# ESCALATE: The White Book

# **Chapter 8:** Description of the experimentations in Switzerland (& Italy)

## **Sub-chapter 8a:** The Implementation the Storm and Digalised Euglena cases

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## 8a.1 Introduction

Since some years now researchers in the field of education seek to improve and design pedagogical activities in which learners are invited to enter into enquiry and argumentation processes. This dialogical context is conceived as a fruitful arena for knowledge co-construction.

Using argumentation as a learning tool in school context however raises questions and difficulties at different levels, institutional but also psycho-sociological : argumentation is rarely an object of study neither a familiar communicative tool in classroom, as teachers sometimes think that organizing debates is time consuming and do not feel comfortable with this kind of social organization. Designing argumentative activity is indeed a difficult matter. From the participants' side, argumentation communication may be perceived as a situation where relationship is at risk (V & Andriessen) as it involves confrontation and expression of conflicts.

In the frame of the ESCALATE project, we felt the importance both to explore the psychosocial issues of argumentation in learning, in particular mediated by TIC, and to work with teachers or future teachers on designing TIC mediated argumentative scenarios in sciences. In this perspective we designed a course for students in Psychology and Education and elaborated with their help some argumentative cases in science that we tested in the classroom and analyzed. In order to sustain and facilitate argumentation and learning processes, we used the software called Digalo (developed in the frame of the DUNES project[4]) that gave interesting cues in previous studies (Muller Mirza, Tartas, Lambolez & Perret-Clermont, 2006; Muller Mirza, Tartas, Perret-Clermont & de Pietro, 2007).

In this text, we shall present implementations of two scenarios (or cases): the first one is called the Storm case and the second one the Digalised Euglena case. Both have been developed and tested in several classrooms in Switzerland. In our account we will develop the specificities of the institutional and social context and describe quite precisely our preparatory work, the strategies and methods we have chosen, the main results we reach, the teachers and the learners' opinions about the whole process. From the analysis of the data gathered, we will try to shed light on the "lessons learned" from an educational point of view.

We therefore will ask in particular, and give some elements of response about:

- how and in which context the cases have been elaborated;
- how and in which context they have been implemented;
- how the experiments have been perceived by the teachers, what they think about the use of Digalo and the activity's contributions in terms of learning ;
- how the experiments have been perceived by the participants, what they think about the use of Digalo, and the gains in terms of learning and argumentation it is possible to infer from the data.

[4] DUNES (Dialogical argUmentative Negotiation Educational Software) is an European project coordinated by Baruch Schwarz, Hebrew University of Jerusalem, and funded by the Vth Program Frame of the European Commission (IST-2001-34153). It involved 9 participants, academic partners and software developers, from France, Germany, Greece, Israel, Netherlands, Sweden, Switzerland and UK.

Our contribution focuses on the description of two cases' implementations that we did in various contexts, "Digalised Euglena" and "the Storm":

- The **Storm case** had been tested in two different environments:
  - with 9-10 years old pupils in one classroom in Geneva (in the text, we will refer to this experiment by the means of the following acronym "**Storm1prim**" – as it is the first version of this case and we tested it in a primary school))
  - with 12-13 years old pupils in one classroom in Reconvilier-Jura ("**Storm2prim**" – as it is a second improved version of this case that we tested in a primary school)

- The **Digalised Euglena case** had been tested in two environments:
  - with one group of University students in Neuchâtel ("**EuglDig1uni**" – as it is the first version of this case and we tested it in the University context)
  - with 13-14 years old pupils in one class in Le Locle-Neuchâtel ("**EuglDig2sec**" - as it is a second version of this case that we tested with secondary school pupils).

## 8a.2 Argumentation to learn and learning to teach through argumentation

If argumentation is conceived as "helping recognize" the reasonableness of a position (Rigotti & Greco, 2004), and involving at least justification and negotiation mechanisms, it may be used by quite young children in some familiar and meaningful situations (Dunn). Its main features are however objects of development (Golder, 1996), and everyday argumentation, made by children and adults, rarely shows sophisticated elaboration (Kuhn ; Schwarz, 2001). In school, in spite of its potential for leaning – due mainly to the fact that it involves verbal interaction (Mercer) and may lead to the social resolution of conflictive perspectives (Perret-Clermont, 1996 ; Baker, etc.) – argumentation is rarely used as a tool for learning. Working and discussing with teachers (or future teachers) on these issues could be an important point of departure in order to better understand the fruitfulness (but also the difficulties and the limits) of this pedagogical method.

At University of Neuchâtel, we opened a course (from 2005 to 2007) for students in Education and Psychology, future teachers or people who have teaching experiences or are teachers themselves. This course, entitled « Argumentation and leaning », had two main goals : presenting the psychosocial issues of learning by argumentation, and developing and testing argumentative activities in sciences. After some introductory lessons to theoretical backgrounds on argumentation and learning, participants are invited to work in small groups and develop a scenario that they will implement in classrooms. Before the implementation, each scenario is tested among the participants and is modified following their recommendations.

For each case, we have thus chosen the following implementation process:

1. a first preliminary test of the case in a "secure" context, at University: the teachers-students involved in the research and implementation project were asked

in group to test one case; each of them had to play the role of one teacher (who presents the topic, asks questions, animates the debate, gives feedbacks, etc.) or of one learner. This step aimed at familiarizing the researchers with the topic, the main steps and the activities involved by the role of teacher and of the pupils, and at leading them to make some changes in the case according their observations, before the implementation itself in the field;
2. the second step was the cases implementation itself in class with pupils[5].

Through this design, students experiment different social and professional positions, the ones of learner, teacher, and researcher.

Five main interrelated steps structure the pedagogical syllabus of the University course:

- Theoretical and methodological contributions
- Collective work on elaboration of a « good argumentative scenario in sciences » (in small groups)
- The test of a first version of the scenario (among the students, in small groups)
- The test of the scenario with pupils in classroom
- The writing down of the main results of data analysis and reflexive position about the work.

## 8a.3 Some psychopedagogical points of departure for the Storm and Digalised Euglena cases

### 1. Learning objectives

The Storm and Digalised Euglena focus both on two kinds of learning objectives:

- *knowledge acquisition of specific contents in sciences* – according to the pupils age and their previous knowledge about the topic (for instance for the storm case: a better understanding of the main features of a storm; what is a lightning; and for the Euglena case: a better understanding of what is a cell and what are the Euglena characteristics...), and,
- *development of competencies or communication strategies in enquiry and argumentation* (knowing making reference to documents, referring to relevant information, grounding his/her perspective, taking into account the others perspective, asking questions, putting assumptions into questions...).

The topics about the cells (Euglena) and the storms have been chosen as they both provide the opportunity for the learners to acquire knowledge about contents that are of interest in the science curriculum but mostly – by the means of the argumentative scenario – as they may develop rich interactive learning processes.

[5] Two courses have been conducted at University of Neuchâtel by N. Muller Mirza, with some changes: the first one (2006) was more focused on how to develop an argumentative design in science with reflections about scientific reasoning and science development, and the other one (2007) on how to implement an argumentative design in a classroom. Both had been conducted during one semester with about 25 students in 2nd, 3rd and 4th year in psychology and education.

For the Storm and the Digalised Euglena, the pedagogical scenarios are phased and structured though individual, small groups and classrooms activities. The argumentation phase is one among several steps.

The design of the scenarios is grounded in a socio-constructivist approach, putting emphasis on the learner as an actor who is conceived as able to construct new knowledge, in interactions. They also are developed on the basis of some of the previous results from research in argumentation and learning that shed light on the difficulty for children but also adults for engaging into argumentation (Andriessen, Baker & Suthers, 2003; de Voss; Golder, 1996; Quignard). These findings stress the importance of carefully designing the argumentative activity, and in particular, taking into account:

- the *cognitive* dimension (to make sure that participants have knowledge about the topic, in providing for instance pupils with opportunities to make reference to "scientific" information; to make sure that the information are understood…),
- the *affective* dimension (framing the argumentation phase such as it is focused on a content and not on the persons; teacher's presence in order to prevent inter-personal conflicts…), and
- the *communicative* dimension (to agree on a "contract of communication"; framing a controversial and clear question for the debate phase; providing opportunities for interactions and confrontation of perspectives…).
- Our designing choices are also linked to some authors claims about ICT tools affordance for facilitating argumentation and learning (Andriessen, Baker & Suthers, 2003; Schwarz).

## 2. Digalo

Except for one version of the Storm case implemented in a primary school all the cases have been tested with Digalo as a mediational tool. In general during the case's "argumentative phase" one sub-group of learners worked via Digalo since the other one discussed orally.

Digalo seems an interesting technological tool for facilitating argumentation practices in learning environment as it allows (Muller Mirza, Tartas, Perret-Clermont & de Pietro, 2007):

- keeping track of the discursive processes (learners can come back and reason about what has been said and why)
- supporting thinking processes in allowing to write down and thus to make explicit and exteriorise his/her idea
- taking time to reflect upon the arguments of the other participants
- justifying and grounding arguments (by the means of the different windows of the software)
- sustaining articulation between arguments (with the use of the arrows)
- diminishing the face to face stress of argumentation, that is mediated at distance by writing with Digalo, etc.

### 3. Sequencialisation

From these assumptions and according to the topics and populations we adopted a main structure that involves a sequencialisation in phases, articulating collective, small group, and individual works.

The main phases are the following:

- in order to be able to follow the possible development of specific knowledge, we asked the participants, individually, to respond to some questions at the beginning and at the end of the case; we will call these small questionnaires "pre-test" and "post-test" (but we are aware that the terms are not very well appropriated). These questionnaires are also used as a tool for the researchers to see the « pre-knowledge » and representations the learners have about the topic at stake ;
- a moment is devoted to provide some general information to learners in class group about the topic at stake. The teacher uses a power-point presentation for instance and gives written documents including the main information. This step aims at giving or reminding some notions that could play the role of a "knowledge common ground" in the argumentative phase;
- the "controversial" question is presented to the group, for instance: is Euglena a plant or an animal? Does the lightning touch the ground during a storm?
- Sub-groups are constituted. Concerning the Euglena case, a group pro vegetal cell and a group pro animal cell for instance;
- Each group is invited to ground its argumentative position with the help of documents and of the teacher. They write down these points on a common sheet. This step should provide pupils with information that they will use as arguments in the debate phase. They also are asked to read texts, and to learn to select relevant points in complex documents. This phase is also an interactive moment where the pupils are discussing together about the relevance of their choices;
- The sub-groups meet for the debate phase, which is mediated by Digalo or orally. A "contract of communication" is discussed (each person may express his/her position; each person must be listen to; the speech turns are respected, etc.). The groups try to convince the other's group about their respective position relevance, in grounding their own perspective and putting into question the other's. This phase is expected to see participants confronting their perspectives, entering into socio-cognitive conflicts and argumentation processes – and possibly into learning processes;
- A discussion with the group-class is organized by the teacher in order to respond to questions, to synthesize the learning processes, etc.;
- The pupils are asked to respond to a post-questionnaire.

## *General background of the implementations*

In the school contexts, the preparatory work for the implementation consisted first in taking contact with sciences teachers who were known personally by the researchers. It is only once the teachers gave their personal agreements that the educational board of the district, the school direction, the parents and other authorities have been reached for their official agreement.

It is interesting to note that the idea of implementing an argumentative scenario in their classroom has been very well welcomed by the teachers. However an argumentative approach does not seem very well established in the school contexts, but this general observation has to be confirmed. This kind of practice however seems strongly supported by authorities. When discussing with the Neuchâtel school board director (chef du service de l'enseignement obligatoire) he made reference to other experiences in sciences focusing on enquiry and debate practices that he wished to improve and develop, for instance the "Main à la pâte" program – initiated in France in 1996 by Georges Charpak, Nobel Price in 1992 (http://www.inrp.fr/lamap/ ; http://www.unine.ch/laquinzainedelascience/presentation.html).

All the experimentations have been done in collaboration with the school authorities and with the teachers. All the cases have been presented to the learners not by the regular teachers but by the students-teachers.

During the preliminary phase with the teachers we presented them the general frame of the research, its objective and the way the implementation would be done in their class. We discussed and negotiated with them the content of the scenario that would fit their program and their pupils' expertise; the cases and their main phases have been adapted according their comments. A discussion had been organized after the case implementation with the teacher such as to have their general feed-backs.

## 8a.4 The Storm case

### 1. The main steps of the scenario

1) Individual Pretest: (pupils are asked to respond to general questions about the storm phenomenon, for instance: What is a storm for you? What are the main elements that constitute a storm? What are the main steps? How does a storm take place? How can we guess that a storm is arriving?)
2) Presentation of some information about the storm (by the means of a power-point presentation)
3) Groups elaboration (by taking into account responses to pre-test, elaboration of groups in which pupils have diverse preconceptions)
4) Texts presented to the whole classroom about storms; each pupil individually reads them
5) Preparation of arguments in groups (group work): each group prepares an "argumentative map" (written) about some open questions. For example:
   Is a storm an electric phenomenon? Do all clouds give storms? Is it windy when a storm arrives? Does lightning touch ground? Are lightning and thunder linked?
6) Debate with Digalo / orally (about one or two open questions)
7) Individual Post test
8) Plenary discussion (teacher and group work)
9) Feedback from the teacher

From the first version the case implemented in *Storm2prim* has been a bit redesigned. The main changes are linked to the documents proposed to the pupils, the formulation of the questions for the debate phase and the way of elaborating the working groups, due to the different age of the population and advices from the teacher.

## 2. The Storm case in a primary classroom (Geneva)

*Social context*

The class in which this case has been implemented had the following characteristic:

- 22 pupils of 9-10 years old;
- primary school (in this context it means that the pupils have one privileged relationship with one teacher ,who teaches them the main contents in Maths, Sciences, French, etc.;
- mixed population according to their linguistic and cultural backgrounds.

*Data*

- The oral debate has been audio-recorded
- Field notes of the researchers-teachers
- Pre-post questionnaires
- Argumentative maps (written)

*Description of the implementation process*

The teacher was known by one of the two student-teachers involved in the design and the implementation of this case. They discussed with her the topic that would fit the program and the pupils' interests. She had never practiced this kind of activity with her pupils and was very interested by the idea. Open-minded and very active in innovative pedagogical reflection and practices, she collaborated in depth with the student-teachers. She thought that the topic of the storm could be of interest for the pupils in her program. With her help, they designed the scenario (main steps, questions, documents, etc.), presented it to the pupils, framed and animated the debates, etc. Between two sessions, the teacher took 2-3 hours in order to read and work with her pupils on the documents.

