48

INTEGRATING VISUALIZATIONS IN SCIENCE TEACHING: TEACHERS' DIFFICULTIES AND PEDAGOGICAL APPROACHES

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Abstract

This study is a qualitative research where it tries to finding out and analyze the teacher's pedagogical approaches and difficulties to introduce visualizations in science classroom. The use of visualizations in classroom has increased substantially, especially since the development of Information and Communication Technology (ICT). Fourteen in-service teachers were investigated across a teachers' training course to seek their difficulties and pedagogical approaches for integrating these tools in teaching and learning sequences (TLS). During the training teachers were invited to build in group (five groups) teaching learning sequences about some science content using visualizations. The methodology is qualitative and a case study design was adopted. It was analysed the TLS made by them and the audiovisual record of their oral communications to the class. It was also analyzed the final semi-structured interview with these teachers' groups and a final report about the TLS application in classroom. These teachers present mainly pedagogical difficulties in order to select the suitable resource and to realize the full potentialities of these resources and sometimes the role of the teacher towards students and resources in the classroom. The technical barriers were the lack of school computers and appropriated software. The results suggest that these teachers are using mostly constructivist approaches to incorporate the visualizations in classroom trying to take advantage of the interactivity that some of these tools allow. Two groups fall more in transmission view, using this resources mostly to present information and the rest tried to use this resources to build inquiry tasks. They chose above of all multimedia tools to enhance particular concepts and skills and sometimes to innovate presentations. Some difficulties related to pedagogical approaches and technical barriers to use these resources are discussed.
Key words: *approaches, difficulties, visualizations, teacher pedagogical education.*

Introduction

Educational researchers have recently begun to focus on visualizations tools promoting their development in order to help students' learning at all levels (Stieff, Bateman Jr. & Uttal, 2007). Nowadays, visualizations are a part of scientific practice that could influence science education (Linn, 2003). This author argues that visualizations are important to students as they

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. These tools have several potentialities from concretizing abstract concepts to aid understanding spatial relationships (Stieff, Bateman Jr. & Uttal, 2007). Hand-held molecular models have been used for a long time, and its use became massive since the 1970s (Savec, Vrtacnik & Gilbert, 2007), they allow students to appreciate the representation of molecular structures. With the rapid development of technologies these representations became virtual and a wide range of visualization tools is now accessible to teachers and students to visualize experimental data sets, simulate experiments or construct models of imperceptible entities (Stieff, Bateman Jr. & Uttal, 2007). For Rapp (2007) these tools have three characteristics that make them very useful and appealing. First they are quite engaging, if appropriately designed. Using graphics and animations to present information in novel ways can be very impressive. Second, they can be interactive allowing students to manipulates variables and set the pace of interactions. Finally, learning can be improved "by conveying information in a succinct, guided manner that aligns with the nature of mental representations" (Rapp, 2007, p. 54). This is particularly relevant in multimedia tools were the information is presented in different modes and can potentially lead to the construction of mental models.

Moreno and Mayer (2007) present two types of multimedia tools, the interactive and the non-interactive type. In a non-interactive type, the message is presented in a pre-determined way independent of anything the learner does during learning; examples include an animation, video or a textbook passage with text and illustrations. In an interactive type the presented words and pictures depend on the learner's actions during learning, examples include simulations, hypermedia environments, and animation or video with pace controlled by the learner and search engine programs. Simulations are considered one of the most powerful multimedia tools (Hennessy, Deaney & Ruthven, 2006; Rieber, 2005) since they enable to focus attention on particular abstract concepts and isolate variables that are usually combined.

Difficulties to Use Visualizations

According to Balanskat, Blamire and Kefala (2006), teachers had a positive perception of these tools, but strategies for their effective use are still developing. This is particularly seen in VLEs (Virtual Learning Environments) which are gradually being incorporated into science education in several European countries, but its use is still limited and more training is needed to support innovative pedagogy (Balanskat, Blamire and Kefala, 2006). In a review of literature, Bingimlas (2009), found several vantages of using ICT as well as several barriers to the successful integration of ICT in teaching and learning environments. ICT can assist students in their learning and help teachers enhance their pedagogical practice. Nevertheless these benefits, Bingimlas (2009), on his review also discuss the main difficulties of integration of ICT in Education. Following the perspective of Schoepp (2005), this author calls these difficulties as "barriers", which could be defined as something that difficult the use of ICT in 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. The lack of confidence is directly related with the lack of competence in integrating ICT into pedagogical practice (Becta, 2004).

