TEACHERS AND ICT: PROFESSIONAL DEVELOPMENT AND TEACHERS' ROLE

THE ROLE OF TEACHER MEDIATION USING COMPUTER SIMULATIONS IN PHYSICAL SCIENCES TO IMPROVE STUDENTS' EPISTEMIC COMPETENCES – A THEORETICAL FRAMEWORK

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ABSTRACT
We present and discuss the theoretical framework of an ongoing research project about the role of teacher mediation using computer simulations to improve students' epistemic competences in physical sciences. By teacher mediation we mean the languages and actions of teacher and students so that the teacher effort potentially leads to the intended learning outcomes. It is discussed the usage of computer simulations as semiotic registers or as manipulable mediator. Thus, the use of computer simulations may have a potentially significant impact on teachers' languages and actions, as well as on related patterns of classroom interaction. The core of this theoretical framework is synthesized on a model: the Teacher as Mediator Model. Teachers' mediation can influence the epistemic practices and the development of epistemic competences of students, namely by the way they choose and use the epistemic objects, the tasks, the semiotic registers and the manipulable and discursive mediators. The Teacher as Mediator Model can give important contributions to science education in general, and particularly in computer-based learning using computer simulations

KEYWORDS
Computer simulation, teacher mediation, students' epistemic competences, physical sciences

INTRODUCTION

This paper is related to a symposium about using Computer Simulations (CS) in physical sciences classroom (this and other 3 presented on CBLIS 2012). It presents a theoretical framework which is common to various empirical studies that are a part of an ongoing research, namely those that are presented on CBLIS: using computer simulations in pre and in-service primary school teacher training physical sciences (Pinto, Barbot, Viegas, Silva, Santos and Lopes, 2012); learning physics concepts in basic school with computer simulations (Sarabando, Cravino, Magalhães and Santos, 2012); the influence of the teacher's research experience in using computer simulations in secondary school students, in physical sciences (Cunha et al., 2012).

Computer simulations *per si* may not help students develop their knowledge and competences towards the learning goals. Roschelle, Pea, Hoadley, Gordin, and Means (2000) report that using CS may have a minimal effect on students' achievement tests. As stated by Schroeder, Scott, Tolson, Huang, and Lee (2007), in order to have a positive impact in learning the use of CSs needs special care regarding the teacher mediation (TM). However the role of teacher mediation in using CSs has not been considered in most research studies (Rutten, van Joolingen and van der Veen, 2012) in spite the recognition of their need (Adams, Paulson and Wieman, 2008). So, TM is crucial in computer based environments using CSs.

The importance of the mediation role of teachers is well established in science education research literature (Hennessy, Deaney and Ruthven, 2005; Lopes, et al., 2008b; Reiser, 2004; van de Pol, Volman and Beishuizen, 2010; Vygotsky, 1962).

We present a theoretical framework about the role of Teacher Mediation (TM) in using Computer Simulations (CSs). In particular, it addresses how this mediation may improve students' meaningful learning and Epistemic Competences by promoting students' Epistemic Practices (EPs), e.g. questioning, argumentation, formulation of hypothesis, simulation, validation, modelling. Our perspective is: if teacher mediation foments students in developing epistemic practices while working with computer simulations, this could lead to the development of epistemic competences.

We define (Lopes et al., 2008a) TM as the languages and actions of teacher and students as systematic answers to the students' learning demands in their specific development pathways to the intended learning outcomes. Thus, in the study of TM we focus on the languages and the actions of teacher, on semiotic registers and on mediators, particularly manipulable mediators.

Our research in the field of computer based learning is about using CSs. As developed below, these may be used as semiotic registers or as manipulable mediator. Thus, the use of CSs may have a potentially significant impact on teachers' languages and actions, as well as on related patterns of classroom interaction. The core of our theoretical framework is synthesized on a model: the Teacher as Mediator Model.