The case was divided into three main phases, during three afternoons.
The *first phase* was devoted to the « pre-test » of the pupils' knowledge on the storm phenomenon. The student-teachers started by introducing themselves to the classroom and explain their objectives. Then, they told the pupils what was expected of them. This involved their preparation of short notes and their collaboration throughout all the activities. The teacher thought that it was important to do the introduction in her presence so that the pupils would understand that this was not simply a new "game" but a serious activity in which they had to take part even if their usual teacher did not conduct it.

After the introduction, the student-teachers presented the topic that would be studied in class: "storms". Without giving too much information, the student-teachers asked the pupils to give written answers to the following question which had been written on the blackboard: "What does a storm mean to you"?

To help them in their reflections and in order to obtain the most accurate/complete information about their knowledge, after 10 minutes, the following additional questions were written on the blackboard : What are the main elements that constitute a storm? What are the main stages of a storm? How does a storm take place? How can we predict that a storm is going to take place?

Subsequent to this first phase, two groups, the "experts" and the "novices", were created based on the preliminary knowledge of the pupils, which had been evaluated through the answers that they had given in the first stage. The criteria used to divide the class into the two groups was the number of correct terms quoted. The student-teachers chose 9 criteria for selection: specifics types of clouds (black, grey, heavy,...), rain, lightning (light, blinding lights), thunder (noise and loud noise were also accepted), violence, wind, electric phenomena, temperature, meteorological/climatic phenomena. Furthermore, the groups that had been formed were reviewed by the teacher so she could inform the student-teachers of any variables that could hinder the experiment, such as social dynamics in the classroom or relationships between the pupils. The student-teachers were guided the teacher's knowledge about the classroom social dynamics to place the pupils that they were unsure of.

During the days between the first and the second phase of the experiment, the pupils were asked to read in class or individually the documents that they had been given.

*The second phase* is the central stage of the experiment because the pupils have to debate between themselves. This phase therefore begins with small groups (for / against) who discuss controversial questions in order to elaborate an « argumentative map » in each group around the following questions : Is a storm an electric phenomenon? Do all clouds produce storms? Is it windy during a storm? Does lightning touch the ground? Are lightning and thunder linked? The discussions could be based on the documents-resources. The "argumentative maps" (which consist of the arguments elaborated by the group for each question) are written on large sheets of paper. The division into sub-groups (the « for » sub-group and the « against » sub-group) was done randomly and was therefore not based on any criteria other than to obtain two groups with similar numbers and sexes.

After the elaboration of the argumentative maps in each group, the oral debating started. The two sub-groups from each group were reunited to debate their divergent opinions as one group had to defend the « yes » answers to the questions whereas the others had to defend the « no » answers. A certain number of communication rules were established with the pupils so that the debate would run smoothly.

*The third phase* was aimed at collecting answers to the post-test and to answering the pupils' questions. The pupils were asked the same questions as the ones in the first phase : What does a storm mean to you? What are the main elements that constitute a storm? What are the main stages of a storm? How does a storm take place? How can we predict that a storm is going to take place? Then, according to the teacher's recommendations and wishes, the student-teachers gathered the pupils in the lecture hall so that there would be more space for a discussion. This stage was perpared in close collaboration with the teacher, who suggested a number of propositions which were interesting from a didactic point of view. The student-teachers started by asking each pupil in turn if they had any unresolved questions concerning the topic. This was in order to know which elements remained unclear to the pupils and so that the student-teachers could in future adapt the explanations they gave in the first stage of the experiment. Subsequently, the student-teachers started a discussion around the questions that had been asked as their role involved being both sources of information and to provoke the debate. Indeed, before answering the questions, the student-teachers asked the other pupils their opinions. In the third phase of the experiment, the student-teachers suggested a more game-type activity (a crossword) around the topic of the storms in order to answer the questions that still remained unclear. Finally, the student-teachers asked the pupils what they had thought of the activity by asking the following questions : Did you learn anything ? If the answer to this first question is yes, what did you learn? Did you like this way of working? Why did you or didn't you like this type of work ?

### 3. Some results of the experiment

***The teacher's point of view***
The teacher who was in charge of the classroom thought very interesting the whole activity and its pedagogical assumptions about argumentation. However she was dubitative about the difficulty of managing differences in knowledge levels (she observed that good pupils take easily place in the debate and less good are less involved). She also saw some difficulties for some of them to write down and was aware of the importance to choose textual resources of interest but not too difficult for the age and levels of her pupils.

***Pupils point of view***
Many pupils expressed their interest and motivation saying how they felt "cool!" the activity and that they "learned a lot" (new vocabulary, new knowledge about the storm phenomenon). Interesting enough they felt pleasure to work in group, to "learn from each other, saying that "we can listen to what the other say, develop and compare".

***Learning processes: knowledge construction and argumentation***
What can we observe in terms of learning and argumentation processes from the data gathered ?
First, by comparing responses to the pre and post questionnaires to the question : What is for you a storm ? we can observe three main elements :

- a general increasing of the ad hoc vocabulary: at the end of the activity it seems that the pupils were more able to use words like "cumulo-nimbus" rather than "black cloud", or "lightning" rather than "light", or "thunder" than "a big noise";
- a complexification of the understanding of the storm phenomenon: the storm is less often reduced to the only lightning in the post-questionnaire; lightning is one of the components of the storm;
- a better articulation between the different features of the storm and the causality relationship that exists between them.

Here is a nice example that shows the conceptual development from a pupil who wrote :
Pre-test : « I think that a storm is the meeting between hot and warm. When they meet it makes a big « boom » ! It is like a battle. When one of the two is winning the storm stops »

Post-test : « A storm is an electric phenomenon with lightings and thunder. One knows that a storm is arriving when there are cumulo-nimbus… ».

From the transcriptions of the oral debate between the groups « yes » and « no », it is interesting to observe both groups working hard in order to give elements for example to the question « is the storm an electric phenomenon ? ». One group « no », for instance, tries to convince the other group in developing an interesting strategy : they divide the storm in its basic elements. The storm is not an electric phenomenon as the clouds are not electric, as rain is not, as what is surrounding a storm is not, as there is not any "battery" inside it… The group "yes" makes reference to the texts they read and says for instance that Benjamin Franklin shows the electricity by the means of a "cerf-volant" or: "it is written that the movements of electricity that are accumulated inside the clouds provoke electricity". Pupils at this age seem thus able to justify their positions, making reference to texts, to personal experiences or to what adults have said, or even to funny "evidence" when they think that they have to justify a strange affirmation.

They also show that sometimes they can take into account what has just been said in a more or less complex co-construction process, like in these examples:

| | |
|---|---|
| Group No (15): | the clouds it is not electric |
| Group Yes (16): | we have said that the clouds make electricity! |
| Facilitator: | we are in a mess, aren't we? |
| Group No (18): | It is not true they do not make electricity! |
| Group Yes (19): | If… |
| Facilitator: | why do you say "if" Sasha? Angela, an idea? |
| Group Yes: | it is written that the movements of electricity that are accumulated inside the clouds provoke electricity |
| Facilitator: | then? |
| Group Yes: | then in the clouds there is electricity |

Or in this other example:

| | |
|---|---|
| Group No (29): | the clouds are made of vapour of water, thus it is not electric |
| Group Yes (30): | yes, but after it becomes electric |
| (…) | |
| Group No (34): | yes, the clouds inside, there is only vapour of water |
| Group Yes (35): | but after in the clouds, it makes still electricity |
| Facilitator (36): | after what? |
| Group No (37): | but how a cloud can transform itself in electricity? |
| Facilitator (38): | yes |
| Group No (40): | when I touch vapour of water I am not electrified |
| Group Yes (42): | but no, but the vapour of water it goes up and makes the cloud and inside the cloud it makes electricity… |

Reasoning by argumentation seems quite difficult for these young participants and the teacher has an important role to play in reframing, making socio-affective regulation, reformulating or helping to make links between elements of the topic in discussion.

## 4. The Storm case in a primary classroom (Jura)

***Social context***

- 24 pupils of 12-13 years old;
- primary school;
- the regular teacher is one of the student-researcher who took part in the research (but she did not play the role of the teacher in her own class)
- The researchers (a group of 6 advanced students) took the case as it had been tested in Geneva and adapted it to their specific context. They thus played the role not only of designers (in particular, they prepared a new power-point presentation) but also of teachers in the classroom.

***Data***

- Field notes of the researchers-teachers
- Pre-post questionnaires
- Argumentative maps (written and Digalo)

***Description of the implementation process***

The case had been implemented in a primary classroom in which the regular teacher is part of the research (but she did not play the role of designing and giving the lesson about the storm in her own class). She is therefore interested in activities in which pupils are involved in group works and enquiry oriented. She took 1-2 hours with the pupils in order to read and discuss the documents about the storms.
The implementation of the case took 2 times 45 minutes.

## 5. Some results of the experiment

***Teacher point of view***

The fonction of the teacher in this argumentative setting is quite unusual. In working groups s/he has for instance to be aware to give word to everybody and not let some pupils be the objects of jokes when one tries to say something.

***Pupils point of view***

With Digalo pupils felt at ease but faced some problems to write down their ideas. Writing in Digalo took time and slowed down the activity. Beeing four people behind the computer was also an additional difficulty. The children appreciated to discuss behind a computer, because they could clearly visualize the argumentative map. They enjoyed Digalo and this tool, integrated in a learning setting, stimulated their motivation.

***Learning processes : knowledge construction and argumentative processes***

*Construction of knowledge*

The post-tests revealed that the majority of the pupils have gained new understanding of the Storm phenomenon, new understandings elaborated either during the debate and/or during their readings of the texts. More than half of the pupils answered in a more complete way the post-test. They added the elements of the lightning and the flashes to their answers. They regarded these two elements as being important for defining a storm. Moreover the word "thunder" appears also more in the post-tests, because several pupils evoked this topic in their discussion when they had to make the distinction between the lightning and flash.

Although it is difficult to see whether the pupils really included/understood the formation of a Storm, we can claim that there is construction of new knowledge compared to the first meeting.

*Argumentation*

The pupils argued by referring to knowledge or their own experiences, which they tried to synthesize and write down. The pupils were not familiarized with argumentation. Indeed that was not easy for some of them: to argue does not consist merely to express or communicate opinions, ideas, proposals, desires, project, etc. but also to justify them, and to ground them by a reasoning, and a critical attitude towards the other and one self.
During the debate, we saw that the pupils tried to use the arguments they had found in favor of their position during the preparation phase. They were able to take into account

the arguments from the other partners, but it was quite difficult for them to find out new arguments during the mediated discussion.

## 8a.5 The Digalised Euglena Case

### 1. The main steps of the case

The case is constructed around the Euglena cell that shows interesting "ambiguous" characteristics. It has both vegetal and animal properties as it shows for instance autotrophism property (like plants that "nourish" by themselves via photosynthesis) and, under certain circumstances heterotrophism property when absorbing and digesting dissolved organic matter in the water (like animals). Euglena cell is part of the protest kingdom of living that gathers all the mobile and unicellular living beings.

In teaching science, this kind of phenomenon is of special interest. Starting from an ambiguous object can lead learners in science to explore the specificities of the categories that are linked to the phenomenon. It also may permit participants entering into a dialogical work that is at the heart of scientific activity.

Throughout sessions, the pupils work individually and in small groups. They are lead to develop an enquiry approach: in finding answers to some scientific questions, looking for arguments from textual resources and defending their points of view during the argumentative phase. In particular, they are asked, in small group, to prepare and defend one position: Euglena is a vegetal cell vs is an animal cell.

The scenario in made of different steps, as argumentation phase needs to be prepared. After a pre-questionnaire aiming at a better understanding of the learners pre-existing knowledge and representations about the cell topic, the teacher presents the main features of the animal and vegetal cell, and the specificities of Euglena. Small groups are constituted: one will defend the position that Euglena is a vegetal cell and the other the position that it is an animal cell. During an "intragroup" phase of preparation of their main arguments, each group has some textual resources at disposal. They prepare a first "argumentative map" (listing their arguments on a sheet of paper) that will serve as a tool for the debate phase. The debate, mediated by Digalo, follows: both groups try to convince the other and/or to reach a common understanding. Finally the teacher discusses the results of the debate and presents the scientific categorisation of this unicellular. The learners are asked to fulfil a "post-questionnaire", with the same questions as in the "pre-questionnaire". The various steps are structured in the following order:

- Each pupil gives answers individually (pretest)
- In classroom and/or at home, individual and/or in groups: rading of texts about the animal cell and the vegetal cell
- In small groups (groups of pupils are defending the position that Euglena is a vegetal cell, and the others are defending the position that it is an animal cell) : preparation of arguments in each group
- In groups (one group "pro vegetal" debating with one group "pro animal"): debate with Digalo (or orally)
- Post questionnaire (individually)
- Plenary discussion and feedback.

Learners, by exploring the characteristics of the Euglena cell, are expected acquiring new knowledge about:

- the main features of an animal and a vegetal cell;
- the main differences between both;
- the existence of a class of organisms, protests, which are neither animals or plants (and thus make aware that kingdoms of living are more than the 2 we usually know...).

## 2. The case in a University setting

***Social context***

- 25 students in a course of Psychology & Education at University of Neuchâtel (N. Muller Mirza)
- Two students-researchers designed a new version of the case elaborated by IoE (see the document IDEAS) in collaboration with Nathalie Muller Mirza;
- they thus played the role of designers, teachers and of researchers as they recorded and analyzed data gathered in this frame.

***Data***

- Audio records
- Digalo argumentative maps (figure 1)
- Fields notes
- Pre-post questionnaires

## 3. Some results of the experiment

***What do participants think about the design of the case?***
Rather positive appreciation (but not really measured): «I found this activity interesting, the fact to find arguments and counter-arguments opens the fields of the problematic of Euglena. I would like to know much» [J'ai trouvé cette activité intéressante, le fait de chercher des arguments et des contre-arguments ouvre bien les champs de la problématique de l'euglène. J'aurais envie d'en savoir davantage].

