Eurasia Journal of Mathematics, Science & Technology Education, 2013, **9**(3), 301-310

In-Service Training of Chemistry Teachers: The Use of Multimedia in Teaching Chemistry

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Received 15 September 2012; accepted 15 December 2012

Information and Communication Technology has allowed the use of several types of visualizations, especially multimedia environments in science teaching. The aim was to investigate how in-service teachers enrolled in a training course understand the nature and the role of visualizations in science teaching as well as the impact of this training on the change of their conceptions. A questionnaire to identify previous conceptions has been applied. It was analyzed the Teaching Learning Sequence made by them and the audiovisual record of their speeches and semi-structured interview with these teachers' groups. As the main result, we highlight development of the knowledge about these tools, especially on the impact of the visual language on apprenticeship and on the notion of scientific model.

Keywords: teacher conceptions, teacher education, visualization

INTRODUCTION

The use of visualizations in science and science education, especially in chemistry, has grown up during the last decades. Since scientists made microscopic phenomena visible by creating images of atoms, molecular structures, crystal formations, chemical bonding, cellules and electrical circuits, soon its use was found in science education. First it was only through pictures, concrete models, photos, graphics or diagrams, but with the development of the computers and ICT (Information and communication technology) the use of visualizations as increase strongly, both in science and science education. Nowadays, visualizations are a part of scientific practice that could influence science education (Linn, 2003). This author argues that visualizations can help experts to test new ideas and reveal certain aspects of scientific phenomena displaying new insights and allow comparisons with different scenarios. But, visualizations are also important to students. Visualizations can illustrate an idea that words cannot describe and in the same way can introduces students to important aspects of scientific research that are frequently neglected in science education. With the often integration of visualizations in ICT, the benefits and the problems associated to the use of ICT in science education also became benefits and problems of the use of visualizations in science education, especially multimedia environments. In a review of literature, Bingimlas (2009), found several advantages of using ICT and several barriers to the successful integration of ICT in teaching and learning environments. He argues that "While new technologies can help teachers enhance their pedagogical practice, they can also assist students in their learning." (p. 236). Cited by Bingimlas (2009), Grabe and Grabe (2007) claim that technologies can play a role in students' skills, motivation and knowledge and can be used to present information to students and help them to complete learning tasks. Osborne and Hennessy (2003) on their

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DOI: 10.12973/eurasia.2013.934a

ISSN: 1305-8223

State of literature

- It is generally accepted that multimedia environments provide a range of affordances that enable learning of science.
- The current literature suggests that the acceptance and integration of multimedia tools in classroom practice depends on teachers' beliefs/conceptions about these tools and how much they see some aspects of ICT as a threat.
- Teacher training to introduce ICT have focused on providing teachers with technical skills necessary for operating computer hardware and software, rather than to provide teachers with pedagogical skills. These pedagogical skills will allow to produce learning gains in students and that the role of teacher in mediating the use of this tools is of crucial importance.

Contribution of this paper to the literature

- Teachers' beliefs/conceptions, held by the in-service teachers of our study, about multimedia tools were limited and sometimes misplaced. This is of great concern and contributes to a poor integration of these tools into classroom focused mainly on the motivational aspects.
- Our in-service teachers present mainly pedagogical difficulties to use multimedia tools resulting from inadequate training that prevents an exploration of their full potential for learning.
- According to Newton and Rogers (2001) our results suggests that without a pedagogical training it's very difficult for teachers to plan, adapt and evaluate these tools in a fruitful way.

review also stress that along the changes on teaching about science rather than teaching sciences contents, i.e. the changes in views on the nature of science and the role of science education, the increasing use of ICTs can offers modes of teaching and learning moving towards this new view on the nature of science.

