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Full Length Research Paper

Acceptance of interactive whiteboards by Italian mathematics teachers

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Abstract

In recent years, Interactive Whiteboards (IWBs) witnessed a large spread in the schools of many countries all over the world. They offer interesting opportunities to interact with digital content in a multi-person learning environment. This study investigated the acceptance of Interactive Whiteboards among mathematics teachers with IWB experience in Italian Secondary education. Five variables (perceived usefulness, perceived ease of use, ICT experience, facilitating conditions, and attitude towards use) and behavioural intention to use technology were used to build an extended Technology Acceptance Model and Structural Equation Modelling was used for parameter estimation and model testing. The model was tested using responses to a survey from more than 150 teachers who already had the opportunity to test Interactive Whiteboards. The model is found to have a reasonably good fit. Perceived usefulness and attitude towards use have a direct effect on teachers' behavioural intention to use IWBs, whereas ICT experience, facilitating conditions and perceived ease of use affect technology acceptance indirectly.

Keywords: Interactive Whiteboards, Technology Acceptance Model, Structural Equation Modelling, Secondary education.

INTRODUCTION

The aim of this study is to investigate Interactive Whiteboards (IWBs) acceptance among Italian mathematics teachers, teaching in the learners' range from 11 to 15 years old, i.e. teachers from Junior High School and from the first two years of Senior High School.

An Interactive Whiteboard is a touch-sensitive screen that works in conjunction with a computer and a projector. IWBs offer interesting opportunities to interact with digital content and multimedia in a multi-person learning environment (Smith, Fay, Hardman, Frank and Higgins, 2006). Software provided with the boards offers additional functions that improve "technical interactivity" (Smith, Higgins, Wall and Miller, 2005). These functions include (Kennewell, 2006; Mercer, Hennessy and Warwick, 2010):

- Drag and drop**:** an on-screen item can be moved around to classify, process, compare items, ordering terms, etc.;
- Hide and reveal**:** allowing ideas to be stepped in a particular way so that conceptual development takes place, and stepping the development of hypotheses;
- Colour, shading and highlighting**:** emphasising similarities and differences, enhancing explanations, and allowing reinforcement through greater emphasis;
- Matching items: for example, equivalent fractions, a straight line with its graph and an equation with its solution;
- Movement or animation**:** to demonstrate principles and to illustrate explanations;
- Immediate feedback from software, often arising as a direct consequence of one of the other manipulations;
- Indefinite storage and quick retrieval of material.

As a result of these features, IWBs have the potential to enhance demonstration and modelling; to improve the

ABBREVIATIONS

IWB: Interactive Whiteboards; **TAM:** Technology Acceptance Model; **SEM:** Structural Equation Modelling

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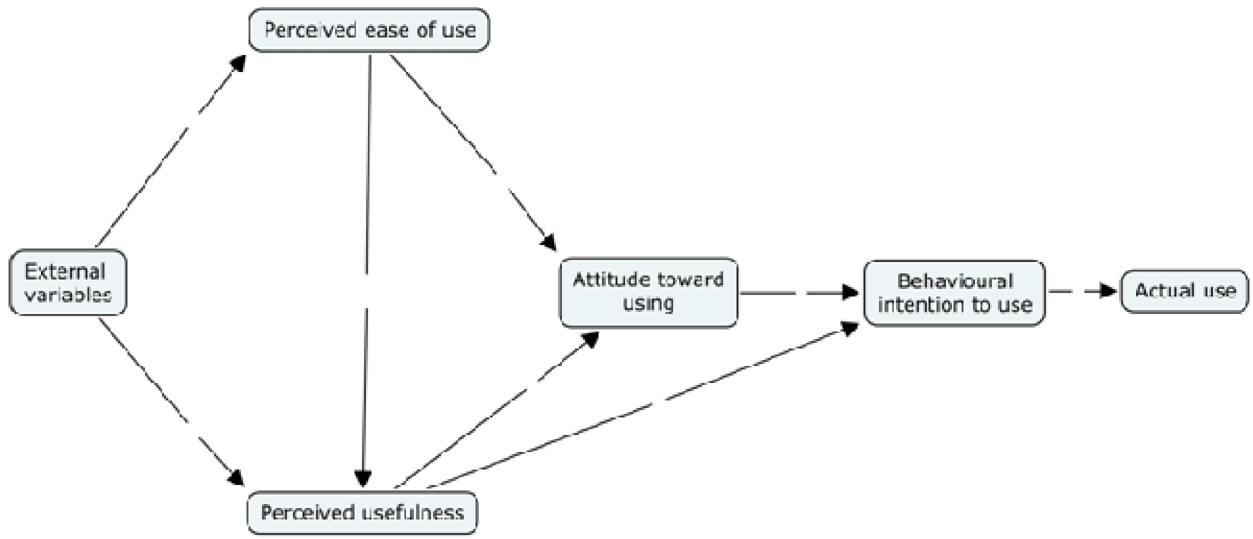

Figure 1. Technology Acceptance Model (Davis, Bagozzi and Warshaw , 1989).

quality of interactions (between teacher and learners as well as between different learners) and teacher assessment through the promotion of questioning; to extend the range of disposable digital resources and foster planning for teaching, and to increase the pace and depth of learning (BECTA, 2004).

In the last ten years, IWBs have largely spread all over the world, e.g., the United States, Australia, Canada, and Mexico (Betcher and Lee, 2009; Fernández-Cárdenas and Silveyra-De La Garza, 2010). In Europe too different countries experimented with IWBs in the schools: specific initiatives have been undertaken in Portugal, Germany, France, Belgium, and the UK (Balanskat, Blamier and Kefala, 2006; Higgins, Beauchamp and Miller, 2007; Prosser and Ayre, 2010). IWBs have become very widespread in school classrooms in the UK since 2001. In 2005, a national survey in England found that nearly half of primary teachers (49%) had made use of dedicated IWBs; in secondary schools, 77% of math teachers, 67% of science teachers and 49% of English teachers said they had dedicated IWBs (Miller, Averis, Door and Glover, 2005).