THE "TEACHER AS MEDIATOR MODEL"

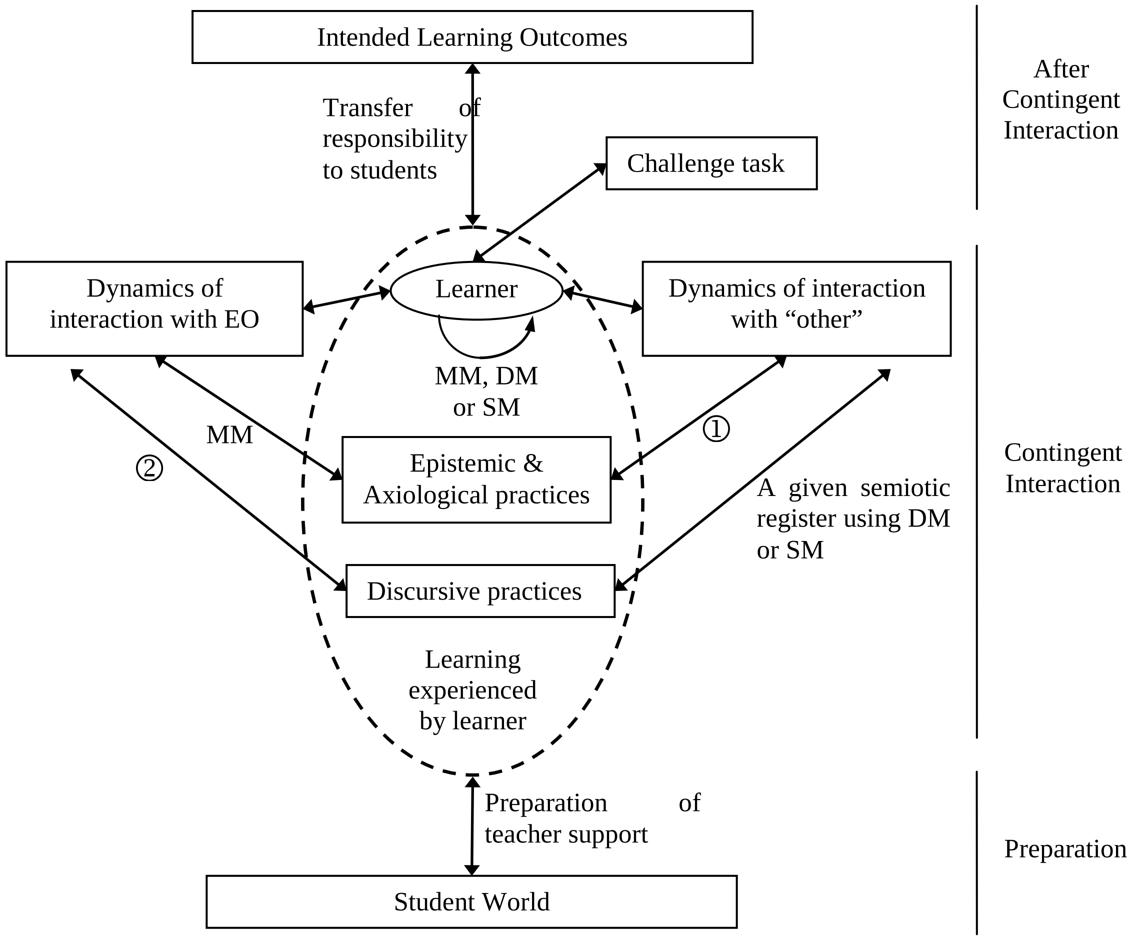
The core of our theoretical framework is synthesized on a model: the Teacher as Mediator Model, which is schematically presented in Figure 1. Its main features are:

I - Relating and distinguishing teaching and learning
Teaching and learning influence each other, but they are distinct process. They coexist temporally in a short period of time. The mediation occurs in three periods: (a) Preparation: preparing information, resources, environments, tasks, as well as their alignment and methods; (b) Contingent didactic interaction: coexistence in time of discursive practices and EPs; (c) After contingent interaction: oriented to internalize and expand students' learning.