Nevertheless these benefits, the problems are still very far from an ending. Bingimlas (2009), on his review also discuss the main difficulties to the integration of ICT into Education. Following the perspective of Schoepp (2005), this author calls these difficulties "barriers", which could be defined as something that makes difficult the use of ICT into Education. The classification of these barriers by researchers has not been consensual. For instance Becta (2004) divided the barriers into categories: teacher-level barriers (individual), such as lack of time, lack of confidence, and resistance to change and in school-level barriers (institutional), such as lack of effective training in solving technical problems and lack of access to resources. Accordingly to the purpose of this paper it will be discussed here the issue of training. Bingimlas (2009), mentioned that the lack of effective training is the most frequently referred barrier in literature to the integration of ICT in education. Also Gomes (2005), referred that is necessary to considerer several components about training, such as literacy digital training, and pedagogical and didactic training in how to use ICT in the classroom. He concludes on his study that that the lack of training concerning the use of technologies in science specific areas is an obstacle to the use of new technologies in classroom practice. Providing pedagogical and didactic training for teachers, rather than simply training them to use ICT tools is an important issue (Balanks et al., 2006; Becta, 2004, Cox, 1999a, 1999b,). In general these studies assert that training programes do not focus on teachers' pedagogical practices in relation to ICT but on the development of ICT skills, which is less than the necessary to an effective use of ICT to support learning by their students. Newton and Rogers (2001), gave to this aspect a special attention and in their work considered that in order to achieve learning benefits from ICT teachers must entail three types of skills: operational skills, procedural skills and pedagogical skills (application skills). The operational skills concerns the manipulation of the computer and features in the software, the procedural skills concerns the manner in which the visual tools are employed for the purpose of achieving learning benefits, and the pedagogical skills will be the planning, adaptation and the tailoring supported on ICT by which the teacher transforms his or her own comprehended ideas so that they may be learnt by students. Also Koehler and Mishra (2005, p.132) claims that "merely introducing techonoly to the educational process is not enough to ensure technology integration since technology alone does not lead to change". On this work they introduce Technological Pedagogical Content Knowledge (TPCK) as a way of representing what teachers need to know about technology in order to achieve a fully integration of technology, pedagogy and content into education.

Considering now the use in general of visualizations in science teaching (not only the ones that are supported by ICT), there is an increasing field of research that have been discussing the use of these tools, regarding their importance and influence. This is a complex issue by itself that often begins on the polysemous definition of the term visualization. According to Gilbert et al. (2008) the definition of the term "visualization" is a central topic that often crosses these studies. There are two conventions, in convention 1, visualization is a verb (to visualize something is to mentally act on it), in convention 2 visualization is a noun (visualization is something in the public realm). We found literature approaching this issue in the sense of convention 1 that

dealt with questions such as: How is a visual representation turned into knowledge? What are the mental processes involved in attaching a meaning to a representation? (Cook, 2006; Gilbert, 2007; Reiner, 2008). Like we mentioned before, there is another trend of research that uses the term visualization in the sense of convention 2, a noun, something that has been placed in the public realm in either a material object, visual, verbal or symbolic form. Here we found several studies (Ferk et al, 2003; Kozma & Russell, 2007b; Santos & Greca, 2005; Savec, Vrtacnik & Gilbert, 2007; Tasker & Dalton, 2006; Wu, Krajcik & Soloway, 2001; Arroio, 2012) that by using a different approach try to evaluate the use of different kinds of visualizations in science teaching and more especially in chemical instruction. It must be also considered that the use of these visualizations (external representations) could be supported by two different learning theories (Kozma & Russell (2005): the cognitive theory and the situative theory. In this work authors propose the use of a situative theory to complement the cognitive theory of multimedia learning. The situative theory characterizes conceptual learning as result of social interactions. From this perspective a classroom is a community of practice where pupils are engaged in activities teacher-oriented that interact with each other and with the tools that are in the setting. According to these authors, this approach is particularly interesting when the goal is learning science as an investigative process "students became chemists" (Kozma & Russell, 2007a, p. 121). When the learning focus is the acquisition of important chemical concepts and principles, the use of the visualizations must be supported by the cognitive theory. The cognitive theory admits an explicit focus on the individual students' reasoning and their brain architecture (memory system etc.). Reasoning is treated as an internal mental phenomenon. The development of cognitive psychology has brought several contributions to this area. Mayer (2001, 2003) describes a cognitive theory of multimedia learning based on three assumptions from cognitive psychology: dual channel (Paivio, 1986), limited capacity (Sweller, 1988) and active processing. The dual channel assumption states that the human brain has separated channels for processing auditory-verbal and visual-pictorial inputs. The limited capacity assumption developed by Jonh Sweller in his Cognitive Load Theory states that the part of the brain called working memory, that processes and manipulate information from the auditory-verbal and visual-pictorial channels, has a relatively small limit. Also there are limits to the amount of information that can be processed from each channel as well as non-additive overall limit. The third assumption developed by Mayer (2001) states that learning occurs when the student actively selects, organize, and integrate information from each channel. So, based on these assumptions and in research findings from numerous studies Mayer proposes eight principles of multimedia learning for the design of effective multimedia instruction to address the learning of concept and principles. According to this author following these principles will allow students to reach a deeper learning, a learning that results in understanding of difficult concepts and principles which can then be used to solve novel problems. The eight principles are:

