# THE IWB AS A BRIDGE BETWEEN PHENOMEA EXPLORATION AND INTERPRETATION OF ELECTROMAGNETIC PHENOMENA IN CONSTRUCTION OF FORMAL THINKING

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## Abstract
The diffusion of the Interactive Whiteboard in schools is in continuous increasing, but, too often, it was simple used to catch students' attention or transpose on the "big screen" the class activities. In this paper is described a pilot study regarding the development of a Module of Formative Intervention for Prospective Primary Teachers in which the IWB as the role of supporter for the creation of a powerful context in which developed formal interpretation of electromagnetic phenomena starting from the analysis of experimental situations.

## 1. Introduction
Interactive Whiteboard (IWB) promotes the in-class cooperative activity and students' involvement (Glover et al., 2005). Its intuitive and friendly interface has the potential to support dynamical cooperation between students, opening discussions that, with the support of the graphical interface, promote the description of students' ideas.
The added gain which motivates the use of the IWB is related to its structural characteristics and the adopted interactive strategies in addition to the innovative educative styles that it promotes (Bell, 2002). The nature of IWB as open environment proposes new learning goals for science education, such as the gradual construction of scientific models of interpretation from those based on spontaneous common sense. The ways in which it become effective should be the object of teachers' formation in the view of allowing them to acquire operational skills (Michelini et al., 2013).
A research based on a new approach to IWB use, which we call "Conceptual Modeling" was carried out in a Module of Formative Intervention (MIF) concerning electromagnetic interactions within the Physics Education course held at the University of Udine for Prospective Primary Teachers (PPT) during the academic year 2012-13.

## 2. IWB and electromagnetic phenomena analysis
In electromagnetic phenomena, literature highlights different kind of conceptual knots on magnetic and electromagnetic interactions, both in in static (Viennot and Rainson, 1992; Tornkwist et al., 1993; Guisasola et al., 1999; Thong W M and Gunstone, 2008) and in dynamic situation (Maloney et al., 2001).
Pedagogical Content Knowledge (Shulman, 1987) in teacher education experiential model (Fera et al, 2012) require the contribution of content research by means of design based research on experimented educational path implemented and analyzed with empirical researches to provide examples of strategies and methods to overcome conceptual knots, but this is not enough.
Vertical curricular perspective have to be taken into account in each step of the gradual building of concepts in learning (Vosniadou, 2008; Michelini, 2005). To highlight the inner coherence that the continuum learning process have to guarantee starting from primary school in the electromagnetic topic treated.
In particular, the role of the field lines representation in the interpretation of the electromagnetic phenomena, is pivotal because field lines are a formal tool that, if used in the proper way, has a real powerful predictive role having an iconographic nature that do not need the mathematical treatment of the electromagnetic interactions (Vercellati, 2010). Therefore, the construction of the field lines representation and their properties had to be one of the main goals in the teaching of the electromagnetic phenomena because they act as referent conceptual tools (Vercellati, 2012).
The use of the IWB in connection with a webcam and simulations allows to create a powerful environment in which students explore the field lines characteristics and their role in a sort of modelling which is conceptual, i.e. *Conceptual Modeling*.

Using the webcam the actual experimental situation can be seen in real time, while with the IWB, the students can represent on a virtual transparent layer their spontaneous interpretative model drawing direct them on the acquired images.
Then, the IWB offer the context in which share and compare the different models and creates the context in which developed a shared model. In addition, the possibility to move this transparent layer on the visualization provided by simulation allow comparing the students' model with the one proposed to the simulation and, interchanging the simulated and the real situation, the core elements of the field line representation are explored and individuated.