50

Teachers' General Knowledge and Pedagogical Approaches to Integrate Visualizations in Classroom

One key aspect of teachers' role in planning and managing learning is the skill to select the right resources for the right teaching and learning objectives (Wellington, 2002). ICT and multimedia tools are new complex resources that can provide a range of affordances that enable science learning (Webb, 2005). In order to integrate this tools teachers' apply to their pedagogical content knowledge (PCK) (Shulman, 1986) together with several other categories of teachers' knowledge (content knowledge, curriculum knowledge, knowledge of learners and their characteristics, knowledge of educational context, etc.) and try to make subject comprehensible to students (Webb, 2010). Nevertheless, according this author teachers need to have also knowledge how the wide range of technologies available may support the content to be taught and the best pedagogical approaches to fit the purposes. This link between content, pedagogy and technologies has been described as technological pedagogical content knowledge (TPCK) (Koeher and Mishra, 2005). So, teachers must think carefully and make some decisions before they reach the classroom in order to take advantage of using it. The pedagogical approach concerns the choice of multimedia tools to be used, its purpose, teacher controlled or hands-on use and its linking with other activities.

Osborne and Hennessy (2003) stress that it's when ICT tools are integrated and balanced with other teaching and learning activities that it provides the greatest benefits. Rather than use these resources in isolation, explicit links should be made between theoretical computer models and reality, before, during and after the computer-based lesson. Also, according to this study, many teachers employ the use of ICT after spending several lessons introducing and discussing some topic area. Some uses multimedia technology only when it significantly enhances the activity and simpler experiments, at least, should be done in a conventional way. In either case, teachers need to develop a balanced approach between practical work and computer methods and the complexity of this relationship is a great challenge to education.

 According to Webb (2005), teachers' pedagogical approaches are a crucial component in the use of ICT in learning and teaching. The challenge is to make teachers believe not only on the affordances of these tools to improve students' learning but also they themselves have a crucial role in planning and managing this learning environments so that affordances match students' learning needs and students are able to perceive and use them (Webb, 2005). New roles for the teacher and students could arise from the use of these tools. Students could be engaged and encouraged to participate more actively in learning and teachers' role could became more focused on enabling learning through interactions rather than spend time in basic organizational and management tasks (Webb, 2010). Also according Cox et al. (2003) it is not clear from literature if these technological resources are being used to introduce new approaches or to reinforce existing teaching approaches. For this author, there are evidences that the use of these resources can change the pedagogical roles of teachers and create moments for rotating roles, promoting student self management, supporting meta-cognition or joint tasks, providing very different learning opportunities. This means a shift from teacher-centred pedagogy to student-centred pedagogy. This new pedagogy has given rise to a considerable number of constructivist approaches that have been developed, but apart from a few differences it can be considered that these are characterized by: identify ideas and points of view of students; create opportunities for students to explore their ideas and test their robustness in explaining phenomena, accounting for events and for forecasting; provide incentives for students to develop, modify and, when necessary, change their ideas and points of view; support their attempts to rethink and rebuild their ideas and viewpoints (Hodson, 1998). However the introduction of these new approaches in classroom is not easy (Baviskar, Hartle & Whitney, 2009). Many lesson plans do not exhibit all the characteristics of a constructivist approach, sometimes they include typical strategies of other approaches. In a more traditional approach the educational practice is characterized by the transmission of knowledge by teacher. This task falls mainly to the teacher exposition of know-

51

ledge to the student, whose role should be a simple depository (Mizukami, 1986). Nevertheless, some studies (Hennessy et al. 2007; Robblee et al. 2000) found cases where teachers try to use these tools to engage students on investigative tasks in order to build their knowledge.

Problem of Research

This study aims to investigate how fourteen Portuguese teachers, who voluntarily signed up in the program, divided in five groups, integrate visual tools in their lesson plans. This study formed a part of a larger research that try to identify some teachers' previous conceptions about the use of models and visualizations in science teaching. In this study it will be identified their main difficulties and their pedagogical approach to integrate these resources. It will be also analysed the impact of a training program on teachers' conceptions and attitudes on visualizations. With this study it is tried to bring some contributions about the difficulties felt by teachers to introduce visual tools, especially multimedia environments and their pedagogical choices with these resources.