- *Multimedia principle: Using both words and pictures rather than words alone can improve deeper learning;*
- *Coherence principle: When extraneous words, sounds, or pictures are excluded rather than included deeper learning is fostered;*
- *Contiguity principle: When words and pictures are presented simultaneously rather than successively deeper learning can occurs;*
- *Modality Principle: When words are presented as narration rather than as on-screen text deeper learning can occur;*
- *Redundancy Principle: When words are presented as narration rather than as both narration and on-screen text deeper learning can occur;*
- *Interactivity Principle: When learners are allowed to control the presentation rate than when they are not deeper learning can occur;*
- *Signalling Principle: When key steps in the narration are signalled rather than non-signalled deeper learning can occur;*
- *Personalization Principle: When words are presented in conversational style than formal deeper learning can occur.*

These eight principles can help teachers to decide which resources are better to foster students' learning and how it's the best way to introduce them in classroom. As it can be seen there is a body of knowledge that deals with pedagogical questions related to the use of these tools associated or not to ICT, which had a great relevance on the didactical choices that should be discussed and presented to teachers during their education in order to help them to introduce these tools in classroom.

With the frequent use of these tools, visual language became the main vehicle of information, and if the learning impact is bigger so is the risk of misconceptions if the choice of the visualization is inappropriate or if its visualization is improper (Briggs & Bodner, 2007). These authors claim that:

> *'Improper visualization may cause flawed representation and lead to incorrect results. This is an important lesson to teachers. We must be very careful of the manner and precision with which we scaffold our pupils as they construct their mental models of domain-accepted concepts. A flawed mental model can have an impact on reasoning beyond what one might expect.' (Briggs & Bodner, 2007, p.70)*

So, teaching and learning with the help of these tools is a complex process, were teachers need to have some knowledge to use visual tools in a profitable way. As it was mentioned before, the situation is becoming more complex regarding the frequent incorporation of the visualization in multimedia environments.

This study aims to show the conceptions of a group of 14 in-service teachers enrolled in a teachers' training course of 40h on the use of visualizations as well the impact of this type of training on the change of their conceptions. According to Ponte and Chapman (2006) some studies show that beliefs and conceptions are important to understand what teachers do and why they do it, nevertheless that it's important to relate them to other aspects of practice. Beside their beliefs and conceptions about visualizations, there is a number of other factors that promote or not the use of these resources and the way they use them. In this case, considering the fact that nowadays a great part of the visualizations are embed in technology, it's use depend strongly on the technical teachers' skills and on the availability of computers, software and internet. On this work it was given a special attention to teachers' conceptions following the perspectives of some authors (Pajares, 1992; Ponte, 1994) that see conceptions as organizing constructs that have essentially a cognitive nature and play an essential role in thinking and acting. We also believe according Ponte (1994) that these conceptions can give a sense to practice but sometimes also can act as blocker to changes, but in any case we need to know them in order to work with teachers in this issue.

METHODOLOGY OF RESEARCH

It was adopted a qualitative research aiming to investigate how in-service teachers (n=14) enrolled in a teachers' training course of 40h, understand the nature and the role of visualizations in science teaching as well as the impact of this training on the change of their conceptions.

Participants

This study was realized with fourteen science teachers from public Brazilian school. Four of them had a graduation in biology and were teaching only natural sciences or biology to fundamental and high school pupils. The others had a graduation in chemistry and were teaching chemistry to high school pupils. These teachers had a wide range of teaching experience that goes from 3 years to 20 years, but the most of them had less than 10 years of teaching experience.The teachers are identified by the codes (T1,T2, etc.)

Training Program

The training program named "The usage of multimedia tools to study contents from chemistry middle School" takes 40 hours and was distributed into 10 sessions of 4 hours each. The main purpose of the training program was to provide teachers with the theoretical framework mentioned on the introduction. The worked topics were:

- *The usage of images and visualization in science education, with focus on chemistry;*
- *Vigostsky Sociocultural Theory, Dual Coding Theory (Paivio, 1986), Cognitive Load Theory (Sweller, 1988), Multimedia Learning Theory (Mayer, 2001);*
- *Features of some visual tools (concrete models, 2D and 3D images, animations, simulations and molecular modelling software).*

The training course exposed them to the learning theories (sociocultural/situative and cognitive) that can support the use of these tools, especially multimedia environments. It was also discussed the nature and role of the models in science. Throughout this training program teachers were invited to build in group one TLS to teach some science content (preferably on chemistry) supported by visual tools, apply them in classroom and make an oral communication to all the class followed by a group discussion.

Instruments and procedures

At the beginning a questionnaire has been applied to identify some previous conceptions on this issue and the results have been analyzed. This questionnaire had eighteen open-ended questions. As was mentioned before, during the training teachers were invited to build in group teaching learning sequences (TLS) about some science content using visualizations. Each teacher group made an oral communication to the class of their TLS followed by a class discussion. All the oral communications to the class were audiovisual recorded and analysed on a later stage, as well the TLS made by them. At the end of the training it was realized a semi-structured interview with each group with the purpose to clarify some issues that appear during their TLS presentation and to analyse the impact of this training program. We choose this qualitative approach which according to Lüdke and André (1986) allowed us to use the natural setting as primary source data, i.e. the teacher enrolled in a training program.