II – Three timescales of TM
The TM of students' learning has three fundamental timescales (Tiberghien and Buty, 2007): (a) *Long* - (unit, course or cycle of studies - from student world to intended learning outcomes); (b) *Meso* - (what happens during the development of a task); (c) *Short* - (maximum contingency of discursive practices and EPs. The first occur in the articulation of the three periods referred in *I*. The others timescales occur mainly in the period of contingent didactic interaction.

III – Two fundamental perspectives and related dynamics
This Teacher as Mediator Model is based on two *perspectives* and the related *dynamics*:
A - Epistemic-axiological perspective. The *dynamics of interaction with the epistemic object* (EO) through manipulable mediators with materiality (Magnani, 2004), in a given or constructed environment, allows a self-regulated learning (Richter and Schimid, 2010) and meta-cognitive processes (Richter and Schmid, 2010). The dynamics of interaction with the EO is the observable behaviour of the students in their interaction, via actions, with the EO. This dynamic is the structured way of the self-regulated learning.
B - Psycho-sociological perspective. The *dynamics of interaction with the other* (peers and teacher) in a certain community, with its rules, work organization, mediators and world vision, is based on psycho-socio-cultural perspectives (Reveles, Kelly and Durán, 2007; Vygotsky, 1962); cultural-historical

activity theory (Engeström, 1999); and argumentation (Toulmin, 1972). The dynamics of interaction with "the other" is the observable behaviour of students in their interaction, via languages, with the other members of the learning community.



Legend: EO – Epistemic object; MM – Manipulable mediator; DM – Discursive mediator; SM – symbolic mediator; ①- Scaffold EP or influence the dynamic of interaction with other; ② - Modify the dynamic of interaction with EO or support the discursive practices in a given semiotic register.

Figure 1. Teacher as Mediator Model

IV – Three types of mediators

Manipulable mediators are manipulable artefacts (e.g., common objects, CS, videos) with material existence (Magnani, 2004) with which a student can work an EO. The human body is important in the constructions of the mind (Damasio, 2010); and the manipulable mediators are important extensions of the human body. A manipulable mediator plays its role only when it is used to extend the student capacity of thinking about the EO. A manipulable mediator can have several functions: epistemic, emphatic, engagement, representing. Discursive mediators are linguistic resources (e.g. questions, analogies, metaphors) used in conversation for arguing, convincing, explaining, narrating, focusing, stating, etc. Symbolic mediators are special signs (e.g., mathematics symbols) that facilitate the thought about thought.

USING THE "TEACHER AS MEDIATOR MODEL"

We present now some crucial instances and recommendations about relating and using the four features presented above — *teaching and learning; timescales; perspectives and dynamics; types of mediators* — and some crucial concepts, namely those referred in the Introduction.

The epistemic and axiological practices deal with manipulable mediators; and they may follow a direction from observable world to theory or from theory to observable world. EPs develop epistemic competencies in long timescale.

In discursive practices there are negotiations to construct meaning, with discursive and symbolic mediators and semiotic strategies. Jakobson (1960) considers six discursive practices, according to their functions. Discursive practices develop discursive competences.

The dynamics of interaction with the EO may be improved by the use of appropriate manipulable mediators; and it is influenced by the choice of the appropriate EO, by the scaffolding of the EP, and by the choice of an appropriate challenging task. The dynamics of interaction with the EO fosters directly axiological and epistemic practices. The EPs take place only if there are interactions with the system under study. The dynamics of interaction with the EO may scaffold the discursive practices and be influenced by them.