In Italy, the adoption of IWBs (in Italian, *Lavagne Interattive Multimediali*) is still at an early stage, although the number of them installed in schools is constantly increasing. In a first period (2005 – 2008) their adoption was supported with a few pilot projects by individual schools, school networks or local school authorities. In 2007 the Ministry of Education planned to deploy IWBs on a large scale by means of a *3-year action programme (2007-2010)* in primary and secondary schools (*Piano Nazionale Diffusione Lavagne Interattive Multimediali, ANSA- MIUR,* 2007). At this moment, most schools have IWBs, but their actual use is still at an experimental stage and is still limited to few teachers (Parigi, 2011).

This study proposes a model, based on Davis' (1989) Technology Acceptance Model (TAM), to investigate the factors that affect IWB acceptance by Italian High Schools mathematics teachers who had the opportunity to test Interactive Whiteboards. The aims of this contribution are:

1. To investigate the current use of IWBs in Italian High Schools by mathematics teachers;
2. To determine factors influencing IWBs acceptance;
3. To test a TAM-based model for IWBs acceptance.

Literature Review

Different models have been developed and tested to predict technology acceptance. Among these models, Davis' (1989) Technology Acceptance Model (TAM) is arguably the most popular. It has received empirical support for being robust and parsimonious in predicting technology acceptance and adoption in various contexts and using a variety of technologies (Legris, Ingham, and Collerette, 2003). Figure 1 shows the TAM model.

The TAM has been developed to explain the relationships between perceived usefulness, perceived ease of use, attitude towards technology, behavioural intention to use and actual use. TAM posits that user adoption is directly and indirectly determined by two related key beliefs, namely, perceived ease of use and perceived usefulness. "Perceived usefulness is defined as the extent to which a person believes that using a particular technology will enhance performing a certain task, while perceived ease of use is defined as the degree to which a person believes that using a technology will be free from effort" (Davis, 1989, p. 320). Davis' results suggest that perceived ease of use is rather an antecedent to usefulness, and this explains why the relation between these two beliefs is unidirectional (Davis, 1989).

Attitude towards using denotes a user's assessment of his capability to use technology; it is affected by an individual's perception or belief of technology's ease of use and perceived usefulness and may influence acceptance decision (Teo, 2009). "The usefulness-attitude relationship seems to be stronger than the ease of use-attitude relationship. Users are driven to adopt an application primarily because of the functions it performs for them, and secondarily for how easy or hard it is to get the system to perform those functions" (Davis, 1989, p. 333).

A critical review of the TAM (Legris et al., 2003) has stressed the need to consider other factors, such as facilitating environmental conditions and ICT experience. These factors may modify user's acceptance, in order to provide a better explanation of the influence that these variables have on the dependent variables specified in the TAM.

Several studies have shown that there are various external factors that influence the acceptance of technology through perceived usefulness and perceived ease of use (Davis et al., 1989; Ngai, Poon, and Chan, 2007; Szajna, 1996). These external variables may directly affect perceived ease of use or perceived usefulness and indirectly attitude towards using and behavioural intention to use. Research results confirm that this influence of external variables on attitude towards using and behavioural intention to use ICT is mediated by perceived ease of use and perceived use, and that their influence indirectly contributes to the explanation of the variance in actual use. Actually, they provide a better understanding of what influences perceived usefulness and perceived ease of use (Legris et al., 2003).

TAM has been used in studying technology acceptance mainly in business environments. As a group, teachers might differ from end-users in ordinary business settings. First, teachers are relatively independent, and have more autonomy in choosing and using technologies in their teaching activities, compared to business workers. Second, public schools are institutions whose objectives fundamentally differ from those of business organizations: the schools are not oriented to profit achievement and teachers are less competitive among them for promotion and resources than in ordinary business settings (Hu, Clark and Ma, 2003).

Research model and hypotheses

This study uses a model that represents the relationships among the six variables considered: facilitating conditions, ICT experience, perceived usefulness, perceived ease of use, attitude towards IWBs use and behavioural intention to use IWBs.

The role of teachers is crucial to the acceptance of a new technology in a school. Teachers' acceptance may be encouraged or discouraged by different factors: facilitating conditions, such as organisational support or easy access to IWB resources, and personal factors, such as experience in using ICT technology.

- Facilitating conditions: facilitating conditions are factors in the environment that influence a teacher's desire to use a new technology. Information and materials availability, technical and administrative support, ease of access to technology are considered important in influencing use of instructional technologies (Groves and Zemel, 2000); poor facilitating conditions (e.g., lack of access to IWBs, inadequate technical support given teachers) may create barriers to ICT use in the classroom (Lim and Khine, 2006; Teo, 2009). Through the survey the following facilitating conditions have been tested: sufficient IWBs number and ease of access to IWBs for teachers' use, technical competence, and ease of retrieving IWBs' educational resources.

So, the following hypothesis is formulated:
H1: Facilitating conditions have a positive influence on teachers' perceived ease of use.

- ICT experience: teachers with a good ICT teaching experience may more easily face technological problems, and are likely more experienced in managing the learning process through technology. As Teo (2009) suggests, in an education setting, technology experience affects the extent and the way technology is used in the everyday instructional practice. Furthermore, it is reasonable to infer that ICT experienced teachers are more likely inclined to use their technological experience in using a new tool (Teo, 2011).

Hence, the following hypotheses have been tested:
H2: Teachers' ICT experience affects positively teachers' perceived ease of use.
H3: Teachers' ICT experience affects positively teachers' perceived usefulness.