Table 1. Categories and subcategories

Categories	Subcategories
Notion of visualization	
Visualizations and learning	Potentialities of visualizations
	Role in learning
Teachers' use of visualizations	Reasons to use
	Criterion
	Difficulties in use

The data from the questionnaire, the transcriptions of the oral communications to the class, the TLS from the semi-structured interviews were analyzed trough a content analysis, building a set of categories suitable for the research questions. On Table 1 we present the set of categories and subcategories.

Three main categories were built. The first category relates to what is the understanding that this group of teachers present about visualization and include the teachers' meaning on this term. The second category "Visualizations and learning", reflects the relationship that this group makes between the use of this resources and students' learning and contains two subcategories: potentialities of visualizations on science teaching and its role in learning.

The third category "Teachers' use of visualizations", explores the teachers' point of view into tree subjects: the teachers' reasons to use these tools, the criteria that underlie their own choices when they use visualizations to teach science contents and the difficulties that are associated to the use of these resources that act as "barriers" to its use in classroom. Each category was analysed on two moments: at the beginning of the training before any discussion and after the training.

RESULTS

Notion of visualization

On the previous questionnaire concerning the theoretical concepts, the answers were very heterogeneous, for some teachers, the term visualization is related to the capacity to interpret an image "the capacity to elaborate in an abstract way a model or an image" or "the watch effect", "interpretation", "to look carefully to an image'. We also had a teacher that related visualization with visual tools and the need to interpret her and build a mental model from this process. Two other teachers also related visualization with visual resource but they also mentioned that "...we need to be able to understand the information that she (the visualization) gave us." For the majority it is a visual tool "what we see" or "images with or without animations", "the way that something is on space", "Visual tools...", "Make concrete abstract things through vision." After the training they began to related visualization with assigning meaning to an image and stress its importance in chemistry in order to build mental models and then the need to use multiple representations. From de final interview, for instance T 13, mentioned clearly: "It is the way we process images, the way we process them (...), starting from the visual tool you build some meaning, a concept, I see visualization in that sense...". T 10 gave also a straight answer:"Visualization it is just that...interpretation of an image, an animation (...)." We also have some teachers that mentioned the two general meanings assigned to visualization (as a tool and as an interpretation). T 11 said:"Visualization has two sides, the visualization that the student does and creates, and the visualization that I present, a film an animation (...). But we have also teachers that still only see visualization as a tool, for instance T12 mentioned: "Visualization could be the model, the image that the student is going to see (...)", or T 4, "It is what you see...". In general they stress that this theoretical framework had changed their perspective about these resources, being now conscious that students may not interpret images in the same way that they do, and always as possible they try to understand what the student build from each image.

Visualizations and learning

From the teachers' answers to the previous questionnaire it was identified four major potentialities for visualizations: make the abstract or invisible real; arouse interest and curiosity, allow to create a link between the students' quotidian and the science content and lastly enhancing students' apprenticeship in general and especially students with special educational needs. After the training, on the TLS two teachers' groups used some software that allows the virtual demonstration of a set of laboratorial works (factors that affect the reaction speed and physical changes). On both cases the teachers realize that these tools could be very useful to substitute practical work, especially when there isn't a laboratory on the school, or when there aren't conditions or time to prepare the practical work, nevertheless they stress that this is not the ideal situation. They also referred that they believe that these tools could bring to students a different look to science. Another group referred on the oral presentation to the class that:

"Another issue that is related with the use of TICs, it's the possibility to have an inclusive education, we know that this is the reality, we cannot run away from this (use of TICs in classroom), we cannot continue to use a traditional class, we have a huge diversity of students and with this resources we can access more students..."

The fourth group also mentioned on the oral presentation that after the training they were more aware of the multiple functions of these resources "...they stimuli the mind, the eyes, the ears...", nevertheless they also mentioned that they were more conscious of the misunderstandings that they can introduce in students mind. They also mentioned that with these kinds of resources "...we can take again (...) repeat any time we need..." and they felt that, especially with students with higher economic resources that they have to compete with students with respect to technologies. Using these resources with students that are used to that it's a challenge but on same way they change the way that students saw teacher' work increasing student's teacher consideration.