***Learning processes: knowledge construction and argumentation***
Data show that learners actualise knowledge not only in the domain of the cell, and the Euglena in particular, but also in argumentative practices, and that both kinds of knowledge are actually interconnected.

In terms of vocabulary the participants use more the ad hoc scientific vocabulary at the end of the test; we can observe an increasing of specific vocabulary from pre to post questionnaire:
In the pre-test, students make reference to common sense and do not generally use a scientific vocabulary in order for instance to define what is an animal:
*L'animal est un être vivant, comme les mammifères par exemple, il se déplace, il vit, tandis que le végétal est aussi vivant, mais ne bouge pas, comme les plantes par exemple* [The animal is an living being, like the mammals for example, it moves, it saw, while vegetal are also alive, but does not move, like the plants for example].

In the post test the contents are more focused and articulated, with the use of more scientific terms.

In the university setting, participants show abilities to focus on relevant topics in order to go further in the debate, responding to the question. They formulated arguments linked to the following domains:

- internal structure (vacuole; choloroplast)
- way of nourishing (hetero/autotrophy)
- external structure (membrane)
- way of moving (flagella)

In terms of argumentation, we can observe students playing their dialogical position (animal vs vegetal) as it was suggested by the animator; it means that they formulate arguments related to the position they have to defend, and stay focused on the task. They articulate their own claim with the one of the other, and take into account the perspective of the opponent.

It is interesting to observe that the groups develop their argument in taking explicitly what has been said by the other group, like in this intervention from the "animal group" (Uni students): "comme vous le soulignez très pertinemment, la vacuole est CONTRACTILE. Encore une preuve tangible de l'animalité de la bestiole." [as you underline it very pertinently, the vacuole is CONTRACTILE. Still a tangible proof of the animality of the small beast] (t.p.9) – this non-valid claim is countered by an other intervention from the vegetal group: "la cellule animale n'a pas de vacuole du tout!!!" [the animal cell have not a vacuole at all!!!].

We can also shed light on some interesting interactions where the groups do not argue in an agonistic way but try other strategies that have as consequence to explore, in a collaborative way, the nature of the object they are discussing about:
"Vous dites que le flagelle et la vacuole sont typique [de l'animal], mais pouvez-vous dire en quoi avec plus de détails? Que dire du fait que la vacuole est un element partagé à la fois des animaux et des végétaux?" [You say that the flagella and the vacuole are typical [of animal], but can you say in what with more details? What to say about the the fact that the vacuole is a shared element at the same time by the animals and plants? " (t.p.12).
Or in this exchange that has a kind of inquiry spirit, when the vegetal group is writing: "on ne sait pas en quoi la membrane est faite. Si elle est faite en cellulose, il s'agit d'un végétal." [one does not know in what the membrane is made. If it is made out of cellulose, it is a vegetal" (t.p.7).

To what the animal group responds: "vous avez mal compris, la cellule végétale n'a pas de membrane du tout!(...)" [you did not understood properly, the vegetable cell have not a membrane at all!] (t.p. 11).

At the end of the discussion, groups in University reach the conclusion that Euglena "is no a normal feature" ("sort de la normalité")...

**4. Digalised Euglena in a secondary classroom**

***Social context***

- 20 pupils of 15-16 years old;
- secondary school level;
- biology lesson

- The researchers (a group of 7 advanced students) took the case as it had been tested in the University setting and adapted it to their specific context. They played the role not only of designers but also of teachers in the classroom.

***Data***

- Field notes of the researchers-teachers
- Pre-post questionnaires
- Argumentative maps (written and Digalo) (figure 2)

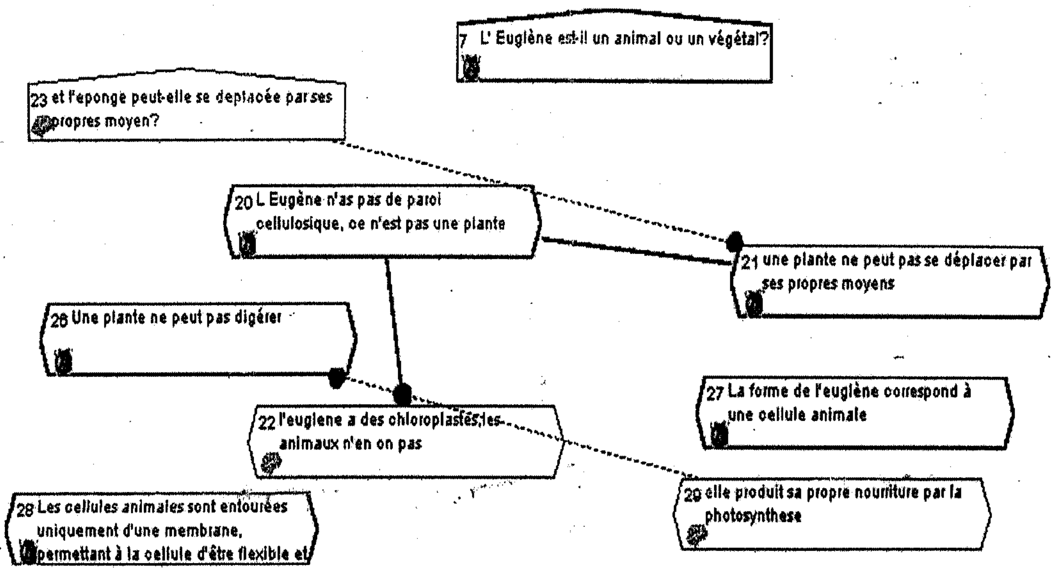


Figure 2: Secondary classroom Argumentative map with Digalo

***Description of the implementation process***

The teacher who is in charge of biology had prepared her pupils in giving 2 lessons about the cell topic before the case implementation. The pupils had therefore some pre knowledge at the beginning of the case.

The implementation of the case took 1 time 45 minutes. After the student-teachers had introduced themselves to the class, they asked the pupils to take an individual written pre-test in order to establish their knowledge. The student-teachers told the pupils that the pre-test was not a test that would be marked and had nothing to do with the evaluation of their school work. Then, they explained the next stage of the experiment which would involve working in sub-groups and participating in debates. Afterwards, the student-teachers introduced the topic and handed out documents that explained the particularities of a plant cell, an animal cell and the Euglena. The student-teachers had considered projecting a series of Powerpoint presentations but abandoned the idea through lack of time. The student-teachers then asked the pupils the following question : « Is Euglena an animal cell or a plant cell ? » and, as previously advised, the student-teachers thereafter divided the class into two groups who had to defend each viewpoint. Two groups of five pupils were formed. One group would work with Digalo and would be supervised by three student-teachers, while the other group would debate under the supervision of another three student-teachers.

Since their arrival in the classroom, the pupils had already divided themselves « naturally » into two groups, as five pupils were sitting on the left side of the classroom and the other five on the right side. In addition, one group seemed much more vocal than the other so, to gain time, the student-teachers kept this « natural » division. They sent the quieter group to work on Digalo while the other five pupils took part in a debate.

The group that took part in a debate was asked the following question : *Is Euglena an animal cell or a plant cell ?* The student-teachers divided the group into two sub-groups. Three pupils were put into the pro-animal group and two pupils were placed in the pro-plant group. The student-teachers then handed out the documentation that supported each position. The pupils were left for ten minutes so that they could find arguments that they would be able to use during the actual debate. The role of the student-teachers was to frame and animate the debate. They had decided that the debate would last approximately fifteen minutes which was an easy target to fulfill.

The group that worked with Digalo was also divided into two sub-groups : three pupils were put into the pro-animal group and two pupils in the pro-plant group. Each sub-group was then placed before a computer in order to be able to debate via the Digola program. Before starting the debate, each group was given five minutes to prepare some arguments to support their position (pro-animal or pro-plant). The student-teachers also explained how the Digalo program worked. The debate via Digalo then took place for fifteen minutes. At the end of the debate, the pupils sat a ten minute post-test so that the student-teachers could establish how much the pupils had learnt.

Finally, the student-teachers conducted a general concluding discussion with the class during which they talked about the particularities of the Euglena cell with the help of a Powerpoint presentation.

***Teacher point of view***
The teacher who was in charge of the classroom was enthusiast by the activity. She showed very interested in the project and felt that it was a pity that the pupils could not have much time for it. She also regrets not having enough time to use debate and argumentation settings in her curriculum (she has only 1 period per week of biology with this group). She wants to come back on the Euglena topic later.

***Pupils point of view***
The pupils felt at ease. They generally seemed very pleased with this experiment.

***Learning processes***
The pupils are able to use the *ad hoc* vocabulary for defining a cell for instance, from the beginning of the scenario. But it seems that they discussed among them and made reference to their notes when fulfilling the pre-questionnaires…

In the argumentative maps, pupils formulated arguments linked to the following domains:
- internal structure (vacuole; choloroplast)
- way of nourishing (hetero/autotrophy)
- external structure (membrane)
- way of moving (flagella).

They thus where focused on the task and used relevant concepts in order to explore and construct knowledge about the phenomenon.

About *argumentative practices*, we can observe from our data that in the Digalo mediated debate, pupils played the dialogical role (Vegetal vs Animal). They started by making reference to the specificities - following the position of their sub-group - of either the animal cell or the vegetal cell ("Euglena has chloroplasts and animals have not" (22)).
We also can observe that the Digalo shapes are well interconnected by the means of the arrows, showing an effort to make links between the interventions. However, the arrows show more the preoccupation to give arguments in order to attack the other's position or ground the group's one, rather to develop and try to better understand the limits of one argument.

We can read for instance:
Animal group: Euglena n'a pas de paroi cellulosique, ce n'est pas une plante [Euglena doesn't have any cellulose wall, it is not a plant]
Vegetal group: Euglena a des choloroplastes, les animaux n'en ont pas. [Euglena has choloroplastes, the animals do not have any]

The reasoning is interesting and valid as the participants seem saying: if Euglena is a plant thus it must have a cellulosic wall like all the plants – since it has not so it is an animal; this argument is countered by the other group who seems to say: if Euglena were an animal – as you think – it would not have choloroplasts, so it is a plant.
They take into account the perspective of the opponent. In the secondary school classroom, we can observe an interesting argumentative strategy: the participants generally do not explicitly give arguments for their own position but attack in a anticipatory move the position of the other. Like here:
Animal group: "Une plante ne peut pas se déplacer par ses propres moyens" [A plant cannot move by its own means] (21)
(Intervention that is counter-argued by the vegetal group who claims:
Vegetal group: Et l'éponge peut-elle se déplacer par ses propres moyens? [And can the sponge move by its own means?])
Vegetal group: "les cellules animales sont entourées uniquement d'une membrane permettant à la cellule d'être flexible..." [the animal cells are surrounded only of one membrane making it possible the cell to be flexible] (28)

***Some general observations***
The pre and post-questionnaires are interpreted in terms of evaluations : the pupils respond to the questions with the help of friends and look at the sheets of their neighbor.
It is interesting to observe a relationship between being at ease with the technical use of Digalo and involvement in the argumentation activity. The slowest students with Digalo were also the ones who hardly found arguments against the other group.
The ludic dimension seems a positive factor that helps children to get involved in the learning activity.

## 8a.6 Lesson learned, and educational implications

### 1. Some difficulties encountered in the tests and way to improve the cases

- The lack of time is the most important limit of the tests: learners did not have enough time to discuss and reflect upon what the activity and their

argumentation; a more longer phase must be dedicated to a conclusive feedback by the teacher, at the end of the scenario;
- In order to avoid the agonistic tendency to argumentation between two contradictory positions, the design should end with a final activity where all the participants are invited to share a same objective (Jackson & Jackson, 1989);
- Assessment-evaluation level: when and what to evaluate (in a teacher point of view) remain an important question (that has not been addressed enough in our tests).

## 2. Contributions from the tests of the cases

In spite of some limits of the cases, it is interesting to see that learners are able to[6]:

- focus on the task and play the role they are assigned to;
- mobilize and use a scientific vocabulary that is made on purpose (even if it is not, a counter-argumentation by the participants them selves is used to correct the non valid claim);
- articulate concepts – or try to;
- make reference in a relevant way to empirical data extracted from textual resources;
- mobilize argumentation skills and construct knowledge in interaction in the same time ("participant exercises his/her argumentative capacities in constructing knowledge with his/her adversary" (Douaire, 2004).

Some of the usual difficulties of argumentative activities in education setting – mainly difficulty to enter into an argumentative dialogue and week argumentation – appear here less visible[7].

Two main reasons (as hypothesis) may explain our observation:

- a "controversy" modality added with a "role playing" modality: learners have to try to find relevant information and resolve a controversy question through dialogue – a communication setting that many studies have shown its efficiency (for instance, Johnson & Johnson, 1989, 1995a); but in doing that it is not really learner's own opinion that is at stake but the one of the "position" s/he is assigned to. The fear to enter into an interpersonal conflict may in that way be a bit less strong (see also Muller Mirza, Tartas, Perret-Clermont & de Pietro, to appear);
- Digalo affordance and its main functionality can also be seen as a facilitator in the argumentation practices – as it allows to formulate claims, make reference to them, and to make articulations. However some technical problems sometimes occur that render difficult or time consuming its use.

The cases we have tested and analyzed in this text show interesting findings and open new questions for the researchers in education and for the teacher who wishes to implement it in his/her classroom. We list hereunder only several of them:

[6] This scenario could be adapted for older pupils in the frame of history of sciences for instance: it could be interesting on the basis of Euglena scenario to develop the role of categorisation in science, the way science is evolving, etc.

[7] We have however to be cautious: the research design is still in an exploratory form; we have access to few data mainly the argumentative maps and the researchers' notes.