- TAM hypotheses (these are the initial hypotheses in the Davis' model except H6, added to test direct influence of perceived ease of use on behavioural intention to use):

H4: Perceived ease of use has a direct positive influence on perceived usefulness.
H5: Perceived ease of use has a direct positive influence on attitude towards using IWBs technology.
H6: Perceived ease of use has a direct positive influence on behavioural intention to use.
H7: Perceived usefulness has a direct positive influence on attitude towards using IWBs technology.
H8: Perceived usefulness has a direct positive influence on behavioural intention to use.
H9: Attitude towards using IWBs technology has a direct positive influence on behavioural intention to use. (Figure 2)

The adapted model only differs in two respects from the Davis model: first, there is a more detailed account of

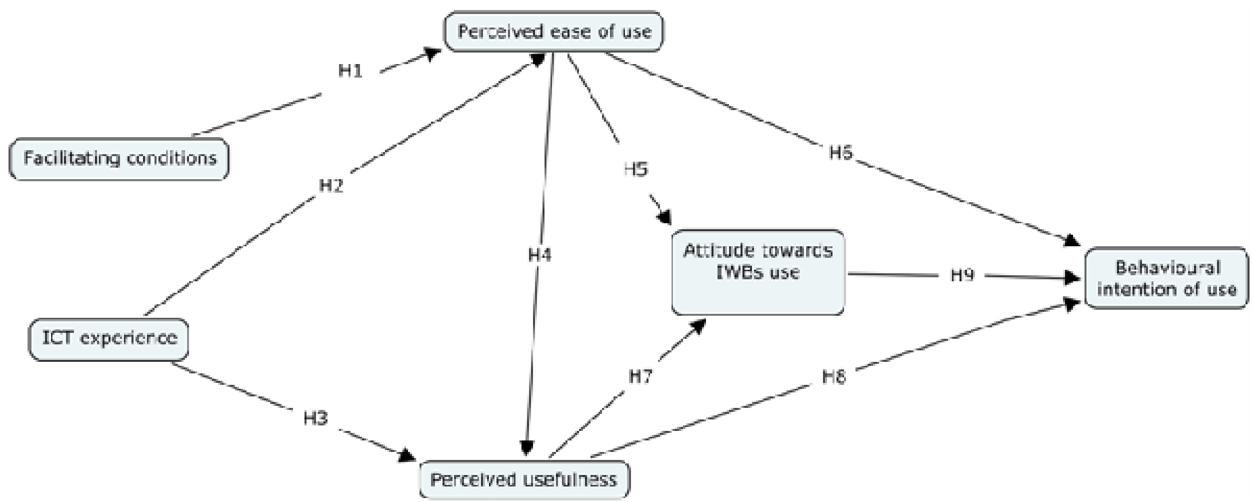

Figure 2. Research model

the notion of external variables (separated in facilitating conditions and ICT experience), and second, a hypothesis (H6) was added about the direct positive influence of perceived ease of use on behavioural intention to use.

METHOD

Measure

A Web-survey instrument was designed to test the constructs and relations in the research model. The survey was divided into two sections: the first required participants to provide information about their status, their school and IWBs facilities in the school, training quality (if they received any), actual IWBs use; the second contained 28 statements on the six constructs in this study. They are: facilitating conditions (four items), previous ICT experience (four items), perceived ease of use (six items), perceived usefulness (six items), attitude towards IWBs using (four items), behavioural intention to use (three items or one item, depending on the group). Each statement was measured on a five-point Likert scale with 1 = strongly disagree to 5 = strongly agree. The items were adapted (and translated into Italian) from previous studies (Ajzen and Fishbein, 1980; Davis, 1989) to make them specific to the present study (see Enclosure 1).

In the sample a group of teachers reported to readily use IWBs in the classrooms whereas another group already had the opportunity to work with IWBs but reported not to use them (yet). Therefore the construct actual use was eliminated from the original model and technology acceptance was measured through behavioural intention to use for both groups. The construct behavioural intention to use was tested by three items on the first group (teachers not yet using IWBs in classrooms); these items did not suit the second group (teachers already using them), so behavioural intention to use was tested by the single item intention to increase use, which denotes a positive attitude toward using the tool.

Participants

Participants were 151 Italian mathematic teachers from Secondary School (junior and senior). As IWBs introduction in Italian schools is relatively recent, the issue was to find teachers that had some IWBs experience (at least at training level) and already had the chance to experiment with them. Therefore, participants were recruited through two main channels: i) through a call in two mailing-lists specific for math teachers interested in technological innovation; ii) through a letter to school principals of several schools (all around Italy) that already have IWBs installed, inviting math teachers interested in IWBs use to respond to the Web-survey (about 50% of invited teachers responded). The sample cannot be considered as representative of the whole of the Italian mathematics teachers, but it is representative of teachers who are involved in maths teaching by innovative technologies, including IWBs.

Model test

The proposed model was examined using a Structural Equation Modelling (SEM). SEM is a comprehensive statistical approach to test hypotheses about relations among observed and latent variables (Hoyle, 1995). What would be considered the primary advantage of SEM is its ability to assess all pathways of a relationship

Table 1. Teachers

	N	Minimum	Maximum	Mean	Std. Deviation
1. Age	144	30	63	50.15	6.83
2. Teaching experience years	151	3	42	23.19	8.69
3. IWBs teaching experience years	151	0	6	1.04	1.37

Table 2. First IWB set in the school

Year	Before 2007	2007	2008	2009	2010	2011
Number of schools	10	10	14	50	40	7

simultaneously even though the dependent variable may become the indicator in a subsequent pathway. SEM enables researchers to answer a set of interrelated research questions in a comprehensive analysis by modelling the relationships among multiple independent and dependent constructs simultaneously (Bollen, 1989; Bullock, Harlow and Mulaik, 1994).

To analyze and confirm the fitness of the structural model, different indices were applied. The model fit of the research model was tested using AMOS 18. A model is said to fit the observed data to the extent that the covariance matrix it implies is equivalent to the observed covariance matrix (Hoyle, 1995). The model fit indices are classified into three categories. The first category includes the absolute fit indices that measure how well the proposed model reproduces the observed data. They include the χ^2 statistic, the goodness-of-fit index (GFI), the standardized root mean residual (SRMR), and the normalized fit index (NFI). The second category of fit indices, parsimonious indices, is similar to the absolute fit indices except that it takes into account the model's complexity. These include the root mean square error of approximation (RMSEA). Finally, the incremental fit indices assess how well a specified model fits relative to an alternative baseline model. An example of incremental fit indices is the comparative fit index (CFI). A Chi-square/degree of freedom of less than 3, GFI, NFI, CFI greater than 0.9, a SRMR of less than 0.1 and a RMSEA less than 0.08 are considered indicators of good fit (Hair, Black, Babin and Anderson, 2010).

