

The Uses of Interactive Whiteboard in a Science Laboratory.

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Abstract

In the last ten years several studies were conducted about the educational use of interactive whiteboard (IWB) in teaching and learning activities, showing different advantages introduced by this technology and analysing different implications for teachers (both from technical and pedagogical point of view). In this context, we planned a research with the aim of analysing the activities that can be performed through the interactive whiteboard in science laboratories, in order to characterize them in terms of both technical features and pedagogical goals. Furthermore, we investigated also the pedagogical approaches used by teachers to plan or to carry out these activities. For these purposes, we video-taped 20 sessions of didactic science laboratories where different science teachers used IWB with their students in an ICT-equipped laboratory, and we classified the video-clips by using three different dimensions of analysis: *Pedagogical Approaches*, *Technical Uses* and *Pedagogical Aims*. These dimensions of analysis allowed us to characterize the practices carried out through the interactive whiteboard in scientific contexts and to study how IWB blends in an inquiry-based science laboratory. Moreover, this analysis led us to identify different *specific IWB practices* that can produce results unattainable by using only traditional educational tools (such as whiteboard, computer and projector).

Keywords

Interactive Whiteboard (IWB), Physics Education, ICTs Technologies, Science Laboratories.

1. Introduction and objectives

In the last ten years several studies were conducted about the educational employment of interactive whiteboard (IWB) in teaching and learning activities. The first researches revealed important advantages in terms of pupils' motivation, attention and behaviour, showing that the activities performed using IWB are more attractive for teachers and students than the practices carried out through other classroom educational tools (Higgins et al. 2007; Smith et al. 2005). Moreover, different studies in education showed that IWB is suited to stimulate the interactions between students as well as between students and teacher (Higgins et al. 2007; Murcia 2008; Schmid 2007) and for this reason it can change both the practical and theoretical aspects of teaching and learning processes.

The multimodal functionality and the interactive nature of IWB give teachers the possibility to treat scientific contents with great flexibility, to choose different pedagogical approaches and to manage multimedia or multimodal representations with more efficiency than traditional educational tools (Hennessy et al. 2007; Jang & Tsai 2012; Kennewell & Beauchamp 2007). In this perspective, IWB provides students the opportunity to learn with different styles (Murcia 2008; Schmid 2007), combining traditional whiteboard actions (like writing, drawing, etc.) with new features (Jang & Tsai 2012), like the functions of capturing, emphasising, storing, and reviewing (Beauchamp & Parkinson 2005). From the science education viewpoint, these Information and Communication Technologies (ICTs) allow teachers and students to model abstract ideas in new ways (Higgins et al. 2007), to address complex and abstract concepts through dynamic representations and to switch easily between the different representations (Miller et al. 2004; Kennewell & Beauchamp 2007).

In the last years, many governments in the world invested great economic resources to provide schools with IWB. Unfortunately, despite all these economic efforts, a great number of teachers does not use IWB in everyday life classrooms or does not exploit its whole potential (Hermans et al. 2008; Glover & Miller 2001): this problem stimulated different researches in order to shed light on the causes of this underuse or inappropriate use of IWB in schools. In this sense, beyond the analysis of the factors that can affect the underuse of the interactive whiteboard, these studies broadened the multiple perspectives through which the

activities performed through IWB could be described. However, three perspectives of investigation were particularly relevant in our context of research.

(i) The first regards the *pedagogical approaches* used by teachers to plan or to carry out the practices that can be performed using an interactive whiteboard. In fact, a large number of teachers (even recognising some possible benefits of using IWB in their lessons) designs general activities with IWB aimed only to motivational and engaging goals without analysing how this technology can improve teaching and learning processes (Hammond et al. 2011). These activities also reinforce a *teacher-centred* approach in which teachers are the main actors (Higgins et al. 2007). On the contrary, some researchers stressed the importance of a *student-centred* approach, using IWB: taking into account the intrinsic hands-on nature of interactive whiteboard, some studies showed that “When the teacher is the only operator of IWB, it may offer little more than traditional computer demonstration” (Murcia 2008; Hennessy et al. 2007).