- the status of "argumentation". It becomes clear from this explorative research and others that argumentation can hardly be considered as a set of skills and rules that would be defined *per se* independently from the social, technological and institutional context in which it is used, and independently of a specific content. We have seen that even rather young pupils are able to enter into a dialogical reasoning about some complex physical phenomenon (even if the cognitive development of argumentation has to be taken into account). Justification by the means of scientific features and articulation of concepts are observed in the argumentative maps through Digalo. However we have to be aware of the complexity of the "psychology of argumentation" in science. It can be seen as obvious that one does not argue on any topic with anybody anywhere... It seems important for example that the individuals who engage in this way of communicating and learning can feel in a secure frame, as argumenting is a risky activity at least for three reasons, that are probably interrelated: for a relational reason (if I do not agree with my friend will s/he stay my friend?), for an epistemological reason (if my opinions and believes are put into question, what is right? Who is right? What is the truth?), and for an identity reason (if my opinions and believes are put into question, it is my own perception of myself, my identity that is at stake: who am I? How am I in an "uncertain" world?). And in the everyday practices of scientists, if argumentation can be located in different places[8], do the pupils feel at ease to put into question topics that have been the object of study of "scientists" during decades?;
- The personal position of the learners towards the topic under discussion. Some lines of research are studying the role and the impact of personal believes of the learners on learning. About some topics, as for instance the natural selection, teachers sometimes puzzle: are the difficulties faced by the pupils due to the inherent complexity of the topic of due to the personal perception of the conflict between science and their religious believes, or is it due to some combination of the two? Perspectives suggest that if learners recognize and become aware of the conflict between their existing knowledge and the scientific conception conceptual change is possible, under certain circumstances (Sinatra, 2003). In argumentation activities personal views are central as learners are asked to make explicit their own perspective on an object. In our designs we made the pedagogical choice to avoid this situation and to assign a position (pro or con; Vegetal or Animal...) to each participant whatever was her/his personal position. However, this dimension remains an issue to have in mind when implementing an argumentative activity. In a more general discussion, the epistemic believes about sciences, its evolution, the status of hypothesis, truth, theories, etc. are of a central interest, both from the learners and the teachers' point of view. It is obvious for instance that the pedagogical choice of the teacher of using an argumentative activity for teaching science is linked to a view of science defined in terms of trying to construct and resolve problems in specific theoretical frames rather to "discover" things that would have been hidden from the beginning of the world (Latour; Jacot & Muller Mirza) ;

[8] There are arguments about what kind and the amount of data to collect (for instance whether the data will be valid and how much is needed to make it reliable); there are arguments about whether a given model is a satisfactory interpretation of the data (for instance, why the Bohr model of the atom is not a satisfactory model); there are arguments about the interpretation of data (for instance, do the rising levels of CO2 mean that the global temperatures will rise)? (IDEAS, p. I.II).

- the role of the teacher. In our design the place of the teacher is not in the front of the classroom but her/his role is central (Lambolez & Perret-Clermont). S/he has not only to mediate (give some scientific information and cues, suggest readings, ask counter-argument question...); but also to moderate (ask questions, guide the discussion, help to focus...) the cognitive and discursive activities. S/he is the guardian of the frame, in its cognitive and relational dimensions. At the end of the activity it is important that s/he concludes the activity both at the content and at the relational levels: to remind the meaning and the finality of the activity, come back to the main points and the process of the discussion, and give the "scientific" position(s) about the topic under discussion, and also discuss about what happened during the dynamic of the discussion;
- the role of the software and its use. Our observation shows that Digalo is perceived as a quite easy to use and friendly tool. However it is important not to underestimate the technical constraints of its use before, during and after the activity (the question of the server, the connections, the firewalls, the availability of the computer room and of the technicians, the teacher's and pupils' familiarity with computer, the configuration of Digalo...). In our experience, it seems that Digalo may be used by the participants as a psychological tool that to a certain extend leads them to externalize their thought and makes it "available" not only for the other but also for themselves. Its use also seems a factor of motivation, as it is quite unusual for the pupils to use computer in science classrooms and because of its interactive and synchronous functions.

From many years now educational psychologists agree that knowledge is not acquired by transmission alone, but by (co-)construction. In putting the learners in argumentation settings we proceed a step further following scholars who claim that learners can be the agents of their own learning: "It is a fundamental tenet of our theory that students have a right to understand, evaluate, and orchestrate their own learning" (Brown & Campione, 1994, p. 270). In the kind of design we have tested the learner does not behave as a receptacle of a previous knowledge but as an actor who is able to act for seeking relevant information, makes hypothesis, agrees to be countered, can reflect upon his/her own productions and the others' ones. The learner can thus experiment a decentration and a reflexive position that may lead to a more meaningful and grounded learning.

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# ESCALATE: The White Book

# **Chapter 8:** Description of the experimentations in Switzerland (& Italy)

## **Sub-chapter 8b:** The WHY DOES IT KEEP ITS BALANCE ? The case of the tightrope walker

*Written by J-F Perret, Gi Haüsermann, L-O. Pochon with the colaboratiobn of L. Oswald, P. Suozzi, A.Zaninelli & C. Gertsch*

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## 8b.1 Introduction

In this paper, we will present the researches we have carried out to elaborate and test a didactic scenario around the concept of balance in physics. We will first describe the initial problem and the didactical scenario which we have elaborated. Then we will present the experiments which were carried out at the University of Neuchâtel (in a the part 1) and at the Alta Scuola Pedagogica of Locarno (in the part 2). In the conclusions we resume the main observations and we give some recommandantions for new implementations of the scenario in other contexts of teachning.

## 8b.2 The problem

To keep one's balance or not is a concrete experiment which is related to the everyday life of the child; this experiment relates to the body (which child have never heard this piece of advice : "don't lean over too much or you will fall down! ") as well as to the objects which are used, for example, in the early and difficult activity of piling up studs to build a tower.

To go beyond the child's experiences and intuitions in order to explore systematically the conditions of equilibrium, we selected a particular physical problem: the children have to make tightrope walkers figurines which keep their balance.

In a first phase a few tightrope walker figurines built up with simple materials are presented to the children. They are asked this initial question: Why do some of them keep their balance and some others do not? The children are given the materials so that they can build tightrope walker figurines and test whether or not they keep their balance.
Our hypothesis is that such a situation stimulates the pupils to engage in exploration, construction, reflection and argumentation ; these behaviours all contribute to the construction of the understanding and conceptualisation of new physical phenomenon.

This situation has the following features:

*Play situation.* Although this is a situation requiring the resolution of a problem with a didactic aim, our situation presents a play aspect. Let us note that it will be important to take this play aspect into account in our analyses. It refers more clearly to a play situation than to a didactic task conceived for a science lesson. Indeed, the play aspect certainly helps the pupils to engage in the concrete task of construction, but it is also likely to make it difficult for the children to mobilise their school knowledge when they try to understand the physical laws in question.

*Intriguing.* Another characteristic of the situation is its surprising aspect. It is intriguing to observe a complex object in a situation of balance when this is not necessarily expected. The difficulty for the children to anticipate with insurance which are the configurations of balance or of imbalance (because they do not understand their conditions) creates cognitive conflicts which are the sources of discussion and reflection between the pupils. In this situation, the non predictibility and uncertainty implies the awakening of curiosity. It is a good starting point to stimulate an activity of questioning and systematic experimentation of the factors concerned.

*Reflective*. The situation invites the pupils to handle simple materials to build by themselves various configurations of the the tightrope walker in balance. Finding a state of balance can be achieved by practical intelligence, by trial and error, and successive adjustments of the materials in order to obtain balance. Indeed, practical intelligence makes it possible to find balance intuitively. The activity of conceptualisation comes afterwards to account for what was obtained on the level of concrete action. From this point of view, our situation is closely related to the tasks studied by J. Piaget in the book « Réussir et comprendre » (1974).

*Complex* (implies several physical concepts). The question of equilibrium was studied in many works from a psychogenetic and didactic point of view. A series of researches uses a matematical balance or mobiles hanging from wire (in the form of a succession of balances). However, our problem distinguishes itself from the case of the mathematical balance because it does not offer a purified or a simple modelisation of a physical law (the physical moment), but proposes a concrete situation which intertwines several concepts of physics. (In this particular case : the physical moment, the center of gravity, the stable and unstable balance). This overlap of several concepts certainly makes the understanding of the problem more complex, but it might induce an investigation and a more open argumentative activity.

## 8b.3 Our didactical scenario

The aim of our scenario is to confront the pupils to the initial question: « Why does the tightrope walker keep its balance or not ? » and to invite the pupils :

- to express hypotheses
- to explore and try out the role of the variables concerned
- to discuss and to argue about their own explanations
- to develop (according to their cognitive level) a first understanding of the physical principles concerned:
  - physical moment,
  - center of mass (gravity)
  - stable/instable balance

The scenario includes the following phases:

***Phase 1: Observing and discussing***
The pupils are invited to observe a set of different tightrope walkers (that have different colours, materials, size, weight, etc.). Then the teacher selects two tightrope walkers (one that keeps its balance and one that does not) and show them to the pupils. They have to answer (orally or in writing; individually or in small groups) to the following question: « why does one of them keep its balance and the other one does not? ».
Finally, the teacher asks the pupils about the other tightrope walkers. They have to anticipate whether they will keep their balance or not and to present good reasons for their answers.

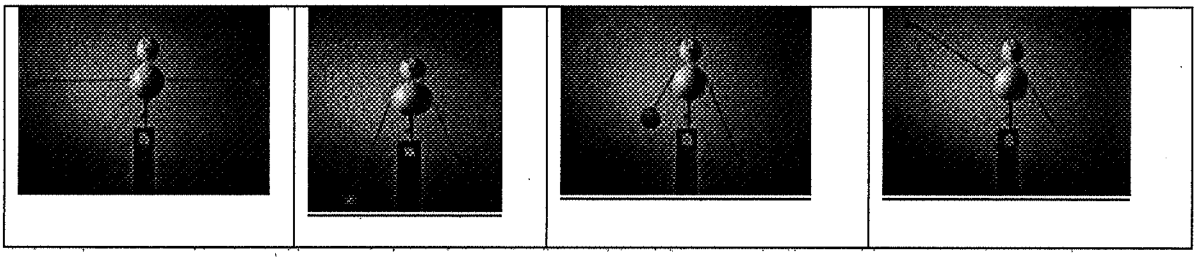
***Phase 2: Building up a tightrope walker***

The pupils have to build up a tightrope walker figurine by themselves using the materials presented (wooden or iron sticks, polystyrene or cotton wool balls, etc.). The aim is to make the man keep its balance.

***Phase 3: Evaluating the conditions of the phenomenon***

Several pictures are shown to the students. They have to anticipate orally (individually or in small groups), what will occur : « will it keep its balance or will it fall down? »

Examples of pictures:



***Phase 4: Analysing some arguments***

A set of different written arguments are presented to the students. They have to decide, in small groups, which ones are right and which ones are wrong.

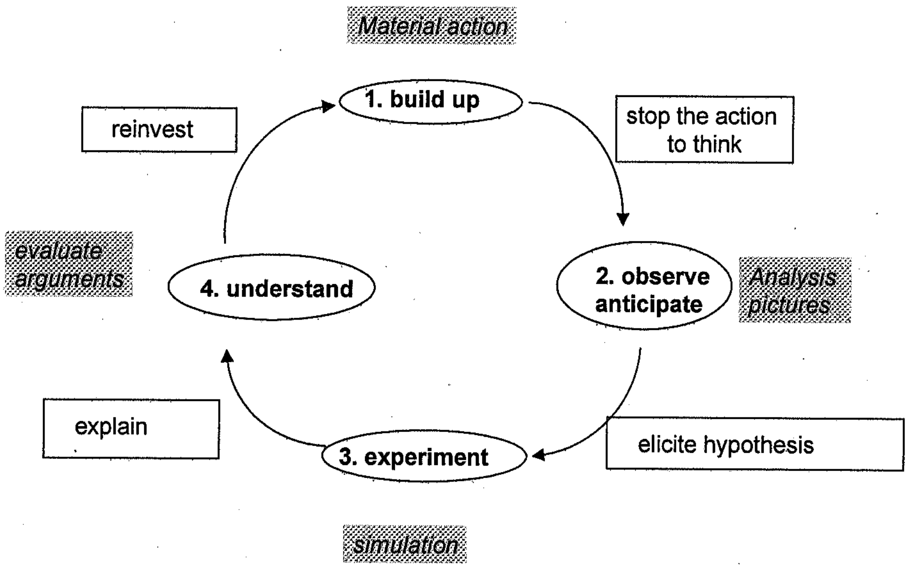
| | | | |
|---|---|---|---|
| To make the tightrope walker keep his balance, you have to… | | | |
| … put sticks which have the same length | right? | wrong? | |
| … put short sticks | | right? | wrong? |
| … tilt the sticks the same way | | right? | wrong? |
| … put weights on the extremity of the sticks | right? | wrong? | |
| … put light weights | | right? | wrong? |
| … bring the tightrope walker to a stand still | right? | wrong? | |
| … make sure that the man isn't too heavy | right? | wrong? | |
| … make sure that the man's leg isn't too short | | right? | wrong? |

***Phase 5: Collective discussion and synthesis***

Here, the aim is to answer collectively to the following questions: « What plays a role in making the man keep its balance? » and « Which are the main conditions? ». The collective discussion has to contain the following notions: gravity, forces, balance (stable/unstable).

**The « grammar» of the scenario**

Our approach aims at establishing a circular move from the concrete activity of construction to the activity of progressive conceptualisation of the problem. This sequence can be represented by the following diagram. The succession of activities and processes represents, in a way, the «grammar» of our scenario.




The scenario is also characterised by the use of multiple representations of the given problem. Indeed, on the way, several types of supports are introduced to deal with the problem of balance: material, diagram, photographs, texts, simulation of the tightrope walker on the screen.
Finally, another dimension which also structures the scenario is the alternation of the individual activities and the collective activities or activities in small group.

## 8b.4 Part 1 : Experiments Carried Out At The University Of Neuchatel

We will successively present the experiments we have completed at the Unine, starting with the exploratory experiments, that initially aimed at testing the interest and the relevance of the situation-problem we had chosen, before going on with the experimentation of a microworld allowing the simulation of a tightrope walker figurine's balance conditions.

### 1 A first exploratory experiment with children aged 8 to 15

An initial exploratory research (May-June 2006), within which the case of the tightrope walker was studied, was carried out in the context of practical work in psychology. The students engaged in this practical work had attended, during the academic year 2005-2006, a course about the ways sciences can be taught. The observations were carried out with young children who were contacted by the students. The test has been conducted with dyads composed of children and students (aged from 10 to 20). 10 dyads were observed. We insisted on the initial question: *Why does the tightrope walker figurine keep its balance or why not?*

The aim was to examine whether the situation-problem led the young learners to identify various variables which can explain balance and whether it causes the confrontation of different points of view (due to distinct centrations or to different conceptual levels).

