SWITCHING FROM EVERYDAY FACTS TO SCIENTIFIC THINKING

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1. Introduction

First year physics is not the same for all freshmen. Certainly each curriculum assigns a relative importance to this subject, and the physics content is selected because of its relevance to attain the desired goals. In engineering courses and other technological careers physics plays a subordinate role. Physics knowledge is directed to practical applications, often without time enough to foster a deep understanding. Therefore, the teacher is usually under time pressure to cover a great amount of content and to provide the students with a repertoire of skills. Besides it, lectures prevail in universities with large enrolment; despite the fact that many other teaching strategies are considered more effective. So, plain lectures to large groups are programmed, but there is still little research on the communicative skills used by teachers in their lectures.

The aim of this pilot study was to investigate the processes by which the scientific knowledge is presented to students attending lectures, and how formalisation is intended using a multi-representational discourse. In short, our focus was on communicative processes in lectures.

2. Background

Language has been seen as a full medium to give adequate expression for everything that needs to be expressed. Some efforts have been made to explain how written and spoken language are used to give accurate descriptions of physical phenomena (Talmy, 2000). But written and spoken language is not enough in the classroom. A better approach to language awareness has forced to look at language as a multiplicity of quite distinct semiotic resources (Kress et al, 1998). Therefore, when teachers try to communicate scientific concepts and processes to their students, they need to use other resources as gestures, drawings, graphs and equations that contribute to give adequate expression to their explanations (Lemke, 1998; Jewitt et al, 2000). The use of this multi-representational discourse (van Dijk, 1985) in scientific explanations must be directed to make the subject matter more accessible, understandable and manageable to students.

There are differences between the language used by the scientific community and the language used in teaching physics. Thematic patterns to be taught are not original because they must be construed with reference to accepted science knowledge. In consequence physics teaching requires a careful analysis of the subject matter, to produce a versioned form adapted for teaching in a given level (Ogborn et al, 1996). That is, a didactic transposition. As a result of such transformation, linguistic and other symbolic resources used by physicists to construct entities, processes, states, relations and outcomes (Ochs et al, 1996) are reviewed, restructured, and fashioned in a suitable form to promote learning. When teachers teach an inverse process is used: everyday facts and previous knowledge are invoked to re-build scientific knowledge in a coherent way from the students’ point of view.

In this work we focussed on the meaning-making process supported by the teacher in a current lecture on physics. Using the results of the analysis, we tried to identify both semantic relationships established along the lecture and summarise the thematic patterns built by the teacher through his multi-representational discourse.

3. Method

From the ontological point of view we were interested in teaching as it occurs in natural settings. So we adopted a qualitative approach to carry out a case study addressed to a deep understanding of the process under study. Three different sources provided the information gathered by the researcher: 1) Video-recording and field notes from direct observation of the whole lecture. 2) The physics syllabus currently used, and the textbooks as a valuable way to establish the didactic sequence in
which the lecture was inserted. 3) An informal interview with the teacher to inquire into his teaching approach and what he considered the most important features in his lectures from the point of view of the subject matter content.

The research was carried out within the usual lectures in the middle of a four-month term addressed to architecture students. The topic of the lecture belonged to first year Physics Program specially designed to reach the specific aims of the technical focus given by the institution. The lecturer had been previously contacted and informed about the purpose of the study and he had agreed to collaborate with us.

After a brief talking with the teacher about the arrangements needed to record the lecture, we proceeded to the observational stage of the research. A ninety-minute lecture was video recorded using one fixed camera, settled in front of the blackboard and among the students to appreciate the lecture as the audience did. The researcher, as a non-participant observer, took field notes to record drawings, graphs and equations not clearly visible in the video. A few months later the informal interview with the lecturer was held. The purpose behind it was to inquire on how he faces his own teaching in this particular context, while avoiding a probable bias created by the proximity of the observational stage.

Subsequently, the lecturer’s speech was integrally transcribed jointly with the other communicative resources used by the speaker. In this way the interactions between the different communicative resources were accurately registered.

4. Results and discussion

We centred our analysis on the development of the thematic patterns of physics, that students must master and use when reasoning about specific contents (Lemke, 1990). So, we went through the video and its transcription searching for the main strategies used by the teacher to build patterns of semantic relationships.

Repetition of key terms with different emphasis each time prevailed, and the main features of the content were highlighted by a reiterative use of naturalistic drawings (Kress and van Leeuwen, 1996).