(ii) The second perspective is related to the underuse of IWB in teaching activities. In order to face this problem, some studies focused their attention on teachers’ abilities and familiarity with ICTs and showed that teachers’ technical skills with IWB influence their attitude to employ it in classroom (Becta 2004; Beauchamp 2004; Glover & Miller 2001). In order to improve teachers’ abilities or familiarity with IWB, some researchers listed different *teaching actions* that can be performed by using this technological tool (we call these *teaching actions* as IWB activities, IWB practices or IWB uses). These researches led us to deal with the second perspective of investigation regarding the analysis of IWB activities carried out in science laboratories from a technical point of view (i.e. *technical uses* perspective).

(iii) Finally, International literature showed that teachers’ difficulties in the use of IWB are related not only to their practical skills with IWB, but also to their beliefs about the potential value of ICTs from a pedagogical point of view (Mama & Hennessy 2013; Hermans et al. 2008). Different studies, analysing the pedagogical implications introduced by the employment of IWB in teaching activities, revealed the existence of relations between teachers’ beliefs and the use of interactive whiteboard (Mama & Hennessy 2013). Since teachers’ beliefs influence also the specific goals (from a pedagogical point of view) that can be reached through IWB activities, we focused our attention on the third perspective of investigation in order to analyse the *pedagogical aims* for IWB practices that can be performed in science laboratories.

The perspectives of investigation above described led us to face the important challenge regarding the classification and the characterization of IWB practices (both from technical and pedagogical point of view) in order to identify the *practices that can be performed only through an interactive whiteboard* (we will call them *specific IWB practices*) and that can produce results unattainable through traditional educational tools (such as whiteboard, computer and projector). In this sense, a specific IWB practice can be defined taking into account the framework proposed by Mama and Hennessy to analyse different teachers’ profiles (Mama & Hennessy 2013). We used their classification (regarding teachers’ profiles) to define two different ways of use the interactive whiteboard: *the integrational* way of use, that allows “to employ technology’s diversifying potential to address students’ needs”, and *the incremental* way of use, through which teachers “enhance their traditional, existing practices” (Mama & Hennessy 2013). In this perspective, we will consider **specific IWB practices** in inquiry-based science laboratories (Hofstein & Mamlok-Naaman 2007) those activities that allow exploiting the whole potential of IWB technology (i.e. the practices that give an extra value if compared with the activities that can be performed through traditional educational tools).

We planned this study in order to answer the following research questions:

RQ1 How can IWB be used in an inquiry-based science laboratory, considering the pedagogical approaches, the technical uses and the pedagogical aims and how much time is employed for these uses?

RQ2. Which of these identified uses can be considered activities that may be performed only through an IWB, in an inquiry-based science laboratory?

2. Design and procedure

In order to analyse how IWB can be used in a science laboratory, we recorded 20 experimental sessions (3/4 hours for each one) carried out in a ICT equipped educational science laboratory¹ in Autonomous University of Barcelona. These sessions were performed by groups of 20-30 secondary school students (of all levels), involving four different science teachers. All the activities were inquiry-based laboratory experiences (Hofstein & Mamlok-Naaman 2007), where students carried out real experiments with data loggers, interacted with simulations, discussed concept and experimental results between peers, etc.

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We divided each session in different video-clips, so that each clip corresponds to a single IWB activity. We obtained 334 video-clips, which represent about 20% of the total time necessary to perform the 20 sessions (i.e. 14,5 hours of IWB video-clips compared with about 70 hours for the 20 sections). Taking into account that students were involved in experimental group-based activities, where (usually) most of time is dedicated to perform qualitative and quantitative hands-on experiments or to analyse experimental results, the time employed to use the interactive whiteboard represents an important part of the whole sessions.

Finally we classified each video-clip using an iterative process, through which we defined a set of categories, according to the qualitative analysis processes (Miles et al. 2014).

3. Results and Discussion

Taking into account the three perspectives of investigation previously described, we defined three dimensions of analysis (see Table 1).