On the previous questionnaire it was founded a few direct references between visualization and learning: one teacher mentioned that the use of visual tools help students to create meanings; another teacher referred the importance of these tools when students are studying structures with tri-dimensionality. A third teacher mentioned that these resources help students to confront their mental models with the scientific models. Also during the interviews the majority mentioned that they have been using these tools mostly to make classes more pleasant in order to run away from "traditional" teaching, to use "something new beside the black board ", but now after the training they insert these tools (on the TLS) as mediatic tools, for instances: -"the animation will be to get a symbolic representation of the particles movement and aggregation…", or , " the modelling activity will be to give students the opportunity to build, testing and socialize mental models". During the presentation they reinforce the notion of "linking this issue to pedagogical questions", "make that ICT has a meaning inside the context that we put the students", they emphasize clearly the use of this tools in a knowledge building perspective where the focus is on the interaction between students, teacher and all these resources. On the oral communication they show some new understanding of the role of this resources when they mentioned "we must embrace them harmoniously with the other curricula components (...) and not just an appendix or a peripheral resource". Another group of teachers justified the use of ICT by writing "multimedia technology can make learning more exciting and relevant to students, through the combination of different resources, stimulating them in several ways". Several teachers also mentioned again the role of these resources linking the macroscopic and the sub microscopic world. For these teachers working on the sub microscopic world of matter is hard "...work with vibrations, to say that the wall has internal movements, they (the students) say no! (...)"

Teachers' use of visualizations

According to the previous subcategories (potentialities and role on learning), in the subcategory "Reasons to use visualizations", the majority of the teachers said on the previous questionnaire that it was to "make easier the understanding of the concepts" or to "improve the student' comprehension of the content", but some teachers also referred that it was to "make the class more pleasant", to "arouse the interest" or to "make the abstract more concrete". Five teachers also referred directly that one of the reasons they used this tools was because they feet pressured by the boarding school to use them. Throughout the oral communication of the TLS, one group said that they felt "almost forced" to use these resources and they feel that is very hard to compete with pupils regardless of technology. They said that they cannot use (visual tools) just because is "pleasant", the students are already living on these environments. According to that, T 14 said: "I believe that is not correct to use a video without a purpose, just because it's different, to be different is not the most important, the most important is the message (...) that promotes meaningful apprenticeship" .They feel the need to keep students' attention, but without losing the focus, i.e., what is the main purpose of these tools. For them the major challenge is to have the notion that multimedia environments have several functions and teachers need some scaffolding to use them properly, willpower and school conditions. On the interview the majority stressed that the reasons to use these tools has changing, their use is now much more related to knowledge building, and in this sense, today on their practices they ask themselves if certain resource are adequate, if the students are enjoying because it's "funny", or if it's really contributing to students' apprenticeship. They said that this training brought up this question and they choose now more carefully this type of resources especially multimedia tools and they have more concerns on "not pass misconceptions", recognizing the strong impact of visual language.

When they talked about the criteria to choose each specific type of visualization the most common answer was "to be [the visualization] related with the teaching content", nevertheless, some teachers also referred the students' age and in the multimedia tools, the duration time. One teacher mentioned that this choice is done according to the students' background and with the level of the students' cognitive development, other teacher referred the resource complexity level. We had

another teacher which said that his choice was done according the availability of the tool. During the oral communication, when questioned by its colleagues on which criteria they used to choose these tools, they mentioned the "complexity of the resource", "the previous students' knowledge" and avoiding images that could create misunderstandings. They referred that they always have fear to introduce misconceptions that are very hard to fix because what is obvious to them is sometimes opaque to students. On the final interview T 13 stressed: "It's a question of ignorance, when you don't know we do (choose something without a criteria), but now we know and we can do, but guilt remains." In general it could be said that nowadays they feel more judicious on their choices, making deeply analyzes of images, thinking not only on the "colours", but also on possible misunderstandings that they can transmit trying to work on that with students.

Another issue that several teachers mentioned it was the difficulties that sometimes could enable them to use these resources. It was identified two types of difficulties both on the previous questionnaire and after the training. On the previous questionnaire several teachers referred technical (operational) difficulties and other mentioned pedagogical difficulties. For some (few) teachers the main difficulty was due to poor teacher's informatics skills. T 14 said: "My knowledge in informatics is very low (...)" or T 12: "I have some difficulties in using power point (...)". Also T 6 mentioned: "I have a great difficulty in search in internet (...)". Two teachers referred problems with access to informatics laboratories or the inexistence of that kind of classroom. At the ending of the training few teachers still mentioned difficulties in operating hardware and software, but given that they have started to try to use this kind of resources during the training, more teachers found that there are other difficulties associated to its use. For instance, T 8 said: "In order to use these resources we must have physical resources, sometimes this is the major limitation, and you need several equipments with the correct setup files." T 13 adds: "Another difficulty it's related with the lack of autonomy that we have to install or uninstall programs (...)".