RESULTS

Demographics and descriptive statistics

Respondents were 49 teachers from junior High School (32%) and 102 from senior High School (68%).

As shown in Table 1, the respondent average age is 50 years (in Italy teachers' mean age is high, *M*=50.60; MIUR, 2010). On average, teachers have considerable teaching experience (*M*=23.19 years, *SD*=8.69).

Teachers have much less experience in teaching by IWBs (*M*= 1.04 years, *SD*= 1.37). After all, IWBs use in school is recent; in most schools they were introduced in 2009-2010, as Table 2 shows.

The mean number of IWBs per school is 6 (*SD*=8.41), but most schools have 4 or less IWBs. Only few schools have more than 10 IWBs.

53% of the teachers attended a training to learn how to use IWBs. The average satisfaction for received training is 3.13 (*SD*=1.15).

54% of the teachers report they actually use IWBs in classrooms, whereas 46% do not use them. Among teachers using IWBs, 57% use them in some lessons, 25% in most lessons, 17% in every lesson, and just one teacher hardly ever.

Reliability

For the six constructs reliability was examined by using the Cronbach α test. Reliability refers to the extent to which the constructs yield consistent results. An α value of 0.70 or more is considered as representing a good internal consistecy (Nunnally, 1978). Reliability results are shown in Table 3.

Reliability for all the contructs widely exceeds the alpha threshold level of 0,70; only the construct Facilitating conditions, that tests aspects of accessibility to IWBs and resources, is at the border level.

Descriptive statistics of the constructs

On a Likert scale from 1 to 5, average perceived ease of use and perceived usefulness are rather high, (perceived ease of use: M= 3.74; SD=0.78; perceived

Table 3. Reliability results

Construct	Cronbach α
Facilitating conditions (4 items)	0.70
Previous ICT experience (4items)	0.84
Perceived ease of use (6 items)	0.89
Perceivede usefulness (6 items)	0.89
Attitude towards IWBs using (4 items)	0.87
Behavioural intention to use (3 items – only for teachers that do not actually use IWBs)	0.85

Table 4. Descriptive Statistics

	N	Mean	Std. Deviation
	Statistic	Statistic	Statistic
Perc. ease of use	151	3.75	0.78
Perc. usefulness	151	3.83	0.73
Attitude towards using	151	4.18	0.69
Facilitating conditions	151	2.73	0.96
ICT experience	151	4.01	0.80
Behavioural intent. to use (only teachers not using IWBs)	68	4.01	0.71
Intention to increase use (only teachers that use IWBs)	81	4.17	0.83

usefulness: M=3.83; SD=0.73). Even higher is average attitude towards using (M=4.18; SD=0.69).(Table 4)

The mean of items testing facilitating conditions (that include statements about access to IWBs, technical problems, facility to retrieve resources) is 2.73 (SD=0.96), attesting some difficulties about these issues.

Responding teachers have generally a good previous ICT experience (M=4.01; SD=0.81).

Teachers who actually use IWBs in classroom (54%) were given a question asked to respond about their intention to increase use: the mean is 4.17 (SD=0.83). Teachers who do not yet use IWBs in classroom were asked to respond about their behavioural intention to use, which is high (M=4.01; SD=0.71).

Analysis of the structural model

IWBs acceptance by teachers not yet using them

As first step, the model was used to test IWBs acceptance on the sample of teachers that reported not yet using IWBs in the classrooms (N=68). External variables considered are facilitating conditions and ICT experience; acceptance is tested through the construct behavioural intention to use.

Model fit

Six common indices of fit that were recommended in the literature (Hair et al., 2010) were employed in this study. The commonly used measures of model fit, based on results from an analysis of the structural model, are summarized in Table 5; all goodness-of-fit statistics are in the acceptable ranges.

Hypothesis testing and path analysis

The results of testing the structural model are presented in Figure 3, showing the resulting path coefficients of the research model.

Table 6 further explains the significant structural relationships among the variables. It shows the standardised direct and indirect effects associated with each of the six variables. A coefficient linking one construct to another in the path model represents the direct effect of an exogenous on an endogenous variable. An indirect effect reflects the impact a variable has on a target variable through one or more other intervening variables in the model. The total effect on a given variable is the sum of the respective direct and indirect effects. The effect sizes with values less than 0.1 were considered small, those with less than 0.3 are medium, and values with 0.5 or more considered large

Table 5. Model goodness-fit indexes

Model goodness-fit indexes	Results in this study	Recommended values
Chi-square/degree of freedom	1.31	<3
Goodness-of-fit index (GFI)	0.97	>0.90
SRMR	0.03	<0.10
Normalized fit index (NFI)	0.97	>0.90
Root mean squareerror of approximation (RMSEA)	0.07	<0.08
Comparative fit index (CFI)	0.99	>0.90

