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THE CROSS-CULTURAL DIMENSION OF SCIENCE EDUCATION

Abstract

Within the framework of an Italian Ministry of Foreign Affairs cooperation project lasting from 1984 to 1991 the National University of Somalia required students to attend a special preparatory term before enrolling in a scientific faculty. The curriculum comprised various tests designed to explore students' level of disciplinary knowledge and their learning profiles. The data collected revealed relevant issues concerning lexical-based conceptual distortions, study habits, problem-solving procedures, graphic perception and, in general, world views and natural event management. Such data supported a constructivist approach to teaching/learning and, at the same time, suggested the adoption of an intercultural attitude also when it is taken for granted that teacher and students belong to the same culture.

1. *The Italian context*

In the early 1980s the Italian school system was seriously lacking in homogeneity. The University, although still reeling under the effects of the 1968 student protests, had undergone an initial reform in 1980[1] and another was to be enacted in 1990[2], whose innovative intention – which nevertheless lacked any significant results – concerned teaching and assessment methodologies. The syllabus of the upper secondary school system, over-burdened by experimentation, was, and still is, subject to laws and regulations dating back to the beginning of the century and which are teacher-centred[3]. The recently approved lower secondary school syllabus showed the decided influence of behaviourist theories that emphasised didactic

planning based on articulation of disciplinary content, but already prescribed students' engagement in a direct and manipulative relationship with naturalistic objects and events[4].

Constructivism appeared on the scene in 1985, when the primary school syllabus was issued[5], and would later provide the unifying and organic foundation for pre-primary education. Thus it was precisely in the 1980s that student-centred teaching methodologies[6] began to be considered in Italy but, in spite of their ideological appeal, met with difficulty in the face of some of the incompatible priorities that most teachers shared. The need, for instance, to ignore or suppress student conceptions that differed from those of the syllabus or textbook as being "wrong"; or the characterisation of teacher engagement as the duty to "convey" her/his knowledge essentially through the preparation of exhaustive and precise lectures.

As far as research is concerned – and specifically science research – the cognitivist cognitive theories (on which constructivism bases its dynamic conception of learning) initially triggered interest mainly in mental representations and the nature of discrepancies between such representations and disciplinary knowledge.

My personal experience in the field of genetics (Bandiera, 1990 e 1991) allowed me to identify and define a series of widely-shared "incorrect" attitudes and "wrong" ideas ranging from the conviction that, as a result of her intense wishes, a mother can affect her unborn child's features, to the possibility of the immediate emergence – even in people – of inheritable features in response to a changed or stressful environment. This convinced me that it would be necessary to unmask these misconceptions in order to address them while planning out a lesson in the disciplinary subject concerned. At the same time, the frequency and substantial similarity of the "folk" explanations used in various Western countries (since they are the stuff of the common person and adopted by most people) made me realise that I myself had heard and expressed these conceptions in my own lifetime, sometimes for years. Some I had rejected,

and some not (or not completely). From the point of view of my acquired skill as a scientist such conceptions did not appear particularly threatening. Rather they seemed (and still seem) to be markers of cultural contiguity and continuity with the social group of which I felt a member that ensured the possibility of communicating with the other members of that group. They were clearly surmountable without any special or specific engagement by teachers and students: in any case something quite different to the scientific conceptions needed to communicate within the community of geneticists.

I owe a lot to my experience with the Somali culture, gained at that special and crucial moment of my transition from genetic to didactic research. It gave me a perception of the importance of the cultural "weave" that – in Western countries also – effectively helps in coping with natural phenomena (and which scientists and science teachers are inclined to set aside, being satisfied with the reliability of scientific experimentation and thought); it also helped to confirm the heuristic effectiveness of constructivist-based research, and, in particular, the need for a didactic methodology to be implemented in order to get a perspective on teacher-student "differences" capable of undermining the educational process.