## 3. The Conceptual Model activity

A learning path (Michelini and Vercellati, 2012), developed with a design based research aimed at achieving the development of a vertical learning path concerning electromagnetism (Vercellati, 2012), was used as base of a MFI for PPT. The MFI involved two small groups of ten students, in an activity attained at the development of an interpretative model from the experimental analysis of the magnetic and electromagnetic phenomenology.
The experimental learning path designed for the primary pupils (Michelini and Vercellati, 2012) was first experience in an Interactive Lecture Demonstration by PPT of phenomena exploration (Michelini and Vercellati, 2011).
Each conceptual step of the explorative path was re-analyzed by means of IWB discussing descriptive and interpretative aspects and adopting spontaneous iconographic representations of the interpretative ideas. Cooperative discussion of models gradually improves the spontaneous conceptual model in a sort of peer review in the group of teachers.
The role of the IWB became important as tool adopted in order to support the bridging from a local to a global interpretation of the different situations observed. This process is one of the most difficult in physics education and the development of educational context aimed to promote this change of prospective is one of the main goals of the educational research.
The situations proposed starts from the simpler ones to the more complex and in particular were addressed the interaction between magnets, magnets and iron objects and between magnet and compasses. The use of the IWB was pivotal to promote the process of clarification and the explicative efficacy of the different interpretative models. Every situation was recorded by a webcam and displayed on the IWB, so that, PPT, using the multilayer function provided by the IWB, could represent their iconographical explicative model drawing them directly on the actual situation acquired; see Fig.1.

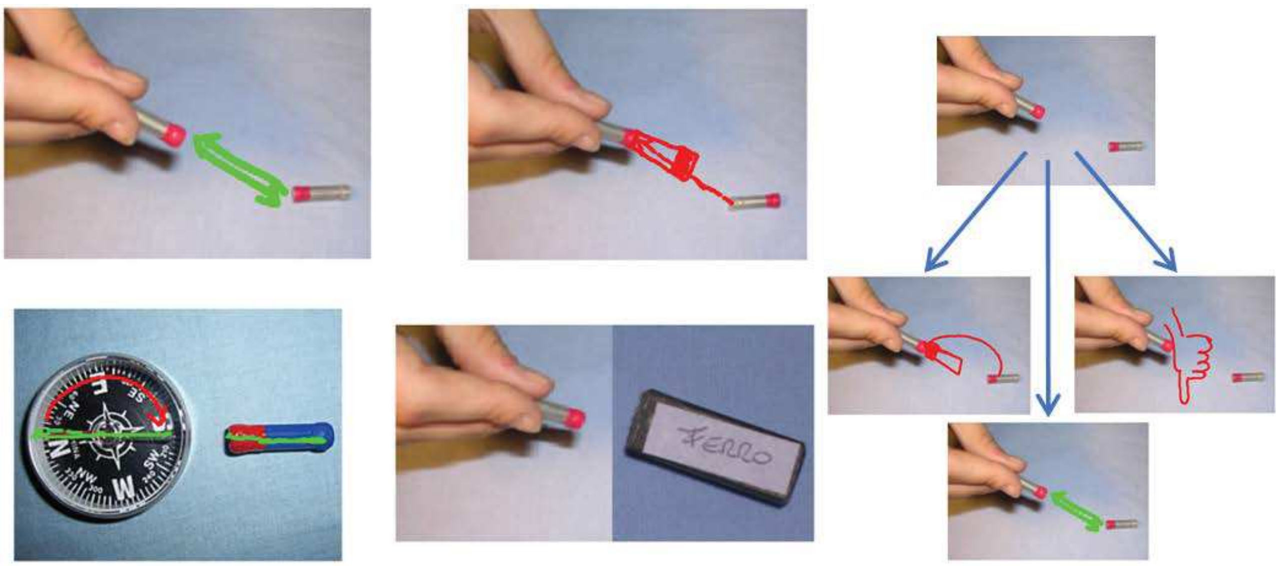


*Figure 1: Examples of students' representation concerning the magnetic interaction proposed.*

During the MFI, data were collected by audio recording of the discussions and using the IWB as a repository of the different proposals emerged.

In the first phase of the Conceptual Modeling activity, the different proposals coming out from the PPT were collected and stored to create a database of the proposed explanations and in the meanwhile have the opportunity to record the path of reasoning followed by the group of PPT (Robinson, 2008). The appropriate role of symbols is found to be a result gained from this phase of the discussion, which was started in a perspective in which arrows and trajectories were used as representations of states of motion or graphical icons rather than as formal symbols despite the PPT knew their formal appropriate meaning. As example, in the upper left frame of Fig. 1 the interaction between the magnets is represented as two opposite arrow, while in the other frame different proposals are reported (i.e. description of the motion of the magnets, representation of the final situation and intuitive iconographical representation represented as a thumbs-down to indicate that there is not attraction in that situation).