***Observations***

During the discussion, children gave numerous kinds of explanations. Here are a few examples :

- *The sticks allow balance (8 years)*
- *If there is a stick that's longer than the other, the man leans (8 years)*
- *Because it is the same weight (9-10 years)*
- *It must be the same on both sides (9-10 years)*
- *It cannot fall down on this side because it's drawn from the other side (9-10 years)*
- *The weight must hold the man, it must always be below the man (9-10 years)*
- *That must compose an axial symmetry, both sides must be exactly the same (10 years)*
- *It is because there is the same length of both sides (11 years)*
- *He keeps his balance when it is the longest stick (11 years)*
- *There is something below which supports it (11 years)*

These spontaneous explanations appear to be:
*- more or less complex as for the relations the children referred to.*
Most of these explanations certainly refer to the equivalence of the elements on each side of the tightrope walker figurine. But when there is a weight that is heavier than the other, or a stick that is longer, the learners rarely take the multiplicative composition of these factors into account.
*- more or less explicit in their formulation of the variables involved*
*- more or less connected to prior knowledge or experiments.*
The mobilisation of prior knowledge is, for example, explicit in the statement made by a 10-year-old child: «That must compose an axial symmetry, both sides must be exactly the same». But as we will see again later, the concepts of physical moment or centre of gravity, which are part of the program of science lessons in the secondary school, are rarely spontaneously mobilised in our situation.

***Discussion***

This first exploratory experiment showed that the situation-problem we selected gives rise to interesting reactions and explanations from the children. Consequently, it seems to be a relevant material to use as part of the didactic approach of the Escalate project.

It also led us to examine a few questions about the way to guide the pupils' activity. Indeed, the dynamics of interaction and argumentation are linked to different pedagogical options:

- Same material for the dyad, or each child gets its own?
- What question should be asked to start the activity with the pupils?
- When does the adult need to stop the action of construction, in order to encourage reflection and discussion?
- What should be done with previous school knowledge that the pupils try to use?
- How should the activity be concluded? With an explicit statement? With formal knowledge?

## 2 Second exploratory experiment with a few university students

This second experiment was set up following an established fact: some psychology students who questioned children when they did practical work found it really difficult to figure out which factors govern the tightrope walker figurine's balance.

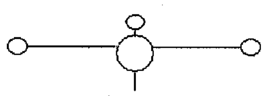
This led us to film two groups of first-year University students when they were confronted with this situation-problem. The two dyads spent 30 and 50 minutes working on it. The two discussions were transcribed.

***Observations***

For these students, the mobilisation of knowledge that was acquired during physics classes is not easy, as shown in the following extract:

(B : the professor ; A1 and A2 : the two students)

B – « What are you doing? »
A1 – « I'm just trying to put the same weight and the same length on both sides. And then see if



that holds »
B – « Intuitively, would you say that it holds? »
A1 – « Intuitively I would say yes »
B – « Why ? Can you explain me ? »
A2 – « In my opinion it doesn't hold »
A1 – « So let's see »
B – « Then wait »
A1 – « Ah all right»
B – « We'll discuss first, because there's a disagreement »
A1 – « So in your opinion, will it fall there ? »
A2 – « I would say yes, that it will fall »
A1 – « Where will it fall ? What did we say ? »
A2 – « It will fall ahead or behind »
A1 – « Why? »
A2 – « Mmh, I don't know...in fact I don't know why. I've got the impression that an inclination on the side is necessary... or rather downwards »
A1 – « Why? »
A2 – « I don't know why »
A1 – « Yes... »
B – « And you, why are you saying that it'll hold ? »
A1 – « That's true, why am I saying that it'll hold ? It's muddling me. Why am I saying that it'll hold ?...The social representation, it's the tightrope walker, it's got two poles»
B – « It's an argument, then you can try to make it hold »
[The tightrope walker falls down]
A1 – « Oh no, that doesn't hold »
B – « Yes, but how can you explain that ? Because a human acrobat would keep his balance. What do we need to take into account ? Maybe this is something we can talk about »
A2 – « The angle. The angle must be tilted towards the bottom»
A1 – « Ah yes, it's interesting. Why ? »
A2 – « I don't know, it's as if... how can I say... »

When the students are invited to use concepts of physics such as the centre of gravity, they turn to them, but with difficulty:

B – « Are there some concepts that come to your mind ? »
A1 – « Yes of course, firstly, the centre of gravity »
B – « Could you explain me a bit ? »
A1 – « Yes, so, first we have the centre of gravity. By definition, the centre of gravity, it's the place on the object that, if someone puts his finger on it, it must keep its balance ».

A2 – « But here [when the tightrope walker figurine keeps its balance], where is the centre of gravity ? Is it in the middle ? »
A1 – « Yes, but if there wasn't this pole [the foot] and if you held it there [where the foot is], it would still keep its balance »
A2 – « So it's in the middle of its belly ? »
A1 – « Yes, it's in the south pole in fact »
A2 – « Say, on this line [vertical line which goes through the center of the man] »
A1 – « Yes, I would say, in the south pole ».

It appeared several times that for these students, the center of gravity cannot be conceived outside the material object. In this situation, the students are confronted with a complex object and not with a simple solid one (sphere or cube), as it is usually the case when in class the teacher introduces the pupils to the concept of centre of gravity. In this situation, the concept is not a noperational. Refering to the human body, these same students will insist several times on the fact that the center of gravity is situated where the navel is.
The observations of students, who are older than the population first chosen (12-15 year-old children), proved to be extremely useful for understanding the dynamics of mobilisation of previous knowledge acquired during the science lessons or by everyday experience.

After learning much from the two exploratory experiments, we felt ready to leave the « laboratory » to test our scenario in a real school situation, with a secondary degree class.

## 3 Experiment in a science class at the secondary school

### The context

The scenario was tested in a secondary degree class (13-14 year-old pupils) in La Chaux-de-Fonds. The experimentation was carried out during a chemistry course (2x 2 lessons). The teacher, who was interested in the project and who agreed to let her class be tested, was found through personal contacts. As Lea Oswald, the collaborator who carried this experiment out, said: « This was carried out thanks to people I knew from my personal network. I first contacted a friend of mine, also a teacher, in December 2006. As he did not have enough time for the experiment, he proposed me to contact a friend of him, who teaches in the same college. I met the teacher, Christelle Gertsch, in February 2007 and we decided on a date, in March 2007, to carry out the experiment ».

Before carrying out the experiment, we needed to ask for the pupils' parents' autorisation through the teacher. All the parents answered positively. It was also necessary to contact, again through the teacher, the director of the college, who granted permission. Finally, we asked the steering committee of the obligatory school of the canton of Neuchâtel for permission.

The experiment was carried out on the 27th and 30th of March 2007, during the time usually spent for chemistry courses. The class (20 pupils) was divided into two groups of 10 pupils. The first group was filmed on Tuesday morning (27th of March) over two 45-minute periods (from 10am to 11.40am). The second group was filmed on Friday afternoon (30th of March) also over two 45-minute periods (from 1.45pm to 3.20pm).

The scenario that we presented to the teacher was accurately followed and besides, she made a few contributions. Firstly, she added a gap text that the pupils had to fill in at the end of the experiment, and secondly, she gave an explanatory and more theoretical card on the phenomenon of balance in order to end the lessons with a temporary conclusive synthesis.

***Observations***

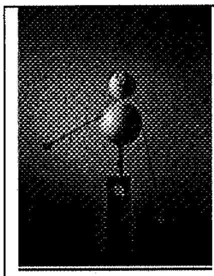
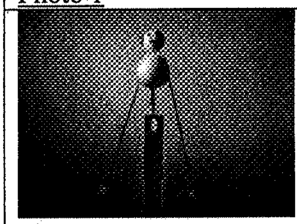
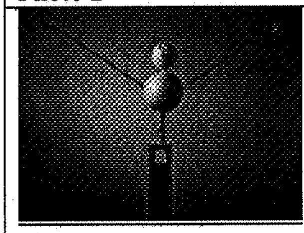
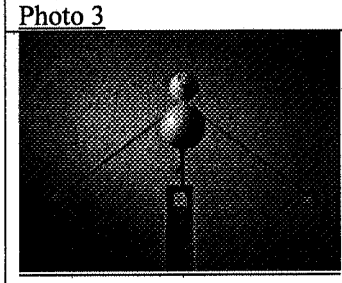
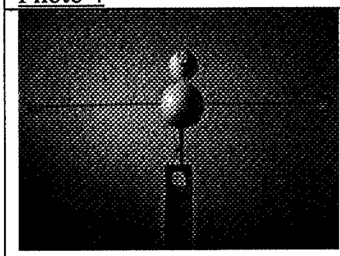
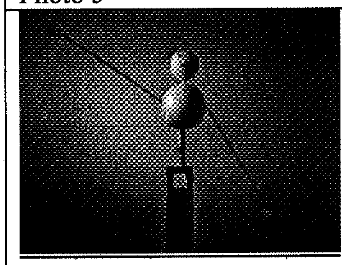
We will now go back to the various phases of the scenario. We will repeat, for each phase, the activity which has been carried out and we will note down the main observations.

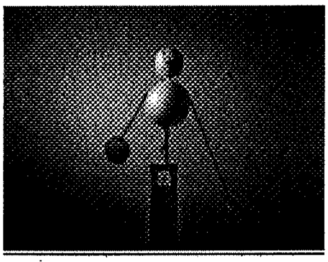
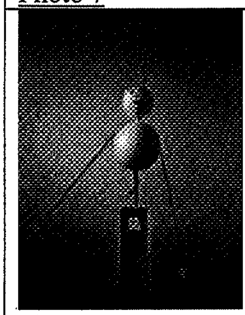
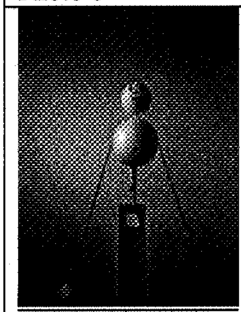
*First stage : Will it keep its balance or not ?*
The teacher presents two tightrope walkers to the class (one which will keep its balance and one which will not) and ask the pupils to predict what will happen. The pupils do not all have the same opinion. Indeed, half of them think the figurine with short and horizontal arms will keep its balance, the other half think the figurine with long and vertical arms will keep its balance. Then, the teacher demonstrates the tests : it is the latter figurine that keeps its balance.

*Second stage: construction of a tightrope walker figurine in small groups of 2 or 3 pupils*
The pupils are invited to build tightrope walker figurines with the available materials (each child gets a tightrope walker figurine and many arms having different lengths).
Often at the first attempt, the pupils manage to make a tightrope walker figurine keep its balance by imitating the figurine presented by the teacher at the first stage. The teacher encourages them to try new configurations (« there are several ways to ensure that it maintains its balance »).The pupils encounter many difficulties in describing what they are trying to achieve : they can identify a few factors, but it is hard to explain why these are important. There is not much discussion between the pupils (perhaps due to tiredness at the end of the week ?). Nevertheless, they try several configurations.

*Third stage : Picture analysis*
Each group receives pictures and the pupils then have to determine whether the tightrope walker figurines could keep their balance or not. They talk together and then write down their arguments on a piece of paper.
Some pictures do not pose any problems, whereas others are the subject of disagreements between the pupils. Several arguments are then formulated and confronted.
Various factors emerge (weight, length, the angle), without reaching collective agreement.
The pupils also have difficulty in combining the factors with one another and explaining why some factors are important in some situations. In order to make the arguments proposed by the pupils more visible, the teacher writes them on the blackboard.

The following arguments were noted down :

| | |
|---|---|
|  Photo 1 | « the weight is not balanced and the sticks are not put the same way » « the weights are uneven and the figurine does not keep its balance » « No, the stick is longer and heavier on the right » |
|  Photo 2 | « Yes, it keeps its balance because the weights are equal, are at the same place on each side and are directed downwards » « Yes, it keeps its balance because the weights are equal and situated at the same height » « Yes because the arms point downwards » |
|  Photo 3 | « No because the arms point upwards and it is more difficult to find stability » « No, because the arms are pointing upwards and this makes it more difficult to find balance » « It is not balanced because there is no weight at the bottom » |
|  Photo 4 | « It does not keep its balance because the weights are too light » « It is not balanced because the weight of the sticks are too light compared to the one of the body » « No, the sticks are too far from the foot and they are too high » |
|  Photo 5 | « No, because it's too long » « No, because the weights are in the middle of the body » « No, it doesn't keep its balance because the weights are in the middle of the body» « No, because the arms are too long and too heavy compared to the body » |
|  Photo 6 | « I think it doesn't keep its balance because of the inclination of one arm downwards and of the other upwards» « I don't think so, because one arm points upwards and the other one downwards » |

| | |
|---|---|
| <br>Photo 7 | « Yes, because the weight is equal, a bit larger and thinner on one side and a bit smaller and longer on the other »<br>« No, because neither the weights are similar nor the lengths»<br>« No, because they have neither the same weight nor the same length » |
| <br>Photo 8 | « No, it is the same length, but not the same position »<br>« No, there are the same weights but they are not positioned at the same place »<br>« Not, the weights are the same but they are not correctly distributed » |
| <br>Photo 9 | « Yes, because there are big differences »<br>« Yes, I think it keeps its balance because the weight isn't much different »<br>« It is balanced, because the arms are close to the small wooden stick (the foot) » |

*Fourth stage :True or false arguments*

The pupils in groups receive a sheet containing a list of arguments. They must determine whether, in their opinion, they are true or false. The pupils try to reach agreement and to combine the different factors that play a role. But they always have some trouble explaining why and when the factors are important.

To make the tightrope walker figurine keep its balance, you have to…

| | Right | Right and wrong | Wrong |
|---|---|---|---|
| … put sticks having the same length | 10 | | 8 |
| … put short sticks | 4 | | 14 |
| … bend the sticks so that they both form the same angle | 9 | 4 | 5 |
| … put weights on both extremities of the sticks | 7 | 1 | 10 |
| … put light weights | | | 18 |
| … bring the figurine to a standstill | 14 | 1 | 3 |
| … make sure that the man isn't too heavy | 4 | | 14 |
| … make sure that the man's leg isn't too short | 4 | | 14 |

Then, the teacher examines each argument again in a collective discussion with the pupils.

*Fifth stage : Introduction to the concept of centre of gravity*

The teacher introduces the concept of center of gravity and establishes a connection with what the pupils have noticed while building the tightrope walker figurine. The pupils are then invited to individually fill in a sheet in order to write down the main factors involved in keeping the tightrope walker figurine's balance.