The first dimension (“*Pedagogical Approaches*” - see **D1** dimension in Table 1) allowed us to investigate in which way teacher involves students in each activity. IWB actions from this perspective were characterised as teacher-centred or student-centred approach: the first refers to the practices when teacher is the main actor (while using IWB) and students are only the audience (*T* category of D1 dimension); the second one refers to the activities where students play a crucial and active role (*S* category of D1 dimension), even if teacher handles IWB, because in these cases his/her actions are guided by students discussions, answers to specific questions, experimental results, etc.

Table 1. The Dimensions of Analysis (D1) Pedagogical Approach, (D2) Technical Uses and (D3) Pedagogical Aims represent the first important result of the study proposed in this paper.

	Code	Name - Definition
D1	S	Student-Centred: IWB activity stimulates students’ interactions between them or with the teacher.
	T	Teacher-Centred: Teacher is the main actor of IWB activity.
D2	WHI	Whiteboard: IWB is used to write, to draw, to use colours, etc...
	PRO	Computer & Projector: IWB is used to show pictures, graphs, experimental results, WEB pages - without interaction with displayed contents.
	WHI+PRO	Whiteboard + Computer & Projector: IWB is used to superpose new tracks on the displayed contents, (draw on a photo, fill a table, etc...) - without any change of the back contents.
	IWB_d&d	Drag and drop group: IWB is used (1) to move/classify/order, (2) to group, (2) to modify the sides of the objects and (4) to capture the images on IWB (screenshot).
	IWB_nav	Navigation: IWB is used to scroll or to change WEB pages or displayed documents.
	IWB_b&f	Back and Forward: IWB is used to refer/display/use previous stored information.
D3	EXP	Explore previous ideas: Teacher makes a specific question in order to explore students’ previous idea about the proposed activity.
	INT&DIS_conc	Introduce and discuss concept: Teacher introduces & discusses concepts, through questions, explanations, discussions, etc.
	INT_proc	Introduce procedure: Teacher introduces the experimental activity “step by step”.
	ANL_data	Analyse data: Students/teachers introduce experimental results to IWB (numbers, tables, graphs, etc...), and organize the displayed data through discussions.
	SUM	Summarize: Students/teachers summarize, structure, organize or revisit the outcomes (results, concepts, ideas) of previous activities.
	APP	Apply: Students apply the outcomes in a different context.

Moreover, the second dimension of analysis (“*Technical Uses*” - see **D2** dimension in Table 1) was aimed to characterise IWB activities whether they could be carried out with traditional displaying tools (like whiteboard, PC and projector) or whether they could only be performed by this tool. In this sense, the first three categories of D2 dimension correspond to IWB uses as a traditional tool, **(a)** displaying pictures, texts, experimental results, like a traditional pc and projector (*PRO* category), **(b)** writing or drawing, like a traditional whiteboard (*WHI* category - see Figure 2C for an example), **(c)** displaying tables, graphs, or any kind of picture and writing on the displayed picture (for example, Figure 2A shows a student that fills some displayed template in order to introduce experimental results; we classified this action like *WHI+PRO* since teacher could propose it to the classroom projecting on the whiteboard the template and students could fill the template without any interaction with the displayed image). The remaining D2 categories (*IWB_d&d*, *IWB_nav* and *IWB_b&f*) represent the uses of IWB that cannot be performed through traditional educational tools (see the Table 1 for more details). In details, *IWB_d&d* practice allows to move objects, sentences, pictures, etc., in order to classify or to order them: consequently, the position of the objects on the whiteboard takes on a conceptual meaning (Figure 2D shows a *IWB_d&d* activity in which teacher classified different sentences, written by students, through drag and drop movements). We grouped in drag and drop category some different IWB practices related with drag and drop movement, like *size modification* of the object displayed on IWB, *grouping* different objects (in order to drag them simultaneously) and *capture* the images displayed on IWB. The last two categories indicates, respectively, the activities through which navigate web pages or documents displayed on the screen (i.e. *IWB_nav*) and retrieve previous stored information (i.e. *IWB_b&f*).

The full set of D2 categories summarize the activities that can be carried out in science laboratories by using an Interactive Whiteboard, according with (and implementing) more general lists available in literature (Miller et al. 2004; Higgins et al. 2007; Beauchamp & Parkinson 2005). However, our classification introduces new elements to the discussion, since it allows establishing which are the effective added values introduced by IWB technologies.