A basic drawing, a horizontal rod supporting two loads near its extremes, was used every time either to expose a new facet of the phenomenon or to make direct linking among real facts, their conceptual interpretation within physical knowledge, or their mathematical formalisation. This variety in presenting the main thematic concepts in the lecture was carried over, not only from one part to another in the lecture but from previous and forthcoming knowledge, both in physics and in other subjects. Besides, semantic relationships were articulated around three main topics: elasticity of materials, internal effect of loading and local deformations.

At the beginning the teacher made an introductory link to the thematic sequence and, at the same time, he began to talk about the discourse itself (metadiscourse):

«now we are going to continue with the theme we began the other day».

This linking to previous activities gave thematic continuity to the teaching going on. But metadiscourse was also used as a mark or signal in the discourse, putting forward relevant points that would be the elements to be taking in account for the students in their process of meaning-making:

«Our working methodology is going to search for normal stresses (...) we will connect them with the flexion moment (...) we will use the geometry (...) to construct a function that is able to describe the curvature of the rod».

A core term, «flexion model», was a constant along the speech acting as a pivot in the teacher’s discourse. Rhetoric and semantic connections were made using analogies from ancient and modern architecture provoking implicit relationships: a strategy directed to transferring semantic relationships and thematic patterns, already known by the students, to new relationships and patterns the teacher was trying to build up.
Meaning-making and formalisation

Relevant elements of the transcript were extracted to analyse the process of meaning making. We focused mainly on how premises were stated through a narrative, and on how the argument was developed to achieve the formalisation.

The process of meaning making began when the teacher put in context the topic to be taught: «After our talking about the moment of inertia we are going to talk about flexion (...) using a model restricted to avoiding additional stresses as shear stresses».

In this way, the teacher engaged the topic in a didactic sequence, giving to the students a sense of continuity and a useful linking to the forthcoming argument. On the other hand he was implicitly anticipating that ‘moment of inertia’ would be an important part in his explanation.

Further he made more drawings, pieces of the curved rod, that he used to build new explanations, giving material support to the premises of the argument: the assumed restrictions of the model. At this moment a closing was done by the teacher, who passed to discuss similar situations in ancient architecture. Here gestures were the most predominant mode used to communicate the behaviour of stones, beams and rods supporting weights.

A coming back to the main line of the argument was done, marked by a change in the intonation and rhythm of the voice. A new and condensed version of the effect produced by loads was made, emphasising the inner behaviour of the fibres into the rod: «...once we had applied the weights, the beam was deformed, its fibres made a rotational movement around an axis (...), perpendicular to its length (...), in this way the plane, initially a vertical one, has become an oblique plane».

This speech would be senseless without the gestures and drawings made at the same time. Really, in this part of the explanation, verbal language had a subsidiary role because the argument relied on visual resources. Figure 1 shows the original transcription matrix where the speech, drawings and gestures used at the same time were registered.

<table>
<thead>
<tr>
<th>SPEECH</th>
<th>GESTURES</th>
<th>DRAWINGS</th>
<th>COMMENTS</th>
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<td>Then, once we have applied the load, the rafter was deformed and it has a rotational movement. And this rotational movement takes place around an axe, perpendicular to the rafter, that, we will draw later,...which coincides with the neutral fibre. This plane, initially vertical, has become an inclined one.</td>
<td>Points to a transversal section in a previous drawing that represents the deformed rafter in 3D and shows how the vertical plane was rotated. He draws an inclined plane, points to the Z-axis and uses one hand to indicate the inclination of the plane.</td>
<td>Visual language prevails: The information is organised by the interplay of two drawings (a previous and a new ones), and the movement of his hand.. Here, verbal speech, gesture and drawings are combined, but verbal language is used as a complement of the visual language (gesture and drawings).</td>
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Figure 1
Beginning of the formalisation process in this lecture

Record of the speech in the original transcription matrix. In the «gestures» column, the observed gestures are described in the same order as they were made; the inclined plane in the «drawings» was the main visual resource to which the teacher came back many times in the subsequent explanations; «comments» reflect field notes.

Then the teacher began to build a set of mathematical hypotheses:

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1 We are using the terms ‘narrative’ and ‘argumentation’ in the Aristotelian sense. That is, for us narrative refers to the formulation of the premises for the argument, which in turn is the process by which the transference from premises to conclusions (in this case, key concepts to be learned) occurs.
«...given any curve -of any size- I can always find a circumference that approaches the curve as closely as we wish around a given point (...) if that point is on the neutral fibre, we would assign a radius of curvature to that fibre».