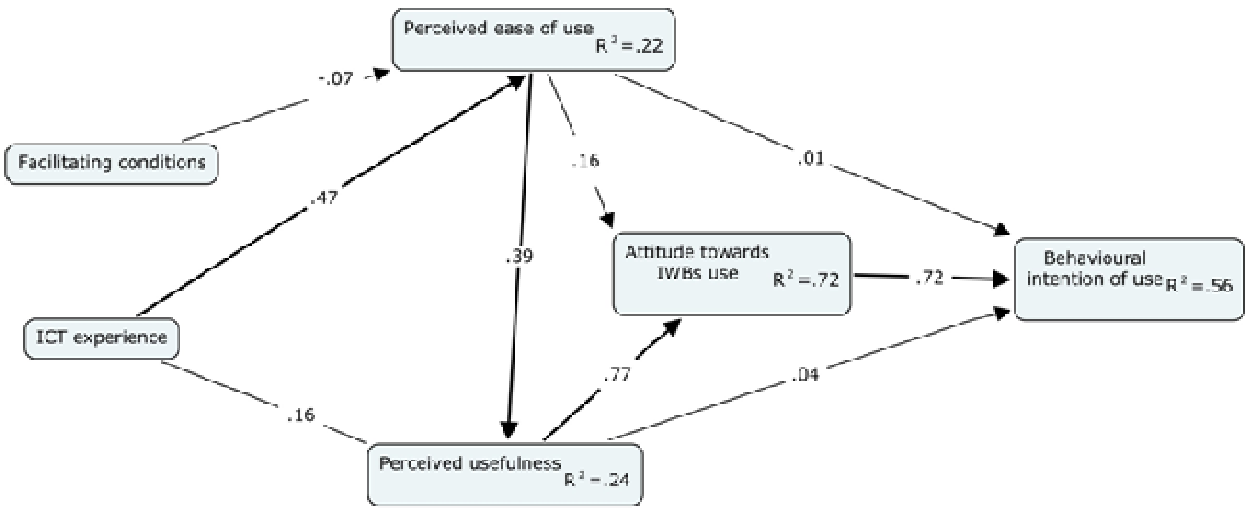

Figure 3. Results of the structural model for teachers who do not use IWBs (significant relationships - coefficients > 0.3- are highlighted)

Table 6 . Direct and indirect effects of variables on the IWBs acceptance for teachers not using IWBs in classrooms.

	Perceived ease of use		**Perceived usefulness**		**Attitude towards using**		**Behavioural intention to use**	
	Direct effects	**Indirect effects**	**Direct effects**	**Indirect effects**	**Direct effects**	**Indirect effects**	**Direct effects**	**Indirect effects**
Facilitating conditions	-0.7	0.00	0.00	-0.03	0.00	-0.03	0.00	-0.02
ICT experience	0.47*	0.00	0.16	0.19	0.00	0.34*	0.00	0.26*
Perceived ease of use			0.39*	0.00	0.16	0.30*	-0.01	0.34*
Perceived usefulness					0.77*	0.00	0.04	0.55*
Attitude towards using							0.72*	0.00
R^2	0.22		0.24		0.72		0.56	

* = p<0.05

(Cohen, 1988).

Hypothesis 1 postulates that facilitating conditions have a positive influence on perceived ease of use. The results show that facilitating conditions have no direct effect on perceived ease of use (path coefficient β = -0.07, P>0.05) and no indirect effect on other endogenous

Table 7. Model goodness-fit indexes

Model goodness-fit indexes	Results in this study	Recommended values
Chi-square/degree of freedom	2.84	<3
Goodness-of-fit index (GFI)	0.95	>0.90
SRMR	0.03	<0.10
Normalized fit index (NFI)	0.93	>0.90
Root mean square error of approximation (RMSEA)	0.15	<0.08
Comparative fit index (CFI)	0.95	>0.90

variables. As a result H1 is rejected.

Path coefficients show that ICT experience has a strong effect on perceived ease of use (β = 0.47, $p<0.05$), and a less strong effect on perceived usefulness (β = 0.16, $p>0.05$). Further, ICT experience has strong indirect influences on attitude towards using and behavioural intention to use (respectively β = 0.34 and β =0.26). As a result, H2 and H3 are confirmed.

Hypotheses 4, 5 and 6 investigate the relationship of perceived ease of use to perceived usefulness, attitude and behavioural intention. Perceived ease of use has a positive direct effect on perceived usefulness (β = 0.39, $p < 0.05$) and attitude (β = 0.16, $p > 0.05$), while it has no significant influence on behavioural intention of use (β = -0.01, $p > 0.05$). In line with Davis (1989), perceived ease of use has a significant indirect effect on attitude through perceived usefulness (β = 0.30, $p < 0.05$) and on behavioural intention through attitude (β = 0.34, $p < 0.05$). Therefore H4, H5 are accepted whereas H6 is rejected.

Influence of perceived usefulness is prominent on attitude towards using (β = 0.77, $p < 0.05$), while influence on behavioural intention is mediated through attitude (indirect effect β = 0.55, $p < 0.05$). Therefore, H7 is accepted and H8 is rejected.

Finally, H9 tests the effect of attitude towards using on behavioural intention to use. The path coefficient β is 0.72 ($p < 0.05$), showing a high influence of attitude on behavioural intention, as predicted in H9.

Table 6 shows the values of the coefficient of determination R^2 for each endogenous variable: for perceived ease of use, R^2 = 0.22, for perceived usefulness, R^2 = 0.24, and for attitude, R^2 = 0.72. At last, the proposed model explains 56% of the variance in behavioural intention to use. This variation is accounted for by the antecedent variables, mainly by attitude towards using, but also, as indirect effects, by perceived usefulness, perceived ease of use and ICT experience. The rest of the variation may be influenced by factors not involved in the present study such as demanding increased workload, curriculum constraints, or teaching support and encouragement in improving IWBs use.

Analysis of the structural model

IWBs acceptance by teachers already using them

The same model was tested on the sample of teachers already using IWBs in classrooms (N = 81). As teachers already used IWBs in classrooms, acceptance is tested through the *intention to increase use*.

Model fit

Indices of model fit are shown in Table 7. All goodness-of-fit statistics are in the acceptable ranges, except RMSEA (0.15); RMSEA can be misleading when *df* and sample size are small, in this case 5 and 81 (Hair et al., 2010).

Hypothesis testing and path analysis

The results of testing the structural model are presented in Figure 4, which shows the path coefficients.

Table 8 presents the standardised direct and indirect effects associated with each of the five variables.

Hypothesis 1 postulates that facilitating conditions have a positive influence on perceived ease of use. In contrast with the results of the first group of teachers, facilitating conditions show a relevant direct impact on perceived ease of use (β = 0.41, $p<0.05$), and an indirect effect on perceived usefulness and attitude towards using. Evidently, when teachers perceive adequate ease of access to IWBs and resources to be available they also perceive the use of technology to be easier and this may strengthen their intention to use technology.

ICT experience has a positive effect on perceived ease of use (β = 0.31, $p<0.05$), while effect on perceived usefulness and on attitude towards using are indirect. Likely, teachers who already use IWBs in their lessons have a clear perception of its usefulness, and previous ICT experience has little or no influence on this perception. As a result, H2 is supported and H3 is rejected.