However these were not the only kind of difficulties presented in using visual tools. Several teachers mentioned in the beginning of the training some pedagogical difficulties related to its use. Some of them stated that they don't have knowledge about their role and potential into students' learning. Other referred that they don't know the differences between animations, simulations and what is the best way to introduce them in the classroom. After the training the majority stressed that the training was important to decrease this difficulties and improve their confidence in using this kind of resources. For instance, T 11 mentioned on the final interview:

> *"The positive (of the training) it was this wake, that really… I didn't work with image with intentionality; I almost didn't consider her into learning. But today, I work with image as an important resource on my class, not such an ornament or accessory. Today she (image) is an integral part and has an important role on my classroom."*

Also, a teacher of the group that applied the TLS on class referred on the group discussion that (T 7):

> *"(…) this video that we used on class, I had for a year, I have already used them, but not this way. We didn't give so much importance to the meanings (…) we (teacher and students) just watched. We used (on the past) animations and we stay there watching the balls… and on the assessments we wonder why they (students) had such bad grades. With this training we emphasize different things with these resources and we had better results. Now when we shall working with new videos, simulations, images our focus will be different."*

The discussion of this group presentation (Group 3) allowed as to discuss another pedagogical issue related with the teacher role during the use of this kind of resources. This group conducted a little research using a video about speed reactions with different approaches. They used the video without any intervention of the teacher, in another classroom they gave previously to students a text about the topic (speed reactions) and on other classroom they used the video questioning constantly students about what they were watching. They conclude that it was when the teacher used the video to challenge students to predict what was going to happen and why (interactive way) that they had better results. On this moment we had the opportunity to briefly discuss the difficulties to conduct and organize a research report (a practice that, unfortunately, is not common among science teachers). They referred that was not easy, but it was important for them to know what went wrong and why. It was possible to discuss through this example the perspective of knowledge construction that (could) happen with these resources.

DISCUSSION

Regarding the concept of visualization, on the previous questionnaire only a few teachers were aware of visualization as give meaning to an image. Now on the final interview they put more emphasis on the image interpretation and its role on building mental models.

Analysing the teachers' comments on the entire training related with the second category, it was found a change on the way teachers saw this tools and by consequence their role in learning. It was observed an increase on the potentialities attributed to these tools. Before this training they recognize some importance on students' apprenticeship especially for contents were

spatial vision is needed or to made concrete the abstract, nevertheless a great emphasis was given to the capacity of this resources to get students attention and make classes more interesting. Now they stressed their understanding that this tools had an impact on learning which they usually were not aware off. They said on the interview that now the use of this tools had "a meaning", they began to recognize the importance of visual language on apprenticeship. The discussion of the sociocultural/situative theory and especially cognitive theories contributed to increasing the knowledge about the possible approaches that they can adopted in classroom when introduce this tools. As they expanded their knowledge about the potentialities of these tools, became evident for them their role on learning and the possible misconceptions that they cou introduce. They said "this training is a wake up call for the potentialities of these tools and for the many possible ways to use them in our classroom". After the training they also revealed that it was very important to discuss the learning theories, "we feel more comfortable knowing that there is a scientific community making research on this area and meet all this authors" and moreover all of them understand the bigger impact that this tools can have on learning independently of the perspective that you adopt (situative/sociocultural or cognitive).

The reasons to use visualizations was to "make easier the understanding of concepts", almost not considering their role in building knowledge. This fact seems to have suffered some changes, but we need more data from their practices to confirm this hypothesis. From their TLS's and looking at their answers, we can recognize a new way to conceive these tools that we hope will have some impact in their classes.

It became very clear during the interventions that a greater concern related to the use of these tools, was searching for a theoretical background that give some sense to the use of these tools behind their attractive role. This fact has a reflection on the criteria, all teachers referred that they are much more careful on their choices of visualizations, trying to anticipate on their practices the impact of each visualization, and latter on make an assessment of what meaning was giving by students. The discussion of multimedia learning theory alerted them to some features that a good multimedia tool should have in order to allow students to reach a deeper learning and avoid "attractive" but complex visualizations that could lead to misconceptions. Also the discussion of the several features of some visual tools (concrete models, simulations, animations, etc.) have allowed them to make better choices according to the purpose of the task.

With regard to the technical difficulties, although the purpose of this training was not focus on develop technical skills, we think that the collaboration between teachers in each group allowed them to develop this skills. For instance T 5 mentioned: "In our TLS we have material that I didn't know how to use then, how to make the download, but T 13 knows a lot and she gave us good tips on how to do that. So, it was more simple and easier to build the TLS (...)". Nevertheless the majority of this teachers revelled did not have great problems with ICT, because they have already done some training focusing on these technical skills and the major technical "barriers" are mainly the access to informatics labs with the needed actualized software to work and show this resources. As it can be seen this teachers related strongly the use of visual tools with technology wish is accessibly to a large number of teachers.