After this initial phase there was a cooperative phase in which PPT, discussing as peers, highlighted strengths and weaknesses of each representation. The level of interpretation (i.e. descriptive, interpretative…) of each proposal was individuate and the proposals were categorized on the base of it. This process allow PPT to isolate the interpretative from the descriptive aspects and the need of provide argumentation during the peer discussion empowered a process of deepening in the understanding of the causes of the phenomena. The evolution of reasoning has gone through the need of recognize the bipolar structure of each magnet and the interaction of each pole with both poles of the other magnet. The transition from the examination of the single interaction (force) to a couple of forces allowed PPT to account the rotation of the magnet while equal poles are approached; indeed a sort of principle of virtual work was used to justify it.

The structure of this activity was then re-proposed for the analysis of the field line representation. The field lines were constructed, step by step, starting from the exploration of the actual system using compasses with the aim of investigate the properties of the magnetic field that emerges from this type of investigation. The obtained pattern of lines is reported in the right frame of Fig. 2.

The obtained pattern of lines was overlapped to a simulation, left frame of Fig. 2, and its main properties (i.e. the symmetry of the pattern, the presence of zones with a greater thickening of lines, the not-constant distance between the lines) were discussed in connection to the representative meaning of the lines as the envelope of the directions of orientations of a compass placed in the space surrounding a magnet.

The distinction between the property of the space represented by the filed lines to the force acting at a point in the space has been addressed indicating the tangent direction at the field lines in one point and the direction of departure of a ferromagnetic ball placed at the same point. In this way, from the cooperative discussion based on the representation in the IWB, emerged the distinction between magnetic field vector force vector at a point of the space near a magnet (Fig. 2). The PPT's graphical symbols, earlier used almost only with iconographic role, now became symbols related with a specific physical meaning in the explored context.

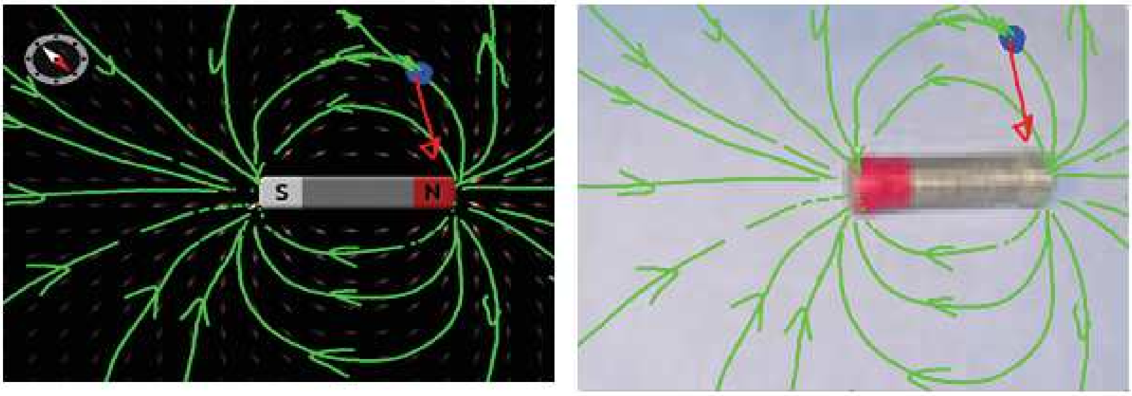


*Figure 2. PPT representation of magnetic field lines and their overlapping to actual and simulated situations.*

The possibility to overlap the field lines to different images, allow to explore the portability of the model and the properties of composition of the magnetic field around a magnet. By comparing the patter obtained with the one generated by two magnets placed orthogonal to one another, the discussion highlighted the hypothesis of vector composition of the magnetic property of the space at equal distance from the poles. This conceptual modeling lays the basis of the vector nature of the magnetic field in the view of a quantitative analysis of the magnetic field vector (Vercellati, 2012).
Indeed, as final activity, the field lines representation was also used to interpret situations of electromagnetic induction in which the predictive and explicative power of this tools was used to identify and explain the situation in which the phenomenon of the electromagnetic induction occurs.