In conclusion, the teacher gives a synthesis of what was treated about balance by repeating the arguments previously formulated and written down on the blackboard. A new discussion is opened in order to bring clarifications. Finally, the pupils are invited to evaluate the lesson and its structure.

## 5 Test of a microworld

In this part, we will present the realisation of a microworld designed to facilitate the systematic experimentation of the variables involved in keeping the tightrope walker figurine's balance. We will first describe the model that was initially designed with the modifications we made after a first experimentation with students.

***The model of the tightrope walker***

The model was designed using simple means. In fact, the tightrope walker has been drawn with the turtle mode in a Logo system (Starlogo). A few parameters are adjustable with cursors and others appear as variables that can be modified using the Logo code. The outline of the « man » (figure 1) is simply a segment and a circle on top. The pole (srtick) is composed of two joined segments that constitute a 90° angle (fracture angle). There are circles on both ends. A small dot represents the rope and another the man's gravity center.

The parameters that can be ajusted with a cursor are :

- The orientation of the pole in relation to the body of the tightrope walker (abar)
- The length of the sticks (the lengths are the same) (ldb)
- The weights on the left and on the right (pdg, pdd)

The other parameters are (figure 2) :

- The man's weight (pdf)
- The man's height (long)
- The height of the pole center (hbr)
- **Fracture angle**

There are two more boolean variables, one (shCG) which indicates if the gravity center of the system is systematically indicated ; another (delOld) which allows or prevents the user from deleting the previous tightrope walker's position once the parameters have been changed.

**Three buttons can be used to display the model on the screen :**

- setup **draws the tightrope walker taking the values of the variables into account. But this button keeps the tightrope walker in a vertical position.**
- movef **sets the tightrope walker in a balanced position (figure 2). In this model, we suppose that the man's feet are fastened to the cable.**
- myst **draws the gravity center when it is not systematically displayed by the boolean variable as it is supposed to do so.**

A fourth button should allow uninterrupted modification, but the operation is difficult to present in this drawing mode.

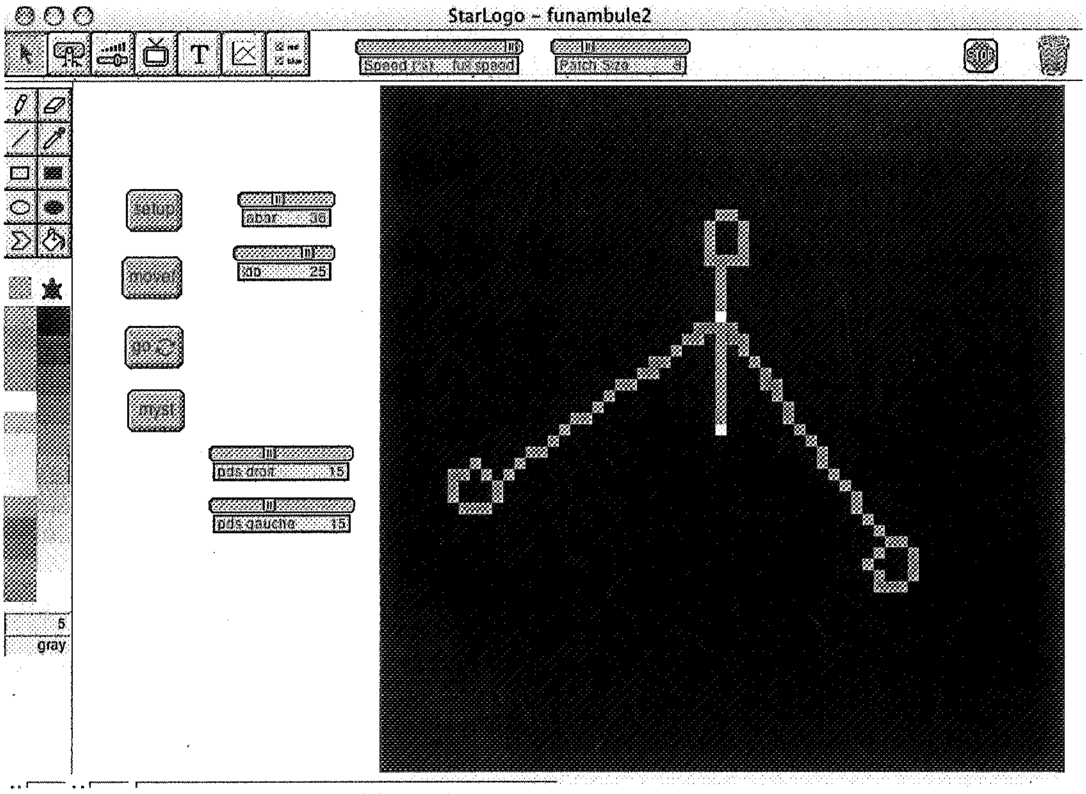



*fig 1. The tightrope walker and his pole*

Observations of the use of this model by two pairs of students, who had had the opportunity to study a «real» tightrope walker made of needles, corks and polystyrene balls, were made.

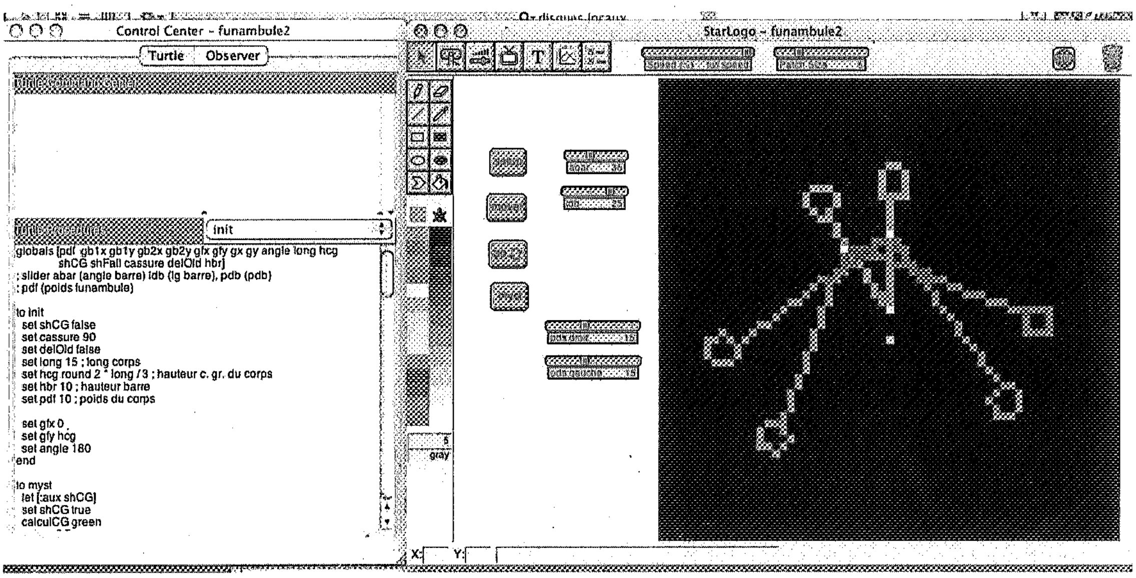



*fig 2. The tightrope walker in a position of equilibrium*

## First observation

The task proposed to the two students remains relatively imprecise : they have to explore the device through handling, which is conducted by one of the two students.

The first critical remark is about the representation. Indeed, the students, influenced by the experimentation with a « real » tightrope walker figurine, encounter trouble in representing the phenomenon in two dimensions. Influenced by the dimension effect, they seem to see the tightrope walker leaning ahead.

Suddenly, their requests refer to the access to an unexisting variable in the form of a cursor: fracture angle (with the idea of placing the pole horizontally). They also refer to the possibility of varying the length of the two poles independently.

We noticed that the modification of the variables without the cursor is not very practical. Indeed, after each change, a compilation is necessary which hinders reflexion. However, this problem should be discussed in relation to the possibilities that the learners partly master the Logo code.

They would also appreciate if they could modify the position of the pole directly with the mouse. This idea of this direct modification will be realised in the second model, while keeping the cursors which concretely represents the value of a parameter.

Another suggestion resulting from this first experimentation is about the possibility of keeping the parameters values in an automatic way and of connecting them to the picture that was obtained. Moreover, according to the experimenters it is an advantage that the simulation on the computer could allow.

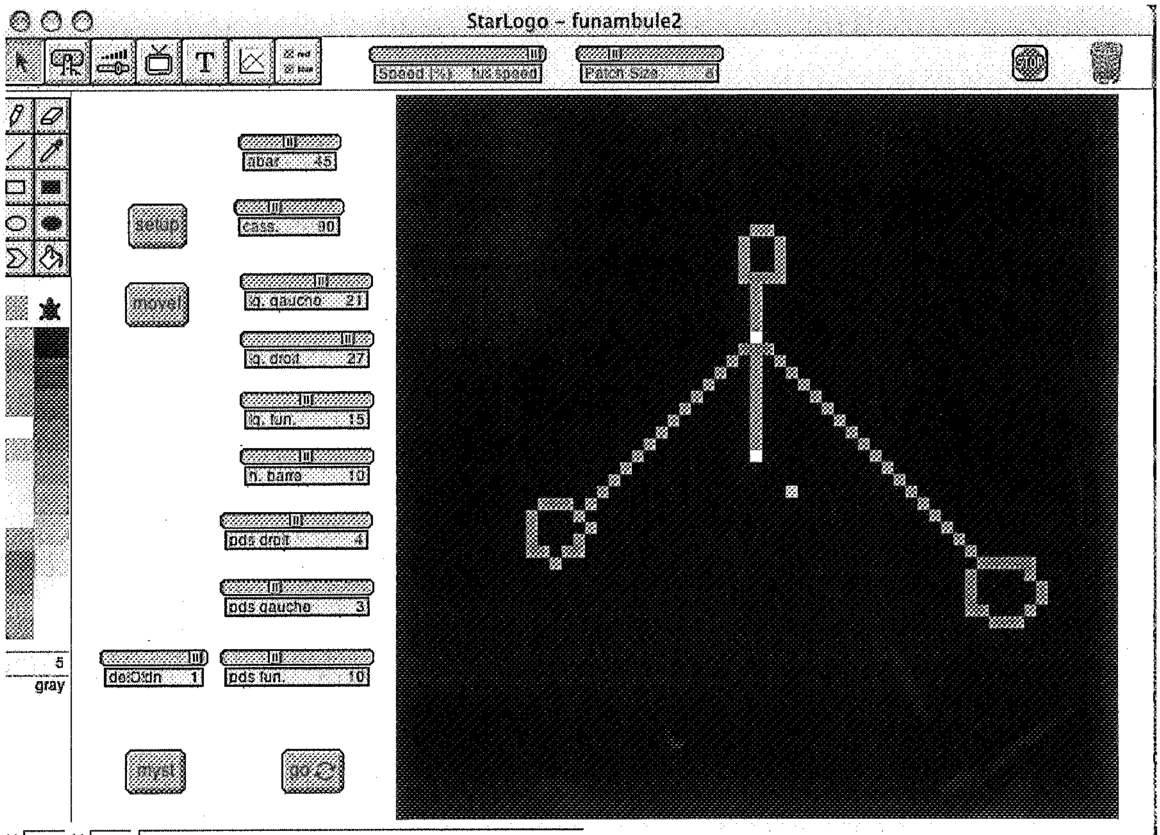



*fig 3. Second version of the model*

At the beginning, the predictions about the final position of the figure are erroneous. The experimenters think that if they tilt the left pole to the left, then the tightrope walker will tilt to the same side. The source of this misconception should be examined : is it the effect of representation or is it caused by the confusion due to a dynamic problem (like taking a run-up ).

The concept of center of gravity is never used spontaneously during the experimentation. The students seem to ignore it when the observers refer to the concept. This aspect will also be discussed.

**Second observation**

Here, all the variables, including the possibility of adjusting the left and right poles independently, appear in the form of cursors (figures 3 and 4).

The task remains imprecise, but this time the students can handle the system directly. They first shyly attempt to explore the values of a few parameters. In a normal situation, the students would have been less intimidated and they could probably have worked more easily.

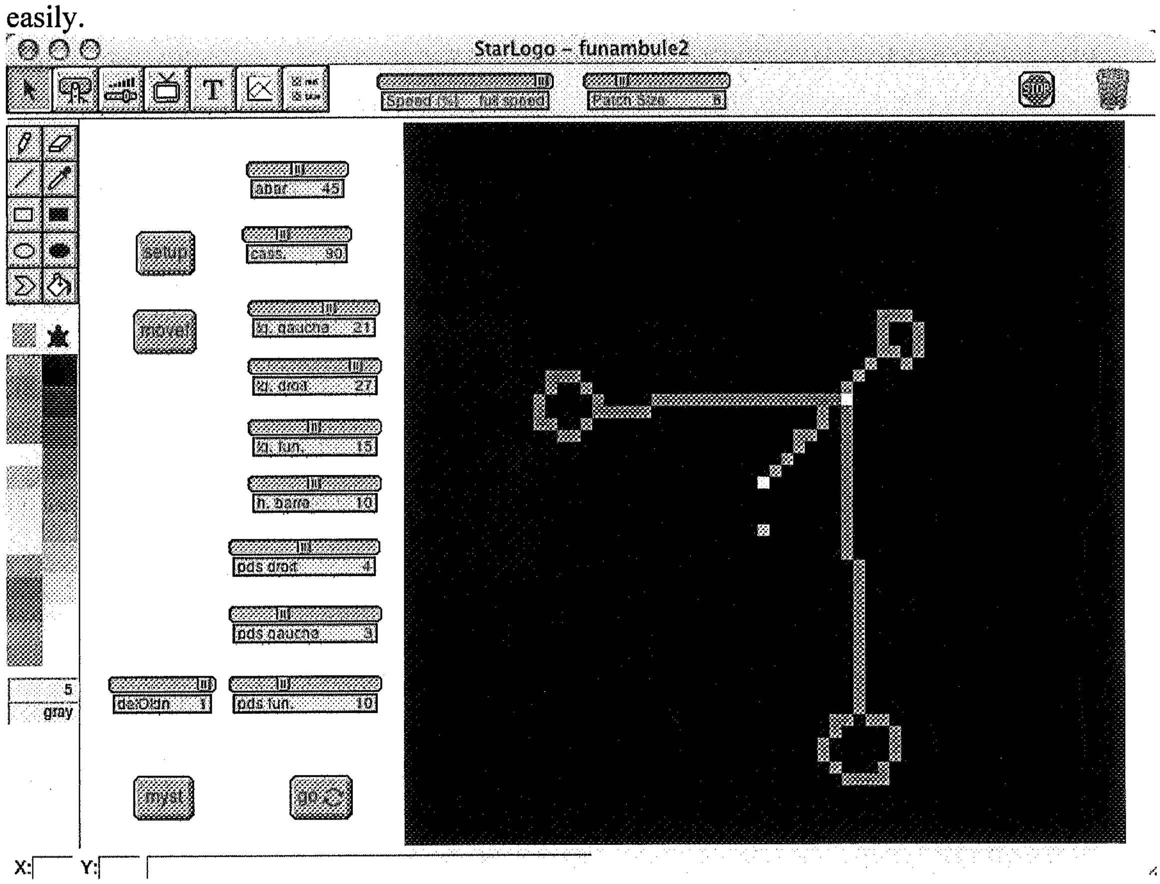



*fig 4. In a position of equilibrium*

The auxiliary hypothesis about attaching the man's feet to the rope gives rise to many discussions about the precise time when the man falls and referring to a physical model in order to check out that the man can lean without falling down.