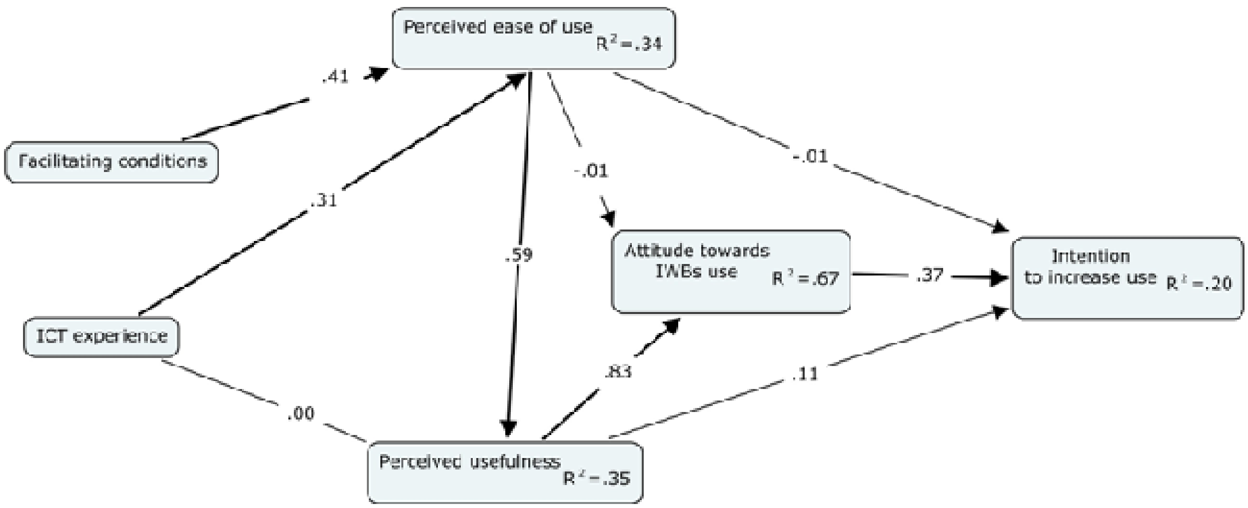

Figure 4. Results of the structural model for teachers using IWBs. (significant relationships - coefficients > 0.3- are highlighted)

Table 8. Direct and indirect effects of variables on the IWBs acceptance. (teachers using IWBs)

	Perceived ease of use		**Perceived usefulness**		**Attitude towards using**		**Intention to increase use**	
	Direct effects	**Indirect effects**	**Direct effects**	**Indirect effects**	**Direct effects**	**Indirect effects**	**Direct effects**	**Indirect effects**
Facilitating conditions	0.41*	0.00	0.00	0.24	0.00	0.20	0.00	0.09
ICT experience	0.31*	0.00	0.00	0.18	0.00	0.15	0.00	0.07
Perceived ease of use			0.59*	0.00	-0.01	0.49*	-0.01	0.24
Perceived usefulness					0.83*	0.00	0.11	0.30
Attitude towards using							0.37*	0.00
R^2	0.34		0.35		0.67		0.20	

* = p<0.05

From the results, perceived ease of use has a positive large direct effect on perceived usefulness (β = 0.59, p < 0.05), significantly larger than in the first group (where it was β = 0.39), confirming that for teachers using technology it is important to feel this use relatively free of effort. Whereas there is no significant direct influence on attitude (β = -0.01, p > 0.05) and on behavioural intention (β = -0.01, p > 0.05). Thus, H4 is supported, while H5 and H6 are rejected. Nevertheless perceived ease of use indirectly influences attitude (β = 0.49, p < 0.05) and intention to increase use (β = 0.24).

Perceived usefulness has a very large positive effect on attitude (β = 0.83, p < 0.05), a less strong effect on intention to increase use (β = 0.11, p < 0.05, indirect effect β = 0.30). Therefore, H7 and H8 are supported.

Effect of attitude towards using on intention to increase use is 0.37 (p<0.05), showing a medium influence of attitude on intention. So, H9 is supported.

Table 8 shows the values of the coefficient of determination R^2 for each endogenous variable. For perceived ease of use, R^2 = 0.19, for perceived usefulness, R^2 = 0.35. While for attitude towards using the antecedent variables account for 67% (R^2 = 0.67), the proposed model can explain only 20% of the variance in intention to increase use; this may depend on the fact that a part of respondents already makes an extensive IWBs use and cannot increase it, and on the fact that some teachers may consider IWBs useful only in some lessons and not in all curricular topics.

Of the four endogenous variables, attitude towards using has the greatest amount of variance accounted by its determinants, i.e. approximately 67%. This is largely due to the effects contributed by perceived usefulness and perceived ease of use, thus stressing the importance of the relationship among these three variables.

CONCLUSION AND DISCUSSION

This study investigated the relationship between facilitating conditions, ICT experience, perceived ease of use, perceived usefulness, attitude towards using and the acceptance of the Interactive Whiteboards (IWBs) among Italian mathematics teachers who teach learners from 11 to 15 years old. The study involved only teachers who had the opportunity to test IWBs, i.e. teachers who are involved in maths teaching by innovative technologies.

Data were collected through a Web Survey including demographic information and statements on six constructs.

The examination of the adoption of IWBs was based on the extension of the Davis' (1989) Technology Acceptance Model (TAM). TAM was specifically designed for explaining and predicting user acceptance of specific types of technology. It posits that user adoption is directly and indirectly determined by two related key beliefs, namely, perceived ease of use and perceived usefulness.

The study used Structural Equation Modelling for data analysis. The structural model proposed has been tested and validated and most of the causal relationships between the constructs postulated are well supported. The model was tested separating two different groups of teachers: the first group included teachers that had not yet experienced with IWBs in classrooms, for whom acceptance was measured through behavioural intention to use, the second one included teachers that already used them in classrooms for whom acceptance was measured through intention to increase use.