With respect to pedagogical difficulties, the majority of the teachers referred that was very useful to discuss the two learning theories. Both brought contributions to improve their pedagogical knowledge about this kind of resources, warning them to the bigger impact in apprenticeship and the important role of the teacher in mediating students' learning. This role was strongly emphasized when the Group 3 shared their experience in the classroom. Their research using a video about speed reactions with different approaches helped them to test and probe several features related to the teaching methodology chosen by the teacher and his influence on students' learning. Through this group's presentation they recognized the value of the actions taken by the teacher and the students during the use of these resources. They said (T 7): "(...) it was interesting to see that the interaction of the teacher it was fundamental (...) and the students... sometimes dispute the answers (...)". The active students' involvement in learning situations is also very important and like they observe in other classroom (without the teacher intervention), most of them were "watching their cellular phone" and learning didn't happen or they probably built misconceptions.

CONLCUSIONS

The theoretical conceptions about visualization were superficial and sometimes became misconception. As previously described on this paper, visualization was first mainly related to a tool, and at the end also related to the interpretation of something. On the same way they began to realize that the images conveyed in much visualization are representations of something and not reproductions of the reality. According to our results we can say that these in-service teachers have been using visualizations in an intuitive way, based on evidences from their practices they realized that these tools somehow helped students learning. Sometimes we have references to some external pressure to use these tools, but the main reason is to look for new strategies in

order to improve classroom interest and help students' learning. From the previous questionnaire we could see, as mentioned before, some lack on the theoretical background that we think has decreased with this training.

The theoretical discussion on the theories of cognitive and sociocultural area revelled to be very useful, increasing teachers' knowledge about the role and potentialities of these tools and their learning impact. By participating in this training teachers were confronted with building a TLS in group and had the opportunity to shar them with all class improving the knowledge about practices, processes, strategies, procedures and methods of teaching and learning including visualizations, this is improving their pedagogical knowledge in this area. Besides some technical difficulties that persist on some of these teachers the lack of pedagogical knowledge will be the great "barrier" to introduce them in a profitable way. So, we believe that we were able to soften the naïve vision that these resources can only make classes more pleasant, and we think that the training had a positive impact on their conceptions about visualizations and we could observe a changing on the reasons and criterion to use these tools.

We hope to have contributed to make the teachers more reflexive with regards to using visualizations. Furthermore, we are aware that this training is a first step to change.this. The discussions during the training provided teachers with new resources and different perspectives to support its use, but these experiences need to be lived on practice and discussed several times to promote a sustained development. The data discussed here points to the importance of the in-service training to use this resources and the need to increase research in training programs that helps teachers to make a better use of this resources.

ACKNOWLEDGEMENTS

The authors thank the CAPES Brazilian agency for financial support (scholarship).

REFERENCES

Ardac, D. & Akaygun, S. (2004). Effectiveness of multimedia instruction that emphasizes molecular representations on students' understanding of chemical change. *Journal of Research in Science Teaching, 41* (4), 317-337

Arroio, A. (2012). Visualizations for Natural Science Education. *Journal of Baltic Science Education, 11* (2), 112-114

Arroio, A. & Honório, K. (2008). Images and Computational Methods in Molecular Modeling Education. *Problems of Education in the 21st Century, 9*, 17-23

Balanskat, A., Blamire, R., & Kefala, S. (2006). A review of studies ICT impact on schools in Europe. European Schoolnet. Retrieved January 30, 2012 from http://www.ec.europa.eu/education

Bimgimlas, K. A. (2009). Barriers to the successful Integration of ICT in Teaching and Learning Environments: review of the literature. *Eurasia Journal of Mathematics & Technology Education, 5*(3), 235-245

Briggs M. & Bodner G. (2007). A Model of Molecular Visualization. In John K. Gilbert (Ed.) *Visualization in Science Education* (pp. 61-72). Dordrecht: Springer

British Educational Communications and Technology Agency (Becta) (2004). A review of the research literature on barriers to uptake of ICT by teachers. Retrieved January 30, 2012 from http://www.webarchive.nationalarchives.gov.uk

Cook, P. M. (2006). Visual representations in science education: the influence of prior knowledge and cognitive load theory on instructional design principles. *Science Education*, 90, 1073-1091.