The idea of center of gravity is mentioned by the students, which gives us the opportunity to present how to display it by operating a sequence which is becoming increasingly automatic: the modification of the parameters (setup, myst, movef, myst). However, the role of the centre of gravity seems to remain mysterious and the students have many difficulties in understanding it because it can be situated outside the object.

A relatively long discussion takes place about the problem around the precision of simulation, as, for example, when the center of gravity is too close to the rope and it does not seem to pivot from the same angle as the rest of the device.

**A new model**

In theory, the device can easily be transferred to any other Logo environment. It was planned to include this version in E-slate using the Logo and Turtle components of this system and taking advantage of the Spreadsheet components to record the successive parameters according to the suggestion of the first students. Thus, several simulations connected to the same project would be available in the same E-slate environment. However, this adaptation will not be available until a technical problem, which seems to occur with the Turtle component in the system version, has been solved.

Another improvement would consist of decreasing the degree of schematisation and of proposing a model more similar to the guiding principles by using a more sophisticated environment than a simple drawing. E-slate contains the « Stage » component which makes it possible to handle shapes representing certain objects and to alter their features (like speed, weight, etc). However, the use of these agents remains a perplexing problem and additional programming in « supervision » mode will remain necessary. This point will be discussed farther.

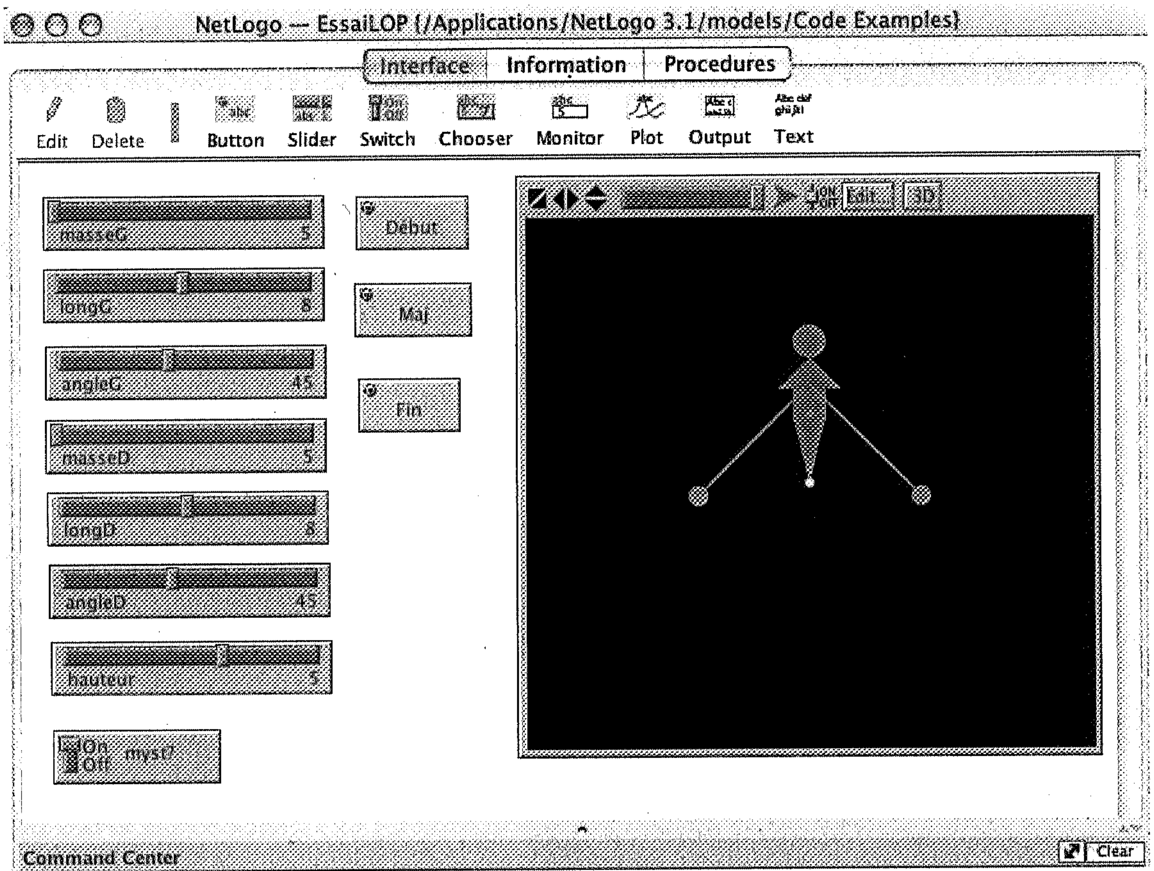



*fig 5. After « Début » : The tightrope walker appears with parameters by «default »*

Unfortunately, it seems that E-slate does not yet allow the forms to be editted, that permits the multiplication of properties that are associated to them (for example, it does not seem possible to give an object the property to be swivelled. The new simulation was thus developed in the NetLogo environment. The model takes the two observations, that were carried out, into account.

The new representation appears on figure 5. It is composed of four objects (agents) : the man, the left and right parts of the pole[9] and the rope. The first three parts have a « center[10] » which is marked. As for the parameters of the pole (the fracture angle and its position compared to the man) which were not « natural », they were replaced by the angle formed between each pole and the man. The button « Début » displays the tightrope walker, the button « Maj » makes the representation conform with the parameters (in a vertical position) (figure 6) and « Fin » (renamed « Pos. Fin ») displays the tightrope walker in position of equilibrium (figure 7). It can be noted that the use of the « switch » can both allow or disallow the display of the center of gravity.

Then a button was added, « Pos. Cont. », which allows the tightrope walker to progressively modify its position of equilibrium as the parameters are modified (figure 8). This partly corresponds to the first experimenters' requests.

9 In fact, the pole is composed of two objects : the stick and the ball, which the programm has to maintain bound together. NetLogo gives the possibility to bind objects, but this is still at the experimental stage and it should be used later.

10 « Natural » centre of gravity which corresponds, in an intuitive perception, to a geometric centre.

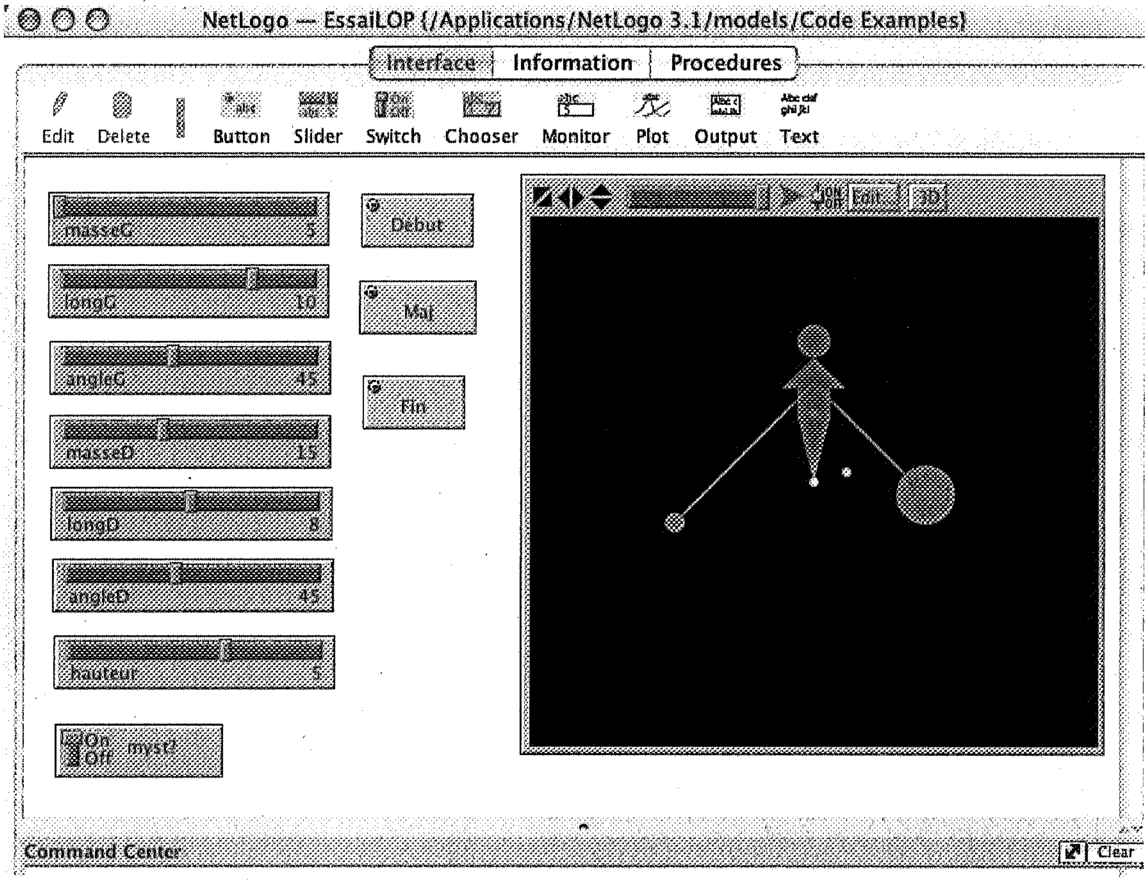



*fig 6. After « Maj », the repreentation is modified according to the parameters.*

The small environment of the tightrope walker permits to give examples of the characteristics of a simulation. First of all, it is obvious that the system has its own time. Furthermor, the « time » factor is omitted if both buttons « Maj » and « Pos. Fin » are used. Openess degree is typical of the systems based on Logo and mainly depends on its practical use and on the teacher's or learner's degree of language control.

The degree of schematisation is low, the model is more analogical than structural, particularly in the second version, which allows the continuous rotation of the tightrope walker around its fixed point as the parameters are progressively modified.

Level of modeling : modeling is on an intermediate level. The tightrope walker's position depends on the centre of gravity of the system. A more primitive modeling (based on basic concepts) would only apply the center of gravity and the laws of attraction to simple object. A more sophisticated modeling would calculate the position of the tightrope walker directly, without using the centre of gravity which would emerge from the laws of attraction and equilibrium.

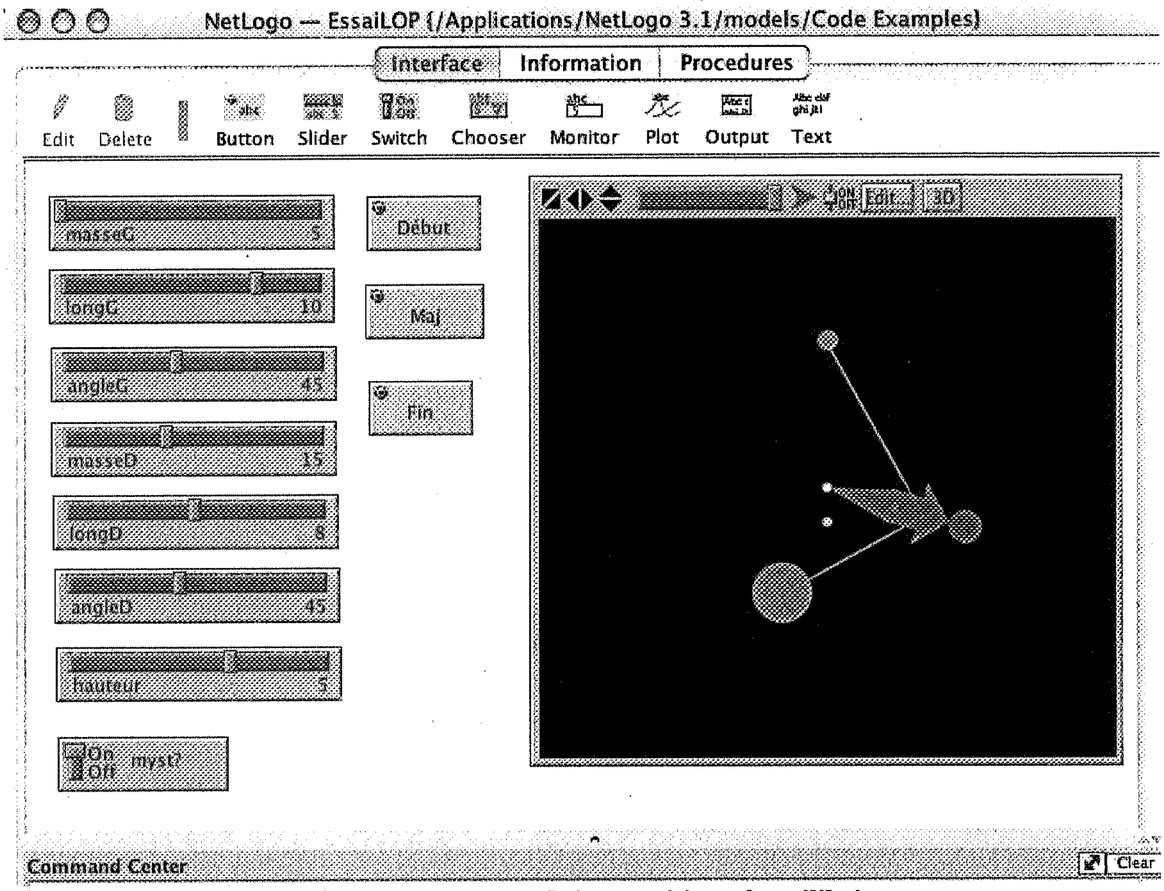



**fig 7. After « Fin », the tightrope walker stands in a position of equilibrium.**

In the first simulation, the programming is fully done in the supervision mode, there are no other agents besides the « turtle » ; the observer supervises everything. In the second case, other agents are included (some are mass bodies, others are centers of gravity to which the weights are linked ; others are objects whose characteristic is the measurement). However, the whole system is controlled by the external observer. The concept of the center of gravity of a heterogeneous object is also introduced. The agents do not have many interactions (except when the sticks are lengthened, then the adjacent balls are moved away from each other[11]). A more basic modeling would introduce an additional agent, the earth, and the laws of attraction. In this case, the center of gravity of a heterogeneous body would be indicated by the system.