Methodology of Research

General Background of Research

In order to study teacher's pedagogical approaches and difficulties to introduce visual tools in science teaching, during the training teachers were invited to build in group teaching learning sequences (TLS) about some science content using multimedia tools that they could use on their classes. It was adopted a qualitative research aiming to study how in-service teachers (n=14) enrolled in a teacher's training course of 50 h, integrate visual tools on their lesson plan. It was adopted case study research which is considered a preferable strategy when "how" or "why" questions are being posed (Yin, 2002). The researchers had no control of teachers' choices. After the description of their TLS and their application in classroom it was characterized the pedagogical approach that was used to integrate this tools.

Sample of Research

This study was realized with fourteen science teachers from public Portuguese school. They were teaching elementary and secondary levels. All participants referred that they wanted to improve their knowledge about this resources in order to introduce them in classroom. So, they searched for this kind of training program and participated voluntarily in all the activities. In Table 1 it is presented a general characterization of the teachers identified by the codes (T1, T2, etc.) in terms of graduation, subjects they taught and the length time they had been working as teachers at the beginning of this training program. It is also presented the four groups freely formed by these fourteen teachers after some training sessions, that were named A, B, C, D and E.

52

Table 1. General characterization of the teachers.

Groups	Teacher	Graduation	Subjects	Professional time (years)
A	T12	Chemistry /Master in Science Education	Chemistry/Physics and Chemistry A	24
	T13	Chemical Engineering/Master in Chemistry and Physics Teaching	Physics- Chemistry Sciences	1
	T14	Chemistry Teaching/ Master in Sciences Teaching Methodology	Chemistry/Physics and Chemistry A	25
B	T4	Chemical Engineering	Physical- Chemical Sciences and Physics and Chemistry A	20
	T5	Chemical Engineering	Physics and Chemistry A	21
	T6	Industrial Chemistry Engineering / Master in Science Education	Physical- Chemical Sciences and Physics and Chemistry A	19
C	T7	Industrial Chemistry Engineering / Master in Chemistry Teaching	Physical- Chemical Sciences and Chemistry A	28
	T8	Physics and Materials Engineering	Physical- Chemical Sciences and Physics	17
	T9	Industrial Chemistry Engineering	Physical- Chemical Sciences and Physics and Chemistry A	18
	T10	Chemistry and Physics Teaching	Physical- Chemical Sciences	12
D	T1	Chemistry and Physics Teaching	Physical- Chemical Sciences/ Physics and Chemistry A	11
	T2	Chemistry and Physics Teaching	Physical- Chemical Sciences	8
	T3	Chemistry and Physics Teaching	Physical- Chemical Sciences and Physics and Chemistry A	9
E	T11	Chemistry Teaching Graduation/ Master in Sciences	Physical- Chemical Sciences	14

Instrument and Procedures

During the training teachers were invited to build in group teaching learning sequences (TLS) about some science content using visualizations. At the beginning a questionnaire to identify some previous conceptions on this issue have been applied and analyzed. It was observed some of the lessons were the TLS were implemented. On a later stage it was analyzed the TLS made by them, the audiovisual record of their oral communications to the class and the report related to the implementation of the TLS in the classroom. At the ending 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 indentify the impact of this training program.

Training Program

The training program named "The use of multimedia tools to study the contents from chemistry High School" took 50 hours and was distributed into 10 sessions of 4 hours. The main purpose of the training program was to provide teachers with a theoretical framework mentioned in the introduction. The worked topics were:

- The use of models and visualization in science teaching, with focus on chemistry;
- Vygotsky Sociocultural Theory (Vygostky, 1981), Dual Coding Theory (Paivio, 1986), Cognitive Load Theory (Sweller, 1998), Multimedia Learning Theory (Mayer, 2001);
- Features of some visual tools (concrete models, 2D and *3D* images, animations, simulations and molecular modelling software).