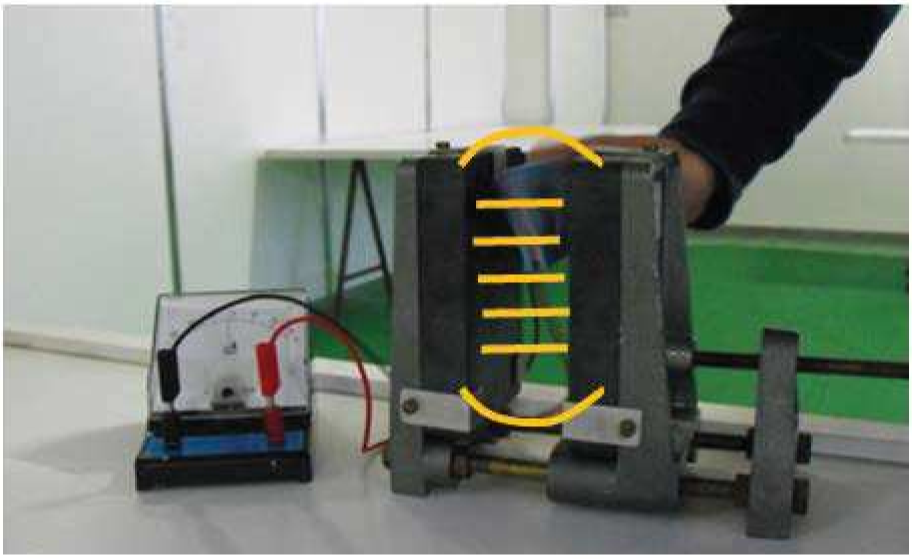

*Figure 3. Representation of the magnetic field lines of two magnet to explain electromagnetic induction.*

It was done by acquiring in real time the actual situation proposed in Fig. 3 representing the field lines of the magnetic field in the surrounding of the couple of the two big magnets and exploring the set of actions that are able to generate an electric current into the wire. In this way the action done were seen by all of the component of the group and, more important, the presence of the representation of the magnetic field as its pattern of field lines represents an objectification of tit that makes it visible and allow PPT to use it effectively in the interpretation of the electromagnetic induction.

## 4. Conclusions

The nature of the IWB as open environment offers many opportunities for new learning goals in the social constructivist perspective. The management of an open environment requires a teacher

familiarization not only with its features and potentiality, but also with learning situations that can be produced with it. The addressed MIF of electromagnetism with PPT highlighted the importance of the sharing and the comparison of ideas to acquiring a mastery of the simplest interpretation of the simplest elements, which characteristics, often taken as obvious in an instructional approach, are not recognized and re-used in the analysis of simple phenomena.
In particular, the IWB offers the opportunity of a conceptual change in the interpretative models that allows the bridging from a common sense to a scientific interpretations of the phenomena in a context of cooperative discussion between learners. The need of conceptual learning of the physical descriptions of phenomena is realized and empowered in terms of conceptual modeling using the IWB when the explicitation of the individual models becomes a kind of peer review work on the interpretations. The experience gained in the context of the magnetic phenomena shows that this process not only leads to the achievement of the peculiar characteristic of abstract entities as the magnetic field, but also to the gradual acquisition of formal meaning of symbols initially naively represented only with an iconographic nature.
The specific facilities of combinations of multi-layer promote PPT reflection on the consequences of some representations and allow them to construct hypotheses concerning important proprieties as the composition in the case of the presence of different magnetic sources. The multimedia nature of IWB allows the connection between the views of dynamic processes, such as the insertion of a coil in a uniform magnetic field, with the representation of the field itself. The connection between the generation of an induced current in the coil and the cutting of the field line is seen, allow to builds a first conceptual modeling (that differs from the previous ones) for the recognition of the variables and the process which produces electromagnetic induction.
The use of the IWB on the educative and the contents planes is needed to have an effective gain from its use in physics education. The use of multilayer representation report to be an effective tools in providing a way of approach in the analysis of the electromagnetic phenomena because it allow to support PPT's peer discussions producing an increasing of the clarity in the way in which the students explain their idea and, in the meanwhile, promote the sharing of opinions.
In addition, the possibility to trace the different proposals and their development among the discussion allow to document the path of reasoning that the discussion followed providing so an effective tool for the acquisition of the consciousness of each one of the sub-bridging argumentation that will construct the bridge between naïve and scientific interpretation.

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