Finally, considering also the aims of the interactions, we introduced a third dimension of analysis (“*Pedagogical Aims*” - see **D3** dimension in Table 1) through which we detected the pedagogical goals for each IWB activity (see **D3** - Table 1), according with (and extending) the classifications available in literature (see for example Beauchamp & Parkinson 2005). In details, taking into account international literature about the *dynamics of learning processes* (see for example Lawson & Karplus 2002) we defined six categories of pedagogical aims in order to identify which typical step of learning cycles corresponds to each specific activity of science laboratories. In this way, we were able to characterize IWB practices in terms of **(a)** exploring students’ previous idea (*EXP* category), **(b)** introducing and discussing different concepts through questions, explanations and discussions (*INT&DIS_conc* category), **(c)** introducing an experimental procedure (*INT_proc* category), **(d)** analysing experimental results (*ANL_data* category), **(e)** summarizing or structuring the outcomes of previous activities (*SUM* category) and **(f)** applying the outcomes in different contexts (*APP* category).

The categories obtained for each dimension of analysis (summarised in Table 1) allowed us to characterize IWB practices recorded during the 20 sessions. In fact, each activity was classified in terms of a specific pedagogical approach, of a defined technical use and of an explicit pedagogical aim. In this way, our classification offers the possibility to define a *3D category system*, in which each dimension of analysis represents a specific *feature* for IWB recorded practices. Taking into account the possible combinations between the defined categories (two categories for D1, six for D2 and D3), our classification (theoretically) allows distinguishing 72 different kinds of IWB practices. However, during the 20 recorded sessions, we observed 54 different IWB practices. The Figure 1 represents the 54 observed activities versus the total time employed to carry out each specific kind of practice: each bar corresponds to a specific activity defined by the 3D category system, while the height of the columns corresponds to the total time employed for each kind of activity.

The analysis of D1 categories shows that approximately 2/3 of IWB activities were focused on students (9 hours of student-centred activities that correspond to the 61% of the total 14,5 hours employed to carry out all IWB practices). In fact, even if teachers are the handler of the interactive whiteboard, most of recorded cases show that learners are the principal actors (for example, most of practices are centred on students’ previous ideas, on their experimental results, on their conclusions, etc...).

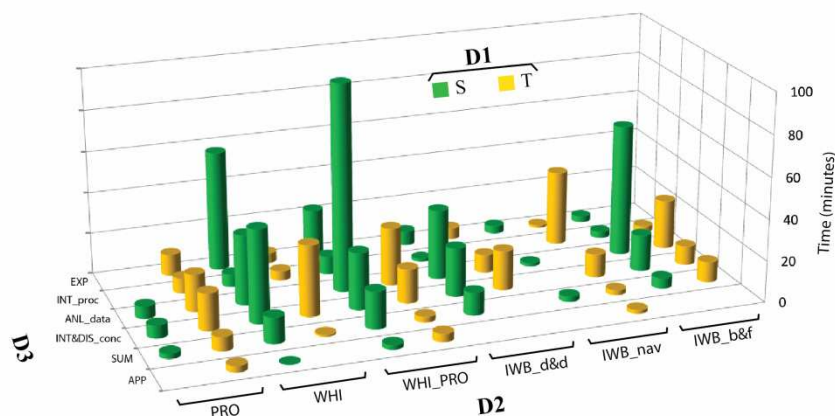


Figure 1. D1 (Pedagogical Approaches *S* and *T*), D2 (Technical Uses) and D3 (Pedagogical Aims) categories compared with the time employed for each activity.

As regard the analysis of D2 categories, the Figure 1 shows that the interactive whiteboard is used for about 61% of time² performing activities that could be carried out through traditional educational tools (like whiteboard and/or projector).