Data Analysis

Through a content analysis were analysed their TLS, the audiovisual record of their oral communications and the final semi-structured interview. Consistent with an interpretative orientation, the data were repeatedly examined to seek salient patterns or singularities related to the research questions. Through an analytical process of questioning and constant comparison (Strauss &Corbin, 2008) it was established a set of categories suitable for the research questions. This inductive method allowed the finding of implicit patterns in data.

Results of Research

Characteristics of Each Group and TLS Description
Group A

Group A consists of three teachers, two of whom had a great experience and a third with only one year of professional experience. Both had a master's degree in education and had known each other previously. They decided to choose the content "Chemical Equilibrium", that both T12 and T14 were teaching, to prepare the instructional sequence. They presented an instructional sequence, rich in detail with content covered, resources used and strategies as well as a full report about the application of instructional sequence in classroom.

The sequence was designed according to the curricular guidelines, and was divided into six lessons. This sequence was built on a theoretical framework based in a constructivist perspective, considering that scientific knowledge should be predominantly built by students, involving a conceptual change, which is intended to occur through activities take place in the classroom and built from the knowledge and previous ideas of students. Of the six lessons that constitute this sequence, this group chose the fourth lesson (two blocks of 90 minutes) to deploy the research activity, where was used a simulation multimedia activity called "Industrial Control Challenge". To this lesson was presented the exploratory worksheet provided students with all issues, tasks, reflections and self-assessment that students should perform in this lesson. The sequence was applied in the classroom by the teacher T14. All activities were carried out in groups of three students maximum so that all group members were fully engaged in the tasks. In this activity have been prevailed research questions that students should put hypotheses to confirm through simulation. They split this lesson in three moments: first, they made the clarification of goals and possible concerns of students about the activity to perform and distribution of students by groups to start the activity; second, realization of activity by each student's group with teacher circulating in the classroom in order to scaffold the difficulties experienced by students. The activity consisted of a research task about the factors that influence the rate of a reaction. The confirmation of the hypotheses raised by the students should be made through a multimedia simulation.

Regarding the difficulties to integrate and use visualizations this group expressed confidence both at a technical and pedagogical level. They stated that they use this type of resources frequently and so have no difficulty in manipulating them. Sometimes they have to ask their students to bring their personal computers to avoid lack of computers in the classroom. At the pedagogical level, they recognize the importance of these resources in learning, particularly for students to visualize abstract concepts.

Group B

Group B consisted of three teachers from the same school who work often together, so they always showed to be a united and collaborative group. All have great professional experience, nearly twenty years of teaching each. Well acquainted with the students, the school and its resources, they decide to develop a teaching sequence about a subject content of Physics and Chemistry of the 8th grade, titled "Sound" that only the teacher T6 was teaching at the time, but they all tend to teach in other years. For this reason, the sequence was applied in two classes of this teacher. They presented a detailed instructional sequence and a report of the application in the classroom.

The sequence consists of two classes 90 minutes. For each lesson is presented a detailed plan, including the lesson moments, resources, competencies and topics to work. They provided a worksheet to students to explore the visuals tools. This group uses a diverse set of visuals tools (concrete models and multimedia). The students were divided in groups to work with the multimedia tools. The lesson alternate in moments where the teacher has a more central role, and times when students explore the resources with the help of the teacher and the worksheet. In the worksheet it was privileged tasks in order to observe and explain. They divided each lesson in two or three moments: one to students realize the task following the worksheet instructions and another one to summarize the content through the joint correction of worksheet answers and a sometimes a third moment to solve questions from the exercise book.

This group, unlike the previous group, reveals to feel several difficulties when integrating these tools in the classroom. The first ones relate to the lack of computers and data-show in some classrooms. The others are related to the selection and use of these resources. Since there are a large number and a wide variety of these features, it becomes difficult and time consuming to choose the most suitable resources for a given learning. This group also mentions that sometimes have to make adjustments because they do not find exactly what are looking for, which also consists of a difficulty. They reveal also doubts about the role of the teacher in relation to resources and students, i.e., how to interact with students and what kind of help should be given to them.