This piece of speech was the announcement of another kind of discourse, in which mathematical language prevailed over verbal, gestual and graphical forms that dominated the communicative process in the first part of the lecture.

Then the lecture was developed almost exclusively on mathematical language. After that, he took advantage of the relationship between length variation and the properties of materials, to speak about the behaviour of materials subjected to tension and compression.

Then he construed a general equation describing the curvature. At this point, a new change in the discourse was done to show how the found equation would be used to solve specific problems in architectonic design.

5. Conclusions

In this analysis and discussion we could identify how new meanings were construed using a dynamic interplay among multiple resources. We have grouped our conclusions under the following headers:

General features of the lecture

The general strategies most frequently used for the development of thematic patterns were: (a) metadiscourse to introduce and to guide the process of meaning-making; (b) drawings and gestures as visual support to move from real facts to its scientific understanding.

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* The meaning-making process was carried on as a back and forward process, proving links to complementary explanations, and coming back to the main line of the argument. At the same time, such complementary explanations were kept, incorporating them in the conceptual framework.

* The lecturer assigned various specific purposes to the new meanings, but purposes appeared mixed because of their overlapping. For this reason, we will only say that some of them take part of further explanations or were used to get a better understanding of the world around us. Sometimes new meanings were grouped to support formalisation, and other times they were used to illustrate practical problems.

* Communicative resources interchanged their roles along the lecture in a complementary way. According to their semantic power verbal, written, graphic or mathematical resources functioned sometimes as the main expressive resource, and other times as support for the others.

Characteristics of the lecturer

Analysing the whole performance of the lecturer we could identify some aspects of didactic interest. In this case the lecturer is a physicist with theoretical physics background, teaching for many years in the same faculty. Despite an observed tendency to give canonical explanations to the students, he frequently went back in his discourse linking different concepts. His efforts is centred around the elaboration of the ideas he considers fundamental to achieve didactic objectives. So he attempted to trace a clear pathway from real life to conceptual knowledge. In the interview it was clear that his focus was to teach a kind of physics that could be useful to the students. The teacher’s whole performance was coherent with his ideas of being explicit about which would be key ideas in his teaching, and the analysis of his lecture shows that indeed he made this essential for the ultimate goal of his lecture.
Implications for educational practice

We feel that this kind of research may be important to show the possibilities of lectures to foster didactic objectives consistent with current theories on effective teaching. In the observed sequence, scientific and everyday facts were repetitively described by means of different communicational modes, a strategy consistent with a constructive approach to teaching, since giving multi-representational descriptions attends to individual differences in meaning-making. This is an important result because for a long time it has been assumed that teaching through lectures is opposed to a constructivist point of view, dismissing its potentiality to do good teaching despite its massive audience.

Communicative effectiveness is an important step in teaching. Not in order to transmit knowledge because knowledge is a personal construction of each learner, but to communicate the importance of the subject to be learned and its main features.

It is well known that teachers' approaches to teaching are influenced by contextual factors such as class size and faculty efficiency criteria (Prosser and Trigwell, 1997). This is especially true in universities where staff conceptions about teaching are centred more in their own academic capabilities and the institutional frameworks requirements of their instruction (Bos & Tarnay, 1999). We believe that now it's the time to promote a new approach to the teaching of large groups, and faculties’ staff should be aware of the necessity to develop communicative skills as an important facet in their qualification as academic lecturers.

Future research

The analysis of the gathered data gave us some insights about future research on communicative processes in lectures:

* Thematic analysis is a useful tool to identify relevant features of different teaching styles in lectures. It isn’t an easy challenge in high level teaching due to the complexity of the contents to be developed in a short time. Therefore, we need to search for new tools or improve the existent ones in order to deal with the complexity of teaching in natural settings.
* It is necessary to do a broad study on lecturers’ individual differences in their explanations, and the way in which students perceive such explanations. This kind of study should lead to a better understanding of the effectiveness of the different communicative strategies currently used in higher education.

6. Final comment

Plain lecturing is very popular but at the same time it is heavily criticised. One critical comment says that lecturing consists in a transference from teacher’s notebook to students’ notebooks without passing through the brain of neither of them. Others point to some well-known facts, e.g. that some of the most learned faculty members are bad teachers. And so forth.

However, the very fact is that in a high number of cases, teaching consists of broadcasting with no communication, which makes imperative more investigation to improve communication in teaching.

References

http://academic.brooklin.cuny.edu/education/jlemke/papers/barcelona.htm