The dynamics of interaction with "the other" can be promoted through the use of symbolic and discursive mediators. This dynamics can scaffold the EPs and be influenced by them. Discursive practices may influence the dynamics of interaction with the EO. This dynamic is the structured way of the mediated learning. It is influenced by changes in the "other" and by the choice of challenging tasks.

The quality of the TM in the contingent interaction may be evaluated by using EPs, discursive practices and their articulation to characterize students' learning experience. The effectiveness of the TM in the long timescale may be evaluated by comparing the attained and the intended learning outcomes.

In the dynamics of interaction with "the "other", this may be present, implicit or at distance. If "the "other" is implicit, then there is no feedback. The Teacher as Mediator Model helps in describing what is happening in e-learning and b-learning: the way the other interacts with the learner determines in a certain way the EPs and the discursive practices that may occur.

The TM is richer if there is an articulation between the dynamics of interaction with the EO and the dynamics of interaction with "the other"; and if teachers' and students' discursive practices and EPs foster each other.

Learning by internalization is possible through the use of mediators used in the dynamics of interaction with the EO and with the other; and through the appropriation of the challenging tasks.

The continuous assessment of students' learning is a type of teachers' and students' discursive practices that aim to validate students' EPs and discursive practices (meta-linguistic function of language).

An adequate sequence of tasks allows the articulation between long and meso timescales of TM. An adequate task allow de articulation meso and short timescales of TM

COMPUTER SIMULATIONS AND THE "TEACHER AS MEDIATOR MODEL"

A CS is an artefact with which the student can operate (see figure 2) in one or several semiotic registers that can be interchangeable. A CS may be: (a) a manipulable mediator, if students can interact with it; (b) a semiotic resource, if is used only to display signs (graphs, values, images).

A student interacts directly with a CS, e.g. by selecting variables from a menu (Chinn and Malhotra, 2002). A CS can replace an EO, because the CS can represent the EO and also the student can interact with CS without interacting with the EO. To interact with the EO, the student need to identify the pertinent variables and not only chose some of them from a menu (Chinn and Malhotra, 2002).

CSs are manipulable mediators with a different status from the one of an EO. When manipulating a CS, a student can obtain new experiences, perceptions and representations about the EO (Richards, Barowy and Levin, 1992). A student can also think in new ways and develop new inquiry skills (Richards et al., 1992). A CS only plays adequately its role of manipulable mediator if there is an EO as a reference: then, the CS helps to understand how the physical world and the models used in CSs are distinct and intertwined (Ingerman, Linder and Marshall, 2009).

When using CSs, students may not be guided by their explicit knowledge; but they are certainly guided by their implicit knowing (Cook and Brown, 1999). CSs may be its powerful in attaining effective learning (Wieman, Perkins and Adams, 2008). Nevertheless, they also may lead to wrong ideas if TM is not appropriate. According to Teacher as a Mediator Model, the use of CS as manipulable mediator is important to improve EPs, if there are discursive practices in the dynamics of interaction with "the other".