Group C

The C group was also made up of four teachers from the same school, all with more than ten years of professional experience, in which two of them had a master's degree. They chose to develop the instructional sequence, a theme that was being taught by two of the teachers (T8 and T9). The sequence has been applied in classroom by T9. As the group B, they also presented a detailed instructional sequence and a report of the application in the classroom. The chosen theme is part of 9th grade, named "Electricity". They used multimedia resources, including videos, static images and interactive exercises, some of them available from the publisher of the books adopted in school (BRIP). The exploration of the visuals was performed along the two lessons by the teacher through projection to the whole class. The sequence consisted of two 90-minute lessons that were divided in several moments that goes from homework correction, teacher exposition of contents, some discussion around questions posed by the teacher and teacher exploration of visual recourses with the occasional help of some student. This group also reveals several difficulties to integrate these tools in the classroom. Similarly to the pre-

vious group, they struggle with the lack of computers and data show some classrooms which inhibit the use of technological resources in an individual way by students. The others relate to the selection of resources and the role of the teacher in the classroom with these resources. Like the previous group, this group mentioned to take a long time trying to choose the most appropriate resource and doubts about the role of the teacher in relation to resources and students, i.e., what kind of strategies are most appropriate to improve student learning.

Group D

This group was composed by three teachers who were not teaching in the same school, but knew each other personally before this training. They had between eight and eleven years of teaching experience and attended irregularly to the training sessions. Like the previous group, they chose the theme "Electricity" that belongs to the 9th year of basic education, to develop the instructional sequence. This subject was being taught by two teachers of this group (T1 and T2) and the instructional sequence was implemented by the teacher T2. As the previous groups, they presented a detailed instructional sequence and a report of the application in the classroom.

This group produced the sequence using various multimedia tools, including simulations and animations. The sequence was divided in two lessons of 90 minutes. The set of tasks to be performed by students in group was provided by the teacher in a worksheet. The tasks included the creation of a wiki, a digital resource that allows the systematization of information and interactivity between teacher and students, in addition to develop rigorous language. The class was divided into groups of three students. The tasks were presented in two phases: Phase 1 (1st lesson) it was delivered the worksheet and asked students to do what was required. In phase 2 (2nd lesson) students learned to use and write on the wiki and complete the task. Students were exploring the sites and doing their assignments while the teacher was going around the class, answering questions and guiding students so they do not disperse and consolidate the concepts that were previously discussed in other lessons. So, the task and the visualizations were used to review concepts and help students to self regulate their apprenticeship. Like Group A, this group expressed confidence both at a technical and pedagogical level. They mentioned that they use this type of resources frequently and so have no difficulty in using them.

Group E

Group E, it is not really a group, although it has kept this name for presentation of results, since it is formed by a single teacher (T11) which turned out to be alone when the groups were formed spontaneously on the basis of personal relationships prior to training. Although it was suggested to her to join one of the groups she chose to stay alone stating that she felt well to draw the sequence alone, so her will was respected. This teacher decided to prepare a didactic sequence, addressing as Group B, the theme the "Sound", of 8th grade, having been applied to three classes of that school year. The teacher presents a very detailed sequence, plus a report of the application in the classroom.

The teacher built a sequence of two 90 minute lessons, with the content or topics to address, skills involved, mobilized resources, assessment methods and the various moments of the lessons with the sequence of activities to develop. Like other groups, the teacher provides students with a worksheet with various tasks to be performed by them divided into several groups. For this teaching sequence were designed and applied research tasks. So, the worksheet encourages students to have a more active and collaborative work, where they pose questions, formulate hypotheses, research information, use different tools (texts, static images, videos, simulations and animations) to collect data, analyze, discuss and communicate results. For this teacher's task can therefore be a starting point to learn science, about science and doing science in the classroom. Within this constructivist view of learning, the teacher assumes the role of advisor and facilitator of learning. The two lessons were divided in three basic moments: first

teacher presents the task; second, the students develop the task and in the end a reflection about the work. With the systematization of the issues addressed during the task, with class discussion and use of a PowerPoint.

This teacher mentioned only operational difficulties related to the position of computers in the classroom that being too close together, facilitate unwanted conversations between groups and create some disturbance in the activities. Regarding the handling of technological resources and its integration in the instructional sequence, this teacher was fairly confident. In Table 2 it presents the five groups and the characteristics of their TLS.

Table 2. Groups and characteristics of TLS.