The results of this study indicate that Italian math teachers who had the opportunities to test IWBs have a good acceptance of this technology. These results are consistent with studies conducted in other countries (e.g. Smith et al., 2005; Someck et al., 2007): teachers favourably welcomed IWBs as a flexible and versatile tool.

Furthermore, our study revealed that the main determinant of technology acceptance is perceived usefulness, mediated through attitude towards using. According to the relationship postulated in the TAM (Davis, 1989), teachers accepting technology possess a positive attitude towards computer use and perceive technology to be useful at the same time. Perceived ease of use is a key variable linking the exogenous variables facilitating conditions and ICT experience with perceived usefulness. Influence of perceived ease of use on perceived usefulness is relevantly stronger for the teachers using IWBs in classrooms confirming the importance of this construct in improving actual use. In both groups the importance of perceived ease of use is further evidenced by its indirect effect on attitude and even on behavioural intention to use.

In the group without actual use, variance of behavioural intention to use is explained by 56%, whereas in the group with actual use variance of intention to increase use is explained by a mere 20%, leaving 80% unexplained. This may depend on the fact that a part of respondents of the second group (42%) already makes an extensive IWBs use and cannot increase it, and on the fact that some teachers may consider IWBs useful only in some lessons and not in all curricular topics. Furthermore, IWBs are a relatively new tool in Italian schools, and, as Someck et al. (2007) suggest, teachers need experience to embed them in their teaching practices and to make best use of their facilities.

Importance of facilitating conditions in ICT acceptance has been stressed in several studies (Levy, 2002; Theo, 2009): teachers' development with IWBs depends on easy and frequent access and teachers prefer to use their regular classroom rather than move to another room. It has been argued (Greiffenhagen, 2002) that use of IWBs as a 'transformative' device is only possible when they become part of the regular classroom life. In this study facilitating conditions (including access to IWBs, ability to face technical problems, facility to retrieve resources) seem to have a relevant role among teachers already using IWBs whereas for the other group of teachers they seem to be not relevant. Clearly, for teachers who do not use IWBs, perception of ease of use and usefulness are not influenced by constraints in accessing the tool and in retrieving resources or by technical problems.

As stated by Vanderlinde and van Braak (2011), ICT experience is an important antecedent of technology intention to use. In this study ICT experience resulted to have a large direct effect on perceived ease of use in both groups, whereas it has influence on perceived usefulness only for teachers not using IWBs. Teachers with good experience in teaching with technological tools are more likely inclined to consider managing a new tool as easy, but when facing actual difficulties this perspective may change.

This study showed evidence that Italian teachers who experienced IWBs are very interested in further IWBs integration into their teaching practice. There might be other factors not explicitly addressed in the current model that influence teachers' acceptance of IWBs. Future research should explore these other variables as well, such as institutional and peer support and enhancement, curriculum constraints, access to relevant teaching training, teachers' ICT professional development, all factors that literature indicated as relevant in implementing ITC integration (Someck et al., 2007; Vanderlinde and van Braak, 2011).

Particular attention should be paid by schools administrators in supporting teachers in their use of this technology, implementing the environmental conditions which can favour successful experiences in teaching (Lee, 2010)

This study has some limitations. First, the sample consisted of teachers who already experienced IWBs responding on a volunteer basis; therefore, the sample size is rather small and cannot be considered as representative of the whole of the Italian mathematics teachers.

A second weakness relates to the use of a questionnaire to measure IWB acceptance. The data were collected through self-reports and this may lead to the common methods bias, a circumstance that might blow up associations between variables (Meade, Watson, and Kroustalis, 2007). Third, the use of behavioural intention instead of actual use may have weakened the explanatory power of the model in this study, although intention to use technology as a construct has been reported to be a suitable index for actual use of technology (Hu et al., 2003).

REFERENCES

Ajzen I, Fishbein M (1980). *Understanding attitudes and predicting social behaviour*. Engelwood Cliffs, N.J.: Prentice-Hall.

ANSA-MIUR (Ministry of Education) (2007). *Piano Nazionale Diffusione Lavagne Interattive Multimediali (National Plan for IWBs spreading)*. Rome, Italy: MIUR.

Balanskat A, Blamier R, Kefala S (2006). *The ICT impact report: A review of studies of ICT impact on schools in Europe.* Bruxelles, Belgium: European Communities, European Schoolnet. Retrieved from http://insight.eun.org/shared/data/pdf/impact_study.pdf

Betcher C, Lee M (2009). *The Interactive Whiteboard revolution: teaching with IWBs*. Victoria, Australia: ACER Press, Australian Council for Educational Research Ltd.

BECTA (2004). *Getting the most from your interactive whiteboard: a guide for secondary schools.* Coventry, UK: BECTA.

Bollen KA (1989). *Structural equations with latent variables*. New York, NY: John Wiley and Sons.

Bullock HE, Harlow LL, Mulaik SA (1994). Causation issues in Structural Equation Modelling research. *Structured Equation Modelling, 1*(3), 253-267.

Cohen J (1988). *Statistical power analysis for the behavioral sciences* (2nd ed.). Hillsdale, NJ: Erlbaum.

Davis FD (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3*),* 319–340.

Davis FD, Bagozzi RP, Warshaw PR (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science, 35*(8), 982–1003.

Fernández-Cárdenas JM, Silveyra-De La Garza ML (2010). Disciplinary knowledge and gesturing in communicative events: a comparative study between lessons using interactive whiteboards and traditional whiteboards in Mexican schools. *Technology, Pedagogy and Education, 19*(2), 173 -193.

Greiffenhagen C (2002). Out of the office into the school: electronic whiteboards for education. Retrieved from ftp://ftp.comlab.ox.ac.uk/pub/Documents/techreports/TR-16-00.pdf

Groves MM, Zemel PC (2000). Instructional technology adoption in higher education: An action research case study. *Int. J.Instr. Media, 27*(1), 57-65.

Hair JF, Black WC, Babin BJ, Anderson RE (2010). *Multivariate data analysis, a global perspective*, (7th ed.). Upper Saddle River, NJ: Pearson Prentice Hall.