The analysis of IWB practices led us to identify some uses that can be considered as specific IWB practices, because they add extra value to science laboratory activities even if they are short in time. For example, all IWB activity grouped in drag and drop categories or the back and forward analysis can be performed only using an interactive whiteboard, and even if they are not very significant from a quantitative point of view (because they need a short time to be performed; see Figure 1 – D2), they are typically student-centred activities (see Figure 1 – D1) that can give relevant contributions from a pedagogical perspective (see Figure 1 – D3). In details, drag and drop (*IWB_d&d*) practices are engaging activities for students, which offer the possibility (a) to classify and analyse experimental results, (b) to classify objects, concepts, data, etc. (c) to discuss concepts, and etc. The Figure 2B shows an example of *IWB_d&d* in which teacher performs a drag and drop action, classifying students experimental results previously written through the *WHI+PRO* practice. This is a typically student-centred example, in which teacher stimulates students' discussions, classifies the experimental results taking into account learners' ideas, and (consequently) helps students to improve their visual representation regarding different concepts or phenomena (that is an important and difficult educational goal in science laboratories, as shown by international literature in the last thirty years).

Another example of student-centred activity that can be performed only using an IWB and that allows exploiting the whole potential of this educational tool is represented by the opportunity to move and analyse back and forward the slide used during the activities (*IWB_b&f*): the Figure 2D shows an example of activity in which teacher uses the texts and draws previously written by students on IWB in order to compare the experimental results with students' previous ideas. This technical function is one of the most mentioned by international literature in education (Higgins et al. 2007) and plays a crucial role in a science laboratory, because it allows teacher and students to discuss the activities previously carried out (i.e. experimental results, analysis of students' spontaneous ideas, experimental predictions in the light of new evidences founded). In this perspective, if we consider the results of our study arising both from the technical uses and from the pedagogical aims analysis, we can state that *IWB_b&f* is the technical use that can enhance the development of learning cycles of science laboratorial activities, that is Predict, Observe and Explain (POE) cycle.

² 9 hours of practices in which IWB is used like a traditional whiteboard and/or a projector, among the total 14,5 hours necessary to perform the whole IWB activities.

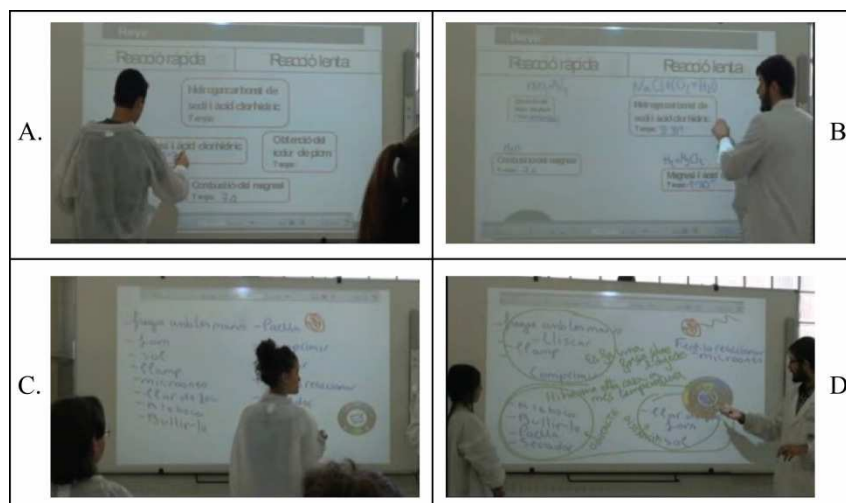


Figure 2. (A) WHI+PRO, in which students fill a template displayed on IWB; (B) IWB_d&d, through which teacher classify students' results through drag and drop movements, taking into account pupils idea about the classification; (C) WHI, in which students write on IWB their previous idea; (D) IWB_b&f, through which teacher uses stored information at the end of experimental activities to discuss different concepts with students.

Finally, further statements regarding the additional benefits that IWB introduces in a science laboratory arise from the analysis of the relationships between the D2 and D3 dimensions. In fact, the Figure 1 shows that some pedagogical aims are mainly developed with particular technical uses. For instance, “explore students' ideas” was mainly reached through *WHI* technical use, because it corresponds to activities in which teacher writes students' ideas, or students come up to the whiteboard to write their experimental results, or their previous idea by answering specific questions, etc. (See for example Figure 2C: student writes on IWB her ideas, answering to teacher's questions).