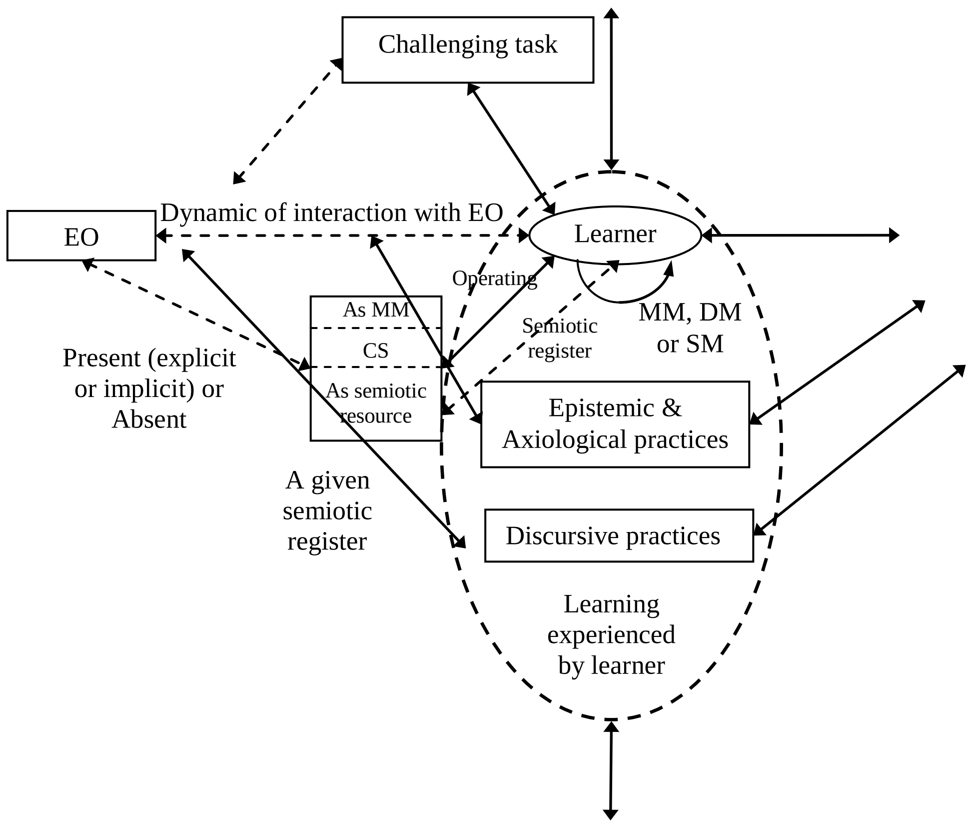


Figure 2. The role of CS in the context of the Teacher as Mediator Model

A CS is predominantly a semiotic resource (figure 2) when used to produce, rapidly, semiotic objects such as visualisations (Sadler et al., 1999), leading to work with different semiotic registers. It becomes a symbolic mediator "to enable more efficient communication of complex concepts and acted as cognitive props, alleviating the need for students to formulate their own mental representations" and to support dialogic communication (Hennessy et al., 2007:145). It is used to support the discursive practices in teaching practices where the interaction with “the other” is predominant; and is used to produce new symbolic mediators and to quickly change from an abstract semiotic register to a more concrete one and vice-versa.

The TM is particularly important in certain occasions, to make the EPs and discursive practices public, by aiding the communication using the several semiotic registers that the CS allows.

CS working as manipulable mediator or symbolic mediator also allows new learning possibilities in the internalization process.

CONCLUSION

CSs are manipulable mediators with a different status from the one of an EO. A CS only plays adequately its role of manipulable mediator if there is an EO as a reference. CSs may be reduced to semiotic resource and work only as symbolic mediator.

CSs may be its powerful in attaining effective learning, but they also may lead to wrong ideas if TM is not appropriate.

According to Teacher as a Mediator Model:
(i) The TM is richer if there is an articulation between the dynamics of interaction with the EO and the dynamics of interaction with “the other”; and if teachers’ and students’ discursive practices and EPs foster each other;
(ii) The use of CS as manipulable mediator is important to improve EPs, if there are discursive practices in the dynamics of interaction with “the other”;
(iii) The TM is particularly important in certain occasions, to make the EPs and discursive practices public, by aiding the communication using the several semiotic registers that the CS allows.

With the Teacher as Mediator Model it is possible to work in new lines of research and development in the field of using CSs: (a) developing new ways of TM (e.g. ways of scaffolding EPs, choices and uses of CSs as manipulable mediator; modifying the dynamics of interaction with EO); (b) news new ways of learning and of conceiving learning when using CSs, namely in relation to types of mediators, discursive practices and dynamics of interaction with the EO; (c) The roles of CSs as symbolic mediators and/or as manipulable mediators to enrich the dynamics of interaction with EO, to support discursive practices and to improve EPs.

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