Cox, M., Preston, C., & Cox, K. (1999a). What factors support or prevent teachers from using ICT in their classrooms? Paper presented at the British Educational Research Association Annual Conference. Retrieved January 30, 2012 from http://leeds.ac.uk/educoldocuments/00001304.htm

Cox, M., Preston, C., & Cox, K. (1999b). What motivates teachers to use ICT? Paper presented at the British Educational Research Association Annual Conference. Retrieved January 30, 2012 from http://leeds.ac.uk/educoldocuments/00001329.htm

Ferk, V., Vrtacnik, M., Blejec, A. & Girl, A. (2003). Pupils' understanding of molecular structure representations. *International Journal of Science Education*, 25 (10), 1227-1245

Gilbert, J. K. (2007). Visualization: a Metacognitive Skill in Science and Science Education. In John K. Gilbert (Ed.) *Visualization in Science Education.* (pp. 9-27). Dordrecht: Springer.

Gilbert, J. K.; Reiner, M. & Nakhleh, M. (2008). Introduction. In J. K. Gilbert, M. Reiner, & M. Nakhleh (Eds.) *Visualization: Theory and Practice in Science Education.* (pp. 1-2). Dordrecht: Springer.

Gomes, C. (2005). Integration of ICT in science teaching: A study performed in Azores, Portugal. In A. M. Vilas; B. G. Pereira; J. M. González & J. A. González (Eds.), *Recent Research Developments in Learning technologies*, Vol. III, (pp. 165-168). Badajoz: Formatex Research Center

Grabe, M., & Grabe, C. (2007). *Integrating technology for meaningful learning* (5th ed.) Boston, NY: Houghton Mifflin

Koehler, M. J. & Mishra, P. (2005). What happens when teachers design educational technology? The development of technological pedagogical content knowledge, *Journal of Educational Computing Research*, 32 (2), 131-152

Kozma, R. & Russell J. (2005). Multimedia Learning of Chemistry. In Richard E. Mayer (Ed.) *The Cambridge Handbook of Multimedia Learning,* (pp. 409-428). New York: Cambridge University Press.

Kozma, R., & Russell J. (2007a). Assessing Learning from the Use of Multimedia Chemical Visualization Software. In John K. Gilbert (Ed.) *Visualization in Science Education.* (pp.299-332). Dordrecht: Springer.

Kozma, R., & Russell, J. (2007b). Pupils Becoming Chemists: Developing Representational Competence. In J. K. Gilbert (Ed.) *Visualization in Science Education*. (pp.121-146). Dordrecht: Springer.

Linn, M. (2003) Technology and science education: starting points, research programs, and trends. *International Journal of Science Education*, 25 (6), 727-758

Lüdke, M., André, M.E.D.A. (1986). Pesquisa em educação: abordagens qualitativas. São Paulo: EPU

Mayer, R. (2001). *Multimedia learning*. New York: Cambridge University Press

Mayer, R. (2003). The promise of multimedia learning: using the same instructional design methods across different media. *Learning and Instruction*, 13 (2), 125-139

Newton, L. & Rogers, L. (2001). *Teaching Science with ICT*, London: Continuum.

Osborne, J., & Hennessy, S. (2003). Literature review in science education and the role of ICT: Promise, problems and future directions. London: Futurelab. Retrieved January 30, 2012 from http://archive.futurelab.org.uk/resources/documents/lit_reviews/secondary_science_review.pdf

Paivio, A. (1986). *Mental representations: a dual-coding approach*. New York, USA: Oxford Uni Press

Pajares, M. F. (1992). Teachers' beliefs and educational research: cleaning up a messy construct. *Review of Educational Research*, 62 (3), 307-332

Ponte, J. P. (1994). Mathematics teachers' professional knowledge. In J.P. Ponte; & J.F. Matos (Eds.), Proceedings of the 18th PME International Conference, 1, 195-210

Ponte, J. P., & Chapman O. (2006). Teachers' knowledge and practices. In A. Gutiérres & P. Boero (ed.), *Handbook of research on the Psychology of Mathematics Education: Past, Present and Future*, (pp.461-494). Rotherdam: Sence Publishers

Reiner, M. (2008). The Nature and Development of Visualization: A Review of what is known. In John K. Gilbert (Ed.) *Visualization: Theory and Practice in Science Education*. (pp. 25-27). Dordrecht: Springer.

Schoepp, K. (2005). Barriers to technology integration in a technology-rich environment. *Learning and Teaching in Higher Education: Gulf Perspectives*, 2 (1), 1-24

Sweller, J. (1988). Cognitive load during problem solving: effects on learning. *Cognitive Science*, 12, 257-285

Wu, H.; Krajcik, J. S. & Soloway, J. (2001). Promoting understanding of chemical representations: pupils' use of a visualization tool in the classroom. *Journal of Research in Science Teaching*, 38 (7), 821-842

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