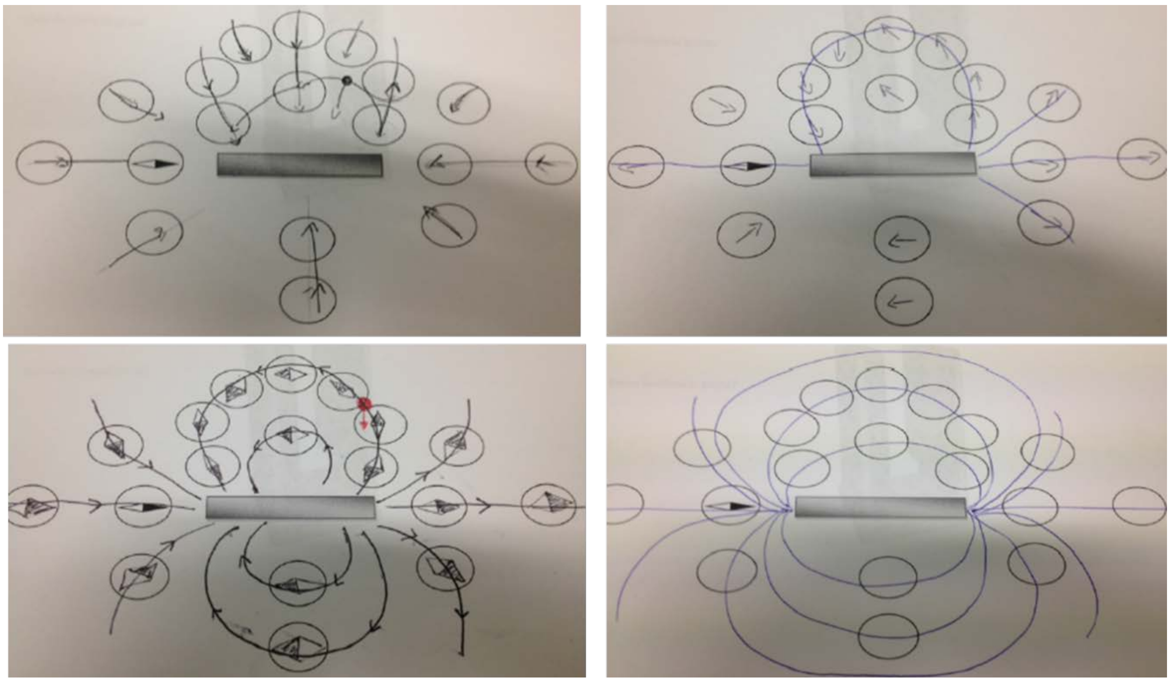

Figure 4. Exemplification draws for each one of the four categories of representation proposed by the PPT

Looking at the data collected during the second phase, the conceptual nuclei individuated by PPT are related only to some of the activities proposed. In particular: no conceptual nuclei are identified for situation 1 and 7; the mutual force involved (situation 2) is mentioned by 5% of the PPT, the polar structure of the magnets (22% - situation 3); the role of the compass as an explorer of the magnetic field (38% - situation 4); the field lines as orientation lines, the properties of the magnetic field (42%) and the difference between field and force (51%, 42%, 39% – situation 5); the role of the electrical currents (51% - situation 6).

While the individuation of the learning knot is related only to three specific situations: Rotation in magnetic interactions and the presence of the two poles (42%, 21% - situation 3); the difference between force and field, the line of orientation and the definition of field (55%, 51%, 15% - situation 5); the sources of magnetic field (15% - situation 6).

However, the more interesting things happen with the analysis of the phase 3 where the PPT had to re-use the situations proposed constructing their own learning path. If we look at the distribution of the use of the situations propose we have that: 97% of the PPT used situation 1, 35% situation 2, 65% situation 3, 26% situation 4, 19% situation 5 and 0% situations
6 and 7 (Figure 5). Therefore, there is no relation between the use of situations and the identified learning knots or the identified conceptual nuclei. The criterion of selection for the situations included in the learning path is based on another criterion, and in particular, it appears to be strongly associated with the level of self-confidence that PPT have facing of each proposed situation. In the planning of the learning path, they avoid situations that are challenging also for them, proposing situations in which they feel to be familiar.