Higgins S, Beauchamp G, Miller D (2007). Reviewing the literature on interactive whiteboards. Learning, Media and Technology, *32* (3), 213- 225.

Hoyle RH (1995). The structural equation modelling approach: basic concepts and fundamental issues. In R. H. Hoyle (Ed.), *Structural equation modelling: concepts, issues, and applications* (pp. 1–14). Thousand Oaks, CA: Sage Publications.

Hu P, Clark T, Ma W (2003). Examining technology acceptance by school teachers: a longitudinal study. *Information and Management 41*, 227–241.

Kennewell S (2006). *Reflections on the interactive whiteboard phenomenon: a synthesis of research from the UK*. UK, BERA (British Educational Research Association).

Lee Mal (2010). Interactive whiteboards and schooling: the context. *Technology, Pedagogy and Education, 19*(2), 133 – 141.

Legris P, Ingham J, Collerette P (2003). Why do people use information technology? A critical review of the technology acceptance model. *Information and Management, 40*, 191–204.

Levy P (2002). Interactive whiteboards in learning and teaching in two Sheffield schools: a developmental study. Retrieved from http://dis.shef.ac.uk/eirg/projects/wboards.htm

Lim CP, Khine MS (2006). Managing teachers' barriers to ICT integration in Singapore schools. *J. Technol. and Teacher Educ.*, *14*(1), 97–125.

Meade AW, Watson AM, Kroustalis CM (2007). Assessing common methods bias in organizational research. Paper presented at the *22nd Annual Meeting of the Society for Industrial and Organizational Psychology,* New York, NY.

Mercer N, Hennessy S, Warwick P (2010). Using interactive whiteboards to orchestrate classroom dialogue. *Technology, Pedagogy and Education, 19*, 195–209.

Miller D, Averis D, Door V, Glover D (2005). *How can the use of an interactive whiteboard enhance the nature of teaching and learning in secondary mathematics and modern foreign languages?* Coventry, UK: BECTA.

MIUR - Italian Ministry of Education (2010). Elaborazione su dati del Ministero dell'Istruzione, dell'Università e della Ricerca (Data elaboration MIUR). Retrieved from http://www.diesselombardia.it/imgdb/sintesidatiscuolastatale0910.pdf

Ngai E, Poon J, Chan Y (2007). Empirical examination of the adoption of WebCT using TAM, *Computers and Education, 48*, 250–267.

Nunnally JC (1978). *Psychometric theory* (2nd ed.). New York, NY: McGraw-Hill.

Parigi L (2011). Quello che si dice della LIM: atteggiamenti, credenze, aspettative degli insegnati nella fase iniziale di adozione (About IWB: teachers' attitudes, beliefs, expectations). ANSA (National Agency for Development of School Autonomy). Retrieved from http://www.scuoladigitale.it/index.php?act=read&id_cnt=20201.

Prosser E, Ayre J (Eds) (2010). *Interactive Whiteboard: National Case Studies*. Brussel, Belgium: European Schoolnet. Retrieved from http://moe.eun.org/c/document_library/get_file?uuid=2db0f7d1-089c-4a3a-b157-db3d65a393b2&groupId=10620.

Smith HJ, Higgins S, Wall K, Miller J (2005). Interactive Whiteboards: boon or bandwagon? A critical review of the literature. *J. Computer Assisted Learning 21*, 91-101.

Smith F, Hardman F, Higgins S (2006). The impact of Interactive Whiteboards on teacher-pupil interaction in the National Literacy and Numeracy Strategies. *British Educational Research Journal, 32*(3)*,* 443 – 457.

Snedecor GW, Cochran WG (1980). *Statistical methods*. (7th ed.), Ames, Iowa: Iowa University Press.

Somekh B, Haldane M, Jones K, Lewin C, Steadman S, Scrimshaw P, Sing S, Woodrow D (2007). *Evaluation of the Primary Schools Whiteboard Expansion Project*. London, UK: BECTA.

Szajna B (1996). Empirical evaluation of the revised technology acceptance model. *Management Science, 42*(1), 85–92.

Teo T (2009). Modelling technology acceptance in education: a study of pre-service teachers. *Computers and Education*, *52*, 302–312.

Teo T (2011). Factors influencing teachers' intention to use technology: Model development and test. *Computers and Education*, *In Press, Accepted Manuscript.*

Vanderlinde R, Van Braak J (2011). A new ICT curriculum for primary education in Flanders: defining and predicting teachers' perceptions of innovation attributes. *Educational Technology and Society*, *14* (2), 124–135.

Appendix

Enclosure 1

List of constructs and corresponding items

Perceived ease of use	• Learning to operate IWB is easy for me. • I believe that it is easy to get IWB to do what I want it to do. • My interaction with IWB is clear and understandable. • I believe that IWB is flexible to interact with. • It is easy for me to become skilful at using IWB. • Overall, I believe that IWB is easy to use.
Perceived usefulness	• Using IWB in classroom enables me to teach more efficiently. • Using IWB in classroom improves my teaching performances • Using IWB in classroom makes teaching more interesting. • Using IWB enhances my effectiveness in teaching. • Using IWB makes it easier to teach. • Overall, I find IWB to be advantageous in my teaching.
Attitude towards using IWBs	• IWBs are an interesting instructional tool • IWBs provide an attractive innovation for teaching • I think that IWBs can help to improve the quality of teaching • Overall, I would like to use IWBs more in my classroom.
Behavioural intention to use	First Group • I am eager to experiment with IWBs in my classroom. • To the extent possible, I would use IWBs in my classroom. • I would consider IWBs a relevant tool in my teaching. Second Group • I intend to increase my IWB use in the future
Facilitating conditions	• In my school there are enough IWBs to satisfy teachers' needs. • In my school it is easy for me to access IWBs. • It would be easy for me to solve IWBs technical problems. • It is easy for me to find good IWB resources (e.g. on the Web).
ICT experience	• I have good experience in using computers for teaching purposes. • I have good experience in using general application software (e.g. word processors, spreadsheets, presentation). • I have good experience in using specific subject (mathematics) software. • During my lessons I often used a set PC/projector.