Groups	Class (year)	Science topic	Lesson number (lesson=90 min)	Visualizations	Mode of visualizations use	Lesson activities
A	11	Chemical Equilibrium	2	Simulation	Pair work with laptops; Worksheet	Introductory whole instructions; Pairs used simulation with worksheet answers;
B	8	Sound	2	Concrete models; Simulation;	Pair work with laptops; Worksheet for multimedia tools	Topic introduction by teacher to whole class; Pairs used simulation with worksheet; Syntheses and homework or exercises correction
C	9	Electricity	2	Video; Animations and simulations; Interactive exercises	Projected display of both tools with the whole class	The teacher introduces content; Teacher use of multimedia tools; Student use of interactive exercises
D	9	Electricity	2	Lab experiment simulation; Animations; Wiki	Pair work with laptops; Worksheet	Topic introduction by teacher; Lab experiment; Whole class presentation of simulations; Written evaluation
E	8	Sound	2	Video; Static images; Simulations; Animations	Pair work with laptops; Worksheet	Introductory whole instructions; Pairs multimedia with worksheet; Whole class syntheses of the concepts involved in a worksheet

Celeste FERREIRA, Mónica BAPTISTA, Agnaldo ARROIO. Integrating Visualizations in Science Teaching: Teachers' Difficulties and
Pedagogical Approaches

PROBLEMS
OF EDUCATION
IN THE 21st CENTURY
Volume 57, 2013

57

Discussion

Analysing the outcomes, it was detected three constructivist approaches (groups A, D , and E), a traditional approach (Group C), and a combined approach (Group B), ranging from strategies based on constructivist views and to strategies more connoted with teaching by discovery.

In the groups A and E the option for a teaching based on constructivist theories of learning is manifested clearly in the introductions of the reports by both groups. The strategies used (placement problem situations, raising hypotheses by students, confirmation of hypotheses and sharing the results obtained by the students) are typical of a learner-centred teaching, in which he has an active role in their learning (Hodson, 1998) and were intentionally chosen by the teachers. In Group D, although the final report did not note an emphasis on constructivist view of the teachers, the type of strategies used follow the didactic aim to engage student in their learning, which was aid by the teacher and the resouces selected for this. In the case of Groups A and E, the clear and secure option for these new models of teaching seems to arise from the fact that three of the four teachers involved in these groups had a graduation in education at master level. Thus, contact with these new approaches is prior to this training and their practices already reflect these new conceptions of teaching. In the case of Group D, although none of the teachers present a master, they completed their initial training in the past decade, so most probably they already had the opportunity to discuss new pedagogical approaches that appear in their practices, emphasizing also that the teachers T2, usually collaborates on projects with a local university, which facilitates access to this knowledge often generated and maintained in academia.

Regarding the Group C, there is clearly, according Mizukami (1986), a transmission of content by the teacher with the aid of resources, the visuals are used to demonstrate and highlight the description of contents, working at the level of memory and attention, with students showing a cognitive passivity in the face of such knowledge.

Group B presents a mixed approach, although the teachers position themselves as adherents of a perspective that recognizes knowledge as a personal construction, the strategies used to weaken the conceptual elaboration, since these are often focused on "discovering something" instead of "find out why". Thus, despite the move away from the traditional approach, student learning takes place, often from sensory observations without making a connection to theoretical frameworks, although this was one of the goals of the group. However, sometimes the intervention of teachers is carried out with the aim of bringing the student to explain what he observed, ie, towards personnel construction. Therefore, it was verified the absence of some elements of the constructivist approach (problem situations or questions, formulating hypotheses, confirmation of hypotheses, etc..), which comes against some literature data suggest that the implementation of constructivism in classroom is not easy (Baviskar, Hartle & Whitney, 2009). According to this study, beyond the fact that the instructional sequence does not contain many strategies typical of this approach, other strategies has been incorporated by this group that fit a more traditional view.

In terms of the types of visualizations chosen predominate the ones incorporated in technology, mainly simulations. This fact is in agreement with evidence from the literature suggesting that the multimedia simulation is one of the most important applications of ICT at the moment (Hennessy, Deaney & Ruthven, 2006), and these teachers, explored some of its potential. All the groups that chose to work with student pairs provided students with a worksheet to drive the activities.