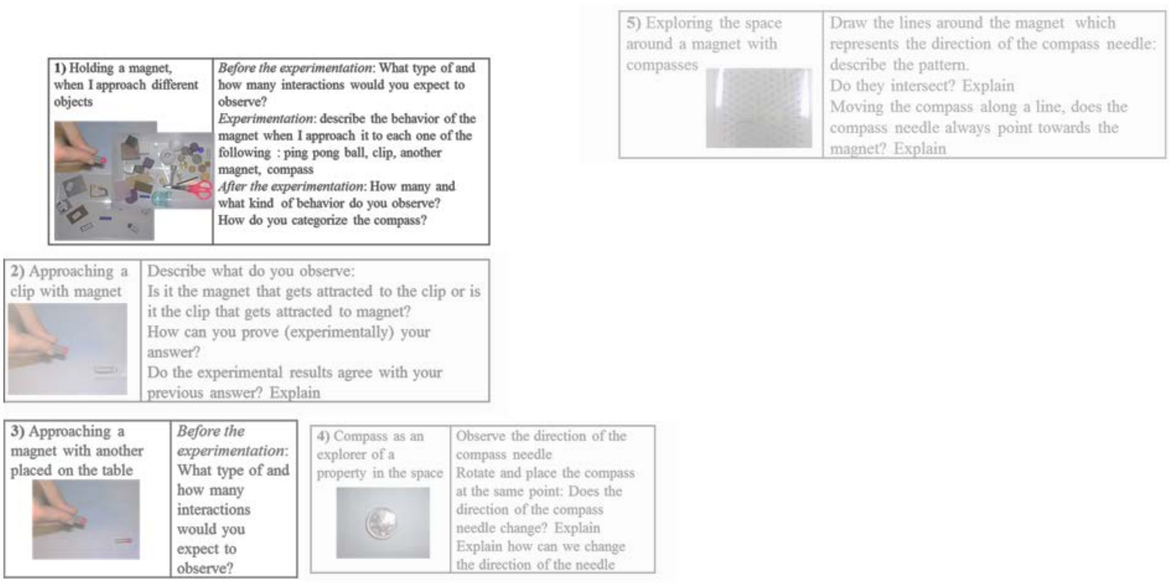

Figure 5. Pictorial representation of the use of the different situation in PPT design work. The transparency of each activity is related to the use that PPT did of it in their work of designing (how could be noticed, activities 6 and 7 are completely transparent)

All of the groups but three, proposed to address the study of the magnet interaction as the first step of their learning path: 59% propose to identify the way in which the magnets interacts; 31% to explore the interaction of the magnet to categorize objects/material, while 9% use other approaches. For more than half of the groups, the learning path consist in a deep analysis of a that situation (57%), while 13% addressed also the reciprocal nature of the interaction and another 13% proposed to introduce the magnetic field and (9%) the field lines.

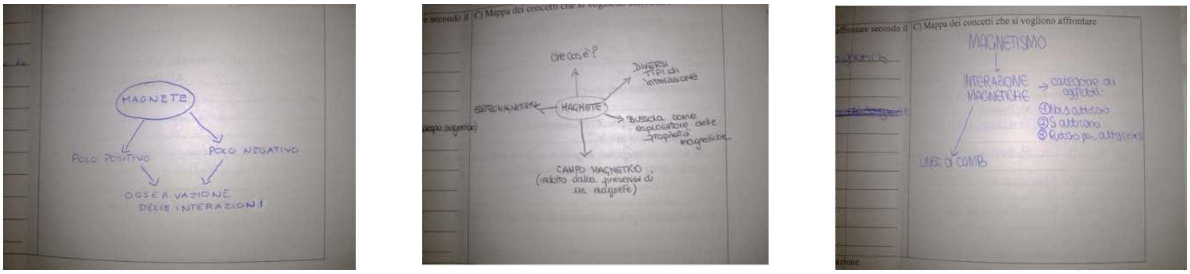

Figure 6. Examples of conceptual maps, designed by the PPT

More than three quarter of the groups began with the selection of the topic, while the remaining quarter began with the drawing of a conceptual map (Figure 6). Only one group mentioned the definition of the learning goals, while others directly design the activities and formulate their key questions. Half of the groups before design the activities and then the questions, while for the other half reversed this process.

Conclusions

Several aspects are shown by the analysis of the worksheets of the three phases. In the first phase, emerges which are the typical approach of the PPT in the addressing the phenomena, and in particular emerge how they strongly referred to their previous school knowledge to give an early interpretation of the phenomena. In particular, PPT reported standard rituals interpretations as the idea that between magnets there is only attraction or repulsion.

In the second phase, the selection of conceptual nuclei and the learning knots, PPT are able to identify the main ones, with particular focus on the aspects that are more surprising for them. In particular, the presence of rotations in the magnetic interactions and the distinction between field and force lines.

In the third phase, during the group and the designing phase, emerges a discontinuity between the work done in the two previous phase. Even if PPT had addressed the phenomena and had identified the conceptual nuclei and the learning knots during the design phase, emerges a reductionist approach. In their learning path, PPT proposed only the first and simpler situations. In this way, they do not include in their learning path several of the important aspect they had identified in the second phase without entering the interpretative plane of the phenomena, but remaining on the descriptive level even if it is addressed in detail. Therefore, emerges the need of a formation phase where PPT had to focus on the interpretative aspects of local conceptual knots overcoming in the planning of pupils activities. It is in fact well known that conceptual familiar referents will be activated on the global plan in a path when are already used on the local level.

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