Another interesting relationship appears when teachers introduce and discuss students' experimental results (pedagogical aims: *ANL_data*). The Figure 1 shows that this pedagogical aim was reached mainly employing two technical uses: *IWB_b&f* and *WHI+PRO*. Regarding the relationship between *IWB_b&f* technical use and the *ANL_data* pedagogical aim, we showed above that IWB gives a crucial contribution if teacher retrieves the previous information performed by students during the lab activities (Figure 2D). The relationship between the *WHI+PRO* technical use and the *ANL_data* pedagogical aim shows that many discussions of experimental results could be performed using a whiteboard coupled with a projector (Figure 2A). However, the only difference between the two uses is that the interactive whiteboard allows teacher to store information displayed on the board. Moreover, the direct interaction with IWB allows the teacher to better manage the activity in terms of agility instead of using a whiteboard-pc-projector. As it has been highlighted by Beauchamp (Beauchamp, 2004), teachers spend a considerable part of time managing the PC and moving back and forth from the desk to the whiteboard.

Finally, an important relationship between D2 and D3 categories is represented by *IWB_nav* technical use and the *INT_proc* pedagogical goal, which consists on navigating through the content of documents, web pages, etc. in order to search information or to introduce a procedure. This is a typical teacher-centred activity that could be performed using a whiteboard coupled to a projector and that can take advantages of IWB employment (as described before) in terms of teachers' agility and of time employed. This statement allows us to observe that IWB can improve also typical teacher-centred activities performed in a science laboratory.

4. Remarks and Implications

This research allows us to classify IWB ways of use, taking into account the pedagogical approaches, the technical uses and the pedagogical aims (**RQ1**).

A first important outcome regards students' involvement during the activities performed using an interactive whiteboard in a science laboratory. In fact, our research leads us to extend the results of different generic studies about the educational role of IWB, since it allows teacher to propose and perform activities that involve students during science laboratory sessions (i.e. IWB could stimulate student-centred pedagogical approaches of teacher).

Moreover, our work proposes a classification of IWB practices carried out in a specific inquiry-based science laboratory. In particular, the analysis of the technical uses leads us to conclude that, although a part of IWB activities can be performed without an interactive screen, there are some unique IWB practices that give sufficient reason to use this tool in science laboratory activities from a pedagogical point of view. In this sense, our study shows that the time distribution of IWB technical uses (obtained in this paper) is influenced also by the intrinsic nature of particular activities related to specific pedagogical aims. Furthermore, this study evidences that the interactive whiteboard introduces benefits also when it is used like traditional educational tools, because it helps teacher to conducting the activity without losing the eye contact with the classroom.

As regard the activities that can be performed only using the interactive whiteboard, they represent the added value given by this technology and allow exploiting the whole IWB potential, even if they are short in time. Finally, our study shows that the relationships between the technical-uses and pedagogical-aims dimensions are unevenly distributed over the time employed to perform all IWB practices during the 20 sessions. This result allows us to conclude that the aforementioned relationships could suggest to teachers the optimal uses of IWB for a specific pedagogical aim.

As regard the second research question (RQ2), the analysis of technical uses and pedagogical aims provides us the possibility to identify some specific IWB practices that can be carried out employing the interactive whiteboard in a science laboratory. For example, the possibility to retrieve stored information adds significant value to the activity previously performed. In this sense, the back and forward action takes advantage from the long-time employed for some practices (that could be performed with traditional educational tools), since it allows to compare students previous ideas or prediction with the outcomes of experimental activities (i.e. the typical predict-observe-explain cycle used in science laboratories). Another example is represented by the drag and drop group of activities that helps teacher to deal with specific pedagogical aims (like the introduction and discussion of concepts or like the analysis of experimental results), since it allows to move and classify the objects displayed on the whiteboard, giving in this way a meaning to the classification from a conceptual point of view. If we take into account also IWB function to store information, we can conclude that drag and drop represent a second kind of specific IWB practice that gives meaning to the long-time employed for the activities that could be performed through traditional educational tools, since it allows to discuss previous results in a new way. Finally, another specific IWB practice is represented by IWB navigation action, since it allows teacher to better manage the activity of experimental procedures' introduction in terms of agility instead of using a whiteboard-pc-projector, improving in this way also a typical teacher-centred activity.

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