These teachers did not show personal difficulties to engage with technological resources. At the technical (operational) level they refer only and the lack of computers. Thus, the difficulties are of institutional nature (Becta, 2004). At the pedagogical level, these Portuguese teachers demonstrate in some cases doubts about the role of the teacher, especially how they should interact with students in the presence of these resources. This is consistent with Webb (2010) who

58

advocate new roles for the teacher and students through these tools. Students could be engaged and encouraged to participate more actively in learning and teachers' role could become more focused on enabling learning through interactions rather than spend time in basic organizational and management tasks. The remaining difficulties (selection and adaptation in the classroom) come from the extensive number of resources available to teachers and due to the absence of discussion of this issue either in initial or in-service training. So, without a theoretical discussion about the decisions about what to choose and what approaches are most suitable based on pragmatical reasons, what is considered to be not enough (Frost, 2005).

Conclusions

In this study it was investigated some aspects related to the integration of visualizations in classroom. These teachers showed a positive perception of these tools. With regard to the difficulties to integrate visualizations in the classroom, pedagogical difficulties were expressed (teachers' papers in classroom and selection and adaptation of this kind of resources resource) and technical difficulties in the case of visualizations embedded on technology. The technical difficulties are well known in literature, but the pedagogical are still less explored. Some researchers (Webb, 2010) point that the use of these resources is changing teachers and students' roles in the classroom, so training is needed. Furthermore, analysing the respective strategies and approaches used, there is a predominance of a constructive approach. These results are consistent with the trends observed in other studies (Hennessy et al. 2007; Robblee et al. 2000). The influence of these new teaching approaches found on several groups of teachers promotes the use strategies that enhance a more personal knowledge elaboration as opposed to a transmission of this. In several cases, there is a tendency to engage students in tasks that exploit their prior knowledge and construction of new knowledge. In most groups, these tasks were supported by the use of ICT, which is in line with the results found by Webb (2010), in which the author states that many educational innovations are possible and supported by technology. In most groups, the teachers try to give some autonomy to the students being, however, sometimes limited to the number of ICT resources. Indeed, during the training was promoted the use of these resources in a constructivist perspective, as meditational means, but the use of these approaches seems to us also related with preconceptions of these teachers about learning. The theoretical constructs discussed and collaborative work allowed them to "go further", designing and applying sequences where the visuals were selected and used in a more conscious way, with the aim of promoting the creation of meanings. Therefore, one suggests that these resources have been used mostly as "partners " for the introduction of innovative teaching methods , however, it was also found groups (B and C) where resources have been used primarily for strengthen existing teaching approaches. One believed that the duration of the training and the type of support provided it was not enough to promote the introduction of these resources in a more innovative way where teachers and resources can challenge students' understanding and reflection, both through discussions with the whole class as through individual work.

Thus the training course allowed blurring some of these difficulties, namely the pedagogical level, in order to allow these two groups of teachers acquire, modify or consolidate their knowledge about the nature and role of these resources in learning, and their role in the selection, design and orientation of activities with these resources. The sharing of ideas and collaborative work among peers allowed a very positive adherence to the challenges during the training.

In spite of the limitations of our study (number of cases) and the use of a training context one could say that the use of visualizations can allow teachers to explore more constructivist approaches or use them in a traditional way, i.e. to explain the contents. What is really the best approach? When is it best to use one and when it is better to use another? Do teachers are taking advantage of the full potential of these resources? What is the best visual tool? The success of these resources in learning depends on the chosen approach or depends on the type of resource

and its quality? So, more research is needed to gather a better understanding of the students' learning impact of these resources and make this knowledge accessible to teachers.

One considered that this study contributed to investigate the problems involving the use of visualizations in the classroom and the importance of teacher training. Indeed, it was found teachers who have a consolidated idea of the influence of these resources on learning, but these notions arise from evidences of the practice, because they had not the opportunity to discuss the theoretical issues associated with the use of visual language and technological resources based on them. It is important to help teachers to choose the best visual tools that fit their purposes and also allow them to experience innovative pedagogies. Thus, more research is needed to understand the teachers' difficulties and what kind of training they should be exposed in order to be able to select visualizations and implement activities in a profitable way. It is also important to investigate how in-service teachers integrate these resources out of a training context to understand their training needs. This knowledge will enable the design of training programs appropriated to their needs.

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