**Discussion**

The new model still remains to be tested. If, as a generic task, the students have to explain (to predict) the position of the tightrope walker according to the parameters involved (to predict whether it will keep its balance on the rope or not), then it is possible to outline a prior analysis (from a didactic point of view) based on the two observations that were carried out.

First of all, the device will have to take into account the knowledge the experimenters have in physics (center of gravity). Then it will be possible to distinguish three stages in

[11] The NetLogo experimental device (3.1), which makes it possible to « **substantially** » define relations between the agents, is not used. It would, however, make the programming of the entire system easier ; for example the rotation of an agent would cause the rotation of the whole.

the resolution of the task.The stages would correspond to three levels of knowledge the experimenters might have about physics (the center of gravity is outside their ZPD, the center of gravity is in their ZPD, a pevious knowledge of the center of gravity exists).

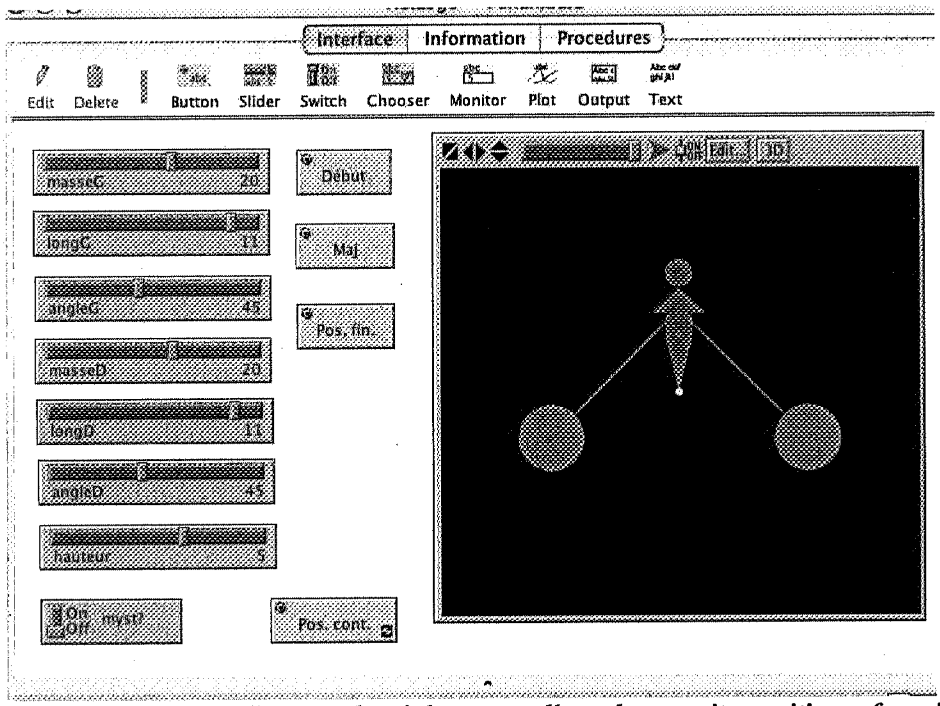



*fig 8. With « Pos. Cont. », the tightrope walker changes its position of equilibrium as the parameters are modified*

1) The first phase is planned for the students who do not understand what the center of gravity is. The first group was almost in this situation. In this case, the tightrope walker should be replaced by simpler, monolithic objects. The predictions will first be about extreme cases. It is not unlikely that the centre of gravity will be perceived like a geometrical center. Balance will be perceived as a result from a distribution of the forms rather than of the masses. Simple three-dimensional handling and constructions on a piece of paper should be added to this « construction » before starting the following stages.
2) The students having heard about the concept of center of gravity (this is the case of the second group), should establish a link between the representation on screen and in reality, note that the model represents the case of the « real » tightrope walker very well, i.e many « facets » (Tiberghien) of the model correspond to reality. The task would consist of « building » the center of gravity of a composite system. We can suppose that if the experimenters alternate the « predictions » (that can be checked with the « Pos. Fin » button) with the simulations (« Pos. cont. »), they will manage to find an « abstract » center of gravity (outside the body) which will help them to efficiently predict the position of the tightrope walker.
3) When the concept of center of gravity is familiar to the students, it is probably more interesting for them to build a part of the simulation. The technical parts would be provided. The task would consist of finding the function which would calculate the position of the center of gravity as well as the procedures necessary to find equilibrium. In the context of a real classroom, in order to justify spending time in learning the language, several works should be planned in the same environment.

## 8b.5 Part 2 : Experiments Carried Out At The Alta Scuola Pedagogica (Locarno)

We will present here a synthesis of the works carried out at the Alta Scuola Pedagogica of Locarno. This graduate school is in charge of the teachers' training in the canton of Tessin. The vice-director, Giorgio Häusermann, is strongly involved in the field of science teaching. More precisely, he organises diverses activities aiming to awake interest and curiosity about sciences. He has collect an amazing set of toys which intrigue the children. These toys were selected and gathered because they demonstrate various physical phenomenons such as force, energy, light, magnetism, floating or balance.

The question of equilibrium appeared to be the best topic allowing the group of Neuchâtel and the group of Locarno to collaborate on the Escalate project. We decided that the Alta Scuola Pedagogica would examine how the observations and discussions, around the toys especially designed to allow the children's awakening of scientific curiosity, can give rise to spaces of investigation and argumentation, according to the objectives of ESCALATE, as well as to opportunities for formulating the acquired knowledge.

The case of the tightrope walker was so integrated into a pedagogical approach which is characterised by a broad approach of the topic of equilibrium.

During the school year 2006-2007, an experimentation was carried out in a primary school in Locarno, with a year 4 class. The experiment was the subject of a detailed report[12]. It was conducted during 5 lessons that were planned from September 2006 to April 2007.

**First lesson : Body equilibrium**

This first lesson aims at intriguing the pupils and at arousing their curiosity about the problem of balance: What does « balanced » mean? The pupils' interest arouses from their own experience. What does happen when someone loses their balance? The aim of this first stage is to create a climate in which a discussion and reflexion about the problem of equilibrium can take place.

Thus, the pupils are invited to walk on a straight line drawn on the ground. Do they manage to walk on the line with the arms against the body or with the arms spread wide ? While balancing a heavy bag in both hands ? blindfolded ? Or while wearing distorting glasses? After carrying out these practical and perceptive experiments, the pupils are invited to formulate hypotheses : What facilitates the state of equilibrium ? What makes it difficult in each situation that was tested?

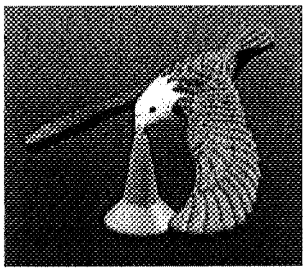
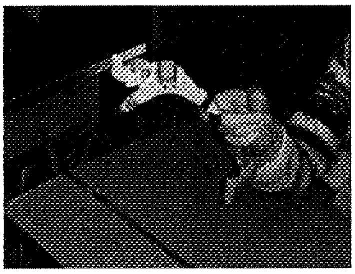
The disusssion allows the children to identify the main factors which play a role in each situation that was tested (such as concentration, the arms being wide spread, the case of looking straight ahead or looking down). The lesson goes on with the presentation of several toys which shows various balancing acts (the loose rope ; the tightrope walker; a ball with a suction pad that adheres to the window pane; three ropes tied to a ring on which it is pulled in three directions; spinning tops).

12 http://did-asp.ti-edu.ch/~giorgioh/liv2/rapportoaprileescalatehtm.htm

The pupils write down their observations and explanations. Almost each child writes something different. An object's balance is often considered as static phenomenon, without taking the role of the movement into account (as for example in the case of the spinning top or the bicycle). During the week, the pupils are invited to continue their exploration and observation inspired by these various toys.

**Second lesson : the toys in position of equilibrium**

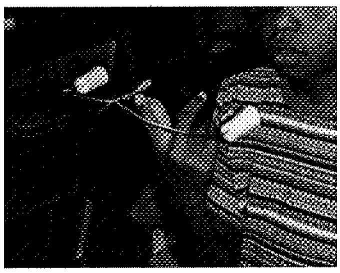
New situations of balance are presented to the pupils. The first one shows magnets attracting the pages of a diary up in the air. Two tightrope walker figurines cycle on a rope without losing their balance (one man is holding two counterweights, the other one is holding only one counterweight at the center). Then the pupils discover two more toys in balance: a bird standing on its beak and an elephant.

When explaining how the bird keeps its balance, some of the pupils, on one hand, mention the role that the weight of each wing plays. Some pupils, on the other hand, first formulate the hypothesis that it is the pointed beak of the bird that allows it to keep its balance.

**Third lesson : building up a bird in a position of equilibrium**

The aim of this lesson is to model a bird in a balanced position from simple materials. What shape does it require ? When does it keep its balance and when does it not?
At the beginning, the children find the task a little difficult. Indeed, they do not know how to start. But two pupils found a solution and this was enough to motivate the others to continue their researches and tests. The children have trouble cutting the wire, because it is thick metal. But in the end, almost all the pupils (except one) succeed in making the bird maintain its balance on the tip of its beak. They also managed to colour the bird the way they prefered it.



During the discussion, that takes place after this phase of construction, it appears that the activity was an opportunity for the children to reflect on the distribution of the weight of their bird and the arrangement of the wings (which must be placed beyond the head) in order to obtain a position of balance.

**Fourth lesson : tests of knowledge and construction of the tightrope walker figurine**

This lesson takes place more than three months after the previous lessons. It is a good reason to check what the pupils learned from the previous activities. They are thus asked a series of questions on the following topics :
- directions and perceptions which play a role in the balance of the body;
- a list of true or false arguments that keep the tightrope walker's balance ;
- analysis of drawings representing tightrope walkers : could they keep their balance or not ?
- the position of balance or unbalance of a mathematical balance according to the distribution of the weights.

After these four tests, which serve as a revision of the observations that were conducted during the previous lessons, the pupils are invited to build a tightrope walker in small groups. The objective is to observe how the children reinvest, in a concrete task, the knowledge acquired during the previous experiments.

In this construction task, the pupils have a real enthusiasm and are fully involved in the search for solutions. At the beginning, the construction has caused a few practical problems. Indeed, it is difficult to put the available materials together, but finally, all the pupils manage to build a tightrope walker in balance. This phase of construction gives rise to relevant discussions within the groups.

**Fifth lesson : balance and floating**

The objective of the last lesson is to explore another aspect of balance, that is, immersion of various solids in a liquid. Why do some objects float, why do some others sink to the bottom of the container, and why do others remain between these two states (neither floating nor sinking) ?. The first topic of this lesson is about the floating body, which leads several pupils to the subject of the role that the air plays in the lungs.

As for the various objects that are successively immersed in the liquid, the pupils refer to the weight of the objects to explain why they are floating. The activity allows the children to discover the concept of density. Indeed, the pupils are encouraged to pay attention to the weight of an object in relation to an equivalent volume of liquid.

## 8b.6 Conclusion

We chose a relatively complex topic about physical equilibrium with the intend to simultaneously promote an activity of experimentation and an activity of reflexion and argumentation. Are these activities relevant from a pedagogical point of view, are they a source of new understanding ? After conducting experiments in several contexts, we can summarised the main observation:

The construction and the observation of a tightrope walker figurine is a didactic activity which, beyond all expectations, appears to be relevant at various ages (experimenters were aged 8 to 20!). The youngest children confronted with this task attempt to identify the factors involved, using their intuitions and their own experiments about balance. For the oldest, the problem is different. Indeed, it is, for them, an opportunity to use, not without trouble, the knowledge acquired during previous science lessons in order to elaborate a model (an explanation) of the situation of equilibrium.

The first simulation tests carried out with the computer prove to be extremely interesting in the process of modifying the times of action and times of reflexion. Simulation requires several variables and commands that are defined or still need to be built. This seems to slow down, at least at the beginning, the activity of handling ( it takes some time to become familiarised with the required software). Experiments need to be continued in order to determine when the computer-mediated activity becomes profitable in comparison with the concrete activity, in particular because it allows the user to quickly change the parameters and to observe the effects.

## 8b.7 Recommendations

To exploit this didactical scenario, the time necessary for handling, reflecting and discussing the observations with the pupils is not to underestimated. For instance, the time necessary to explore and then control the microword, in order to use it efficiently, was underestimated. A 45-minute sequence is obviously too short. The microworld requires some time before it becomes familiar and thus profitable.

Two didactic strategies appears to be particularly profitable: the first consists in asking the pupils to comment on a list of true or false arguments about balance, the second consists in asking them to tell whether tightrope walkers drawn on pieces of paper would be likely to keep their balance. In some situations there is a general agreement and all the pupils share the same opinion. But in some cases, their opinions are different and their answers are sometimes contradictory. The aid of an argumentative map would be here specially useful to structure the discussion.

## 8b.8 Perspective

Developing and experimenting our didactic scenario as part of the ESCALATE project, we have opened a field of research which will be continued during the school year 2007-2008 and undoubtedly later on in several forms. At the Alta Scuola Pedagogica, Giorgio Haüsermann will make use of the ESCALATE research in order to offer a continuous training course on the teaching of sciences. At the Unine, Jean-François Perret and Luc-Olivier Pochon will continue to experiment some didactical scenario and simulation tools with advanced students as part of the Masters Degree in « Psychology and Education ».