2. *A cooperation plan*

When the National University of Somalia (UNS) was founded the Somali government decreed the introduction of Western cultural models (Western scientific topics, a Western conception of the university, Western-style university degrees), and chose Italian as the academic language (teaching and didactic materials were in Italian). Thanks to an initiative set up by the Italian Ministry of Foreign Affairs (Development Cooperation), university students were provided with a special preparatory linguistic-cultural semester that was obligatory before enrolling in a Science Faculty and after having attended an

intensive beginner Italian language course. The curriculum of this semester included Italian for scientific purposes and some courses in basic biology, physics and mathematics (for some students also chemistry and technical drawing). Within the scope of this project, scientific courses were also to offer a basic introduction to scientific logic and methodology and develop the mastering of fundamental scientific concepts. Linguistic propaedeutic activity was also aimed at improving communication skills and developing "scientific" habits.

A team (of which I was a member and also coordinator) was given the task of designing the curriculum. It consisted of linguist experts and experts in disciplinary didactics. First of all we became aware that we had no information about the Somali school system (i.e. curricula, textbooks, didactic methods, learning habits, etc.) and that two solid presuppositions had to be considered: 1) that the Italian language would be considered as the matrix of scientific thought from the point of view of content and structure (this was the reason the language program was tasked with developing a scientific mentality), and 2) that the cultural (and, consequently, behavioural) models conveyed by the Italian teachers were different from the ones conveyed by the Somali students. This meant that an analysis needed to be made of both models in terms of their didactic implications. It therefore seemed to be necessary to define those learning abilities that Italian university teachers considered indispensable, as well as the basic scientific knowledge and specific characteristics of didactic communication as practiced in Italy. Such an identification could only be achieved along the educational path itself and, therefore, a non-traditional main approach was needed that, at the same time, ensured the successful attainment of predetermined goals and, in the meantime, gave the necessary indications for an optimal implementation of the educational plan.

At a methodological level the essential choices were made through the precise application of constructivist principles (promoting meaningful learning, encouraging students to con-

front all new information on the basis of previously acquired knowledge, supporting students' formation of an elementary conceptual network that allowed for the non-arbitrary assimilation of new concepts).

It was also necessary to combine research (the acquisition and analysis of data, definition of project-related hypotheses) with the need to provide teaching materials for the regular activity at the university, supporting logistic organization and teacher training. It seemed reasonable to approach this goal gradually.

For this purpose the sections of the textbook we designed for the linguistic-cultural semester (Bandiera et al., 1989) contained items widely used both in Western school practices and to investigate people's mental representations and conceptions. In the Somali context such items performed an exploratory function. These tests were called *curricular tests* because they were integrated into the units of the textbook. Moreover, two different multipurpose questionnaires were administered both at the beginning and at the end of the courses with the additional aim of evaluating the efficiency of didactic materials and, thus, providing for their gradual adaptation to the specific needs of Somali students. Thus Somali students were tested on their knowledge (in biology, mathematics, and physics), skill (classification, logical reasoning, time orientation, graphic spatial perception and use, geometric formalisation, dimensional comparison) and ability (to classify, to represent, to explain).

From 1984 to 1991 between 400 and 800 students were admitted every year to the Faculties concerned (Agriculture, Chemistry, Geology, Engineering, Medicine and Veterinary Science) and over the years the use of the textbook by the Italian teachers working at UNS, and analysis of the data collected within their curricular activities, revealed the extraordinary differences, obviously deeply rooted in lifestyles, traditional values and language structures, that showed up with the introduction of an official writing system (Somali history, literature, and traditions had always been handed down orally)

and which, despite students' enthusiasm for absorbing Western cultural models, made the use of disciplinary teaching methods immediately imported from Italy senseless (as well as, more than likely, ineffective).

It was only after subsequent research that I was able to confirm the terms of analysis that had been developed at UNS, and their didactic implications, in light of a rich, albeit dated, bibliography on science teaching in intercultural contexts (from Champagne and Saltman, 1964, to Wilson, 1981). Later I would be consoled by W.W. Cobern (1996) who gave authoritative evidence that a constructivist approach to scientific learning can have a positive effect on educational research and the design of science syllabuses for non-Western nations and peoples.

I propose to show particularly meaningful data (the subject of previous treatments in Tedeschini Lalli and Bandiera, 1988; Bandiera and Serra Borneto, 1994; Bandiera, 1995, Bandiera, 2008), on some aspects of Somali student learning profiles that demand attention on account of their macroscopic divergences from the overall intra-cultural context. I will go on to outline their possible influence the teaching/learning conceptions and on educational practices within the national context (which, in the light of the same data, seems also to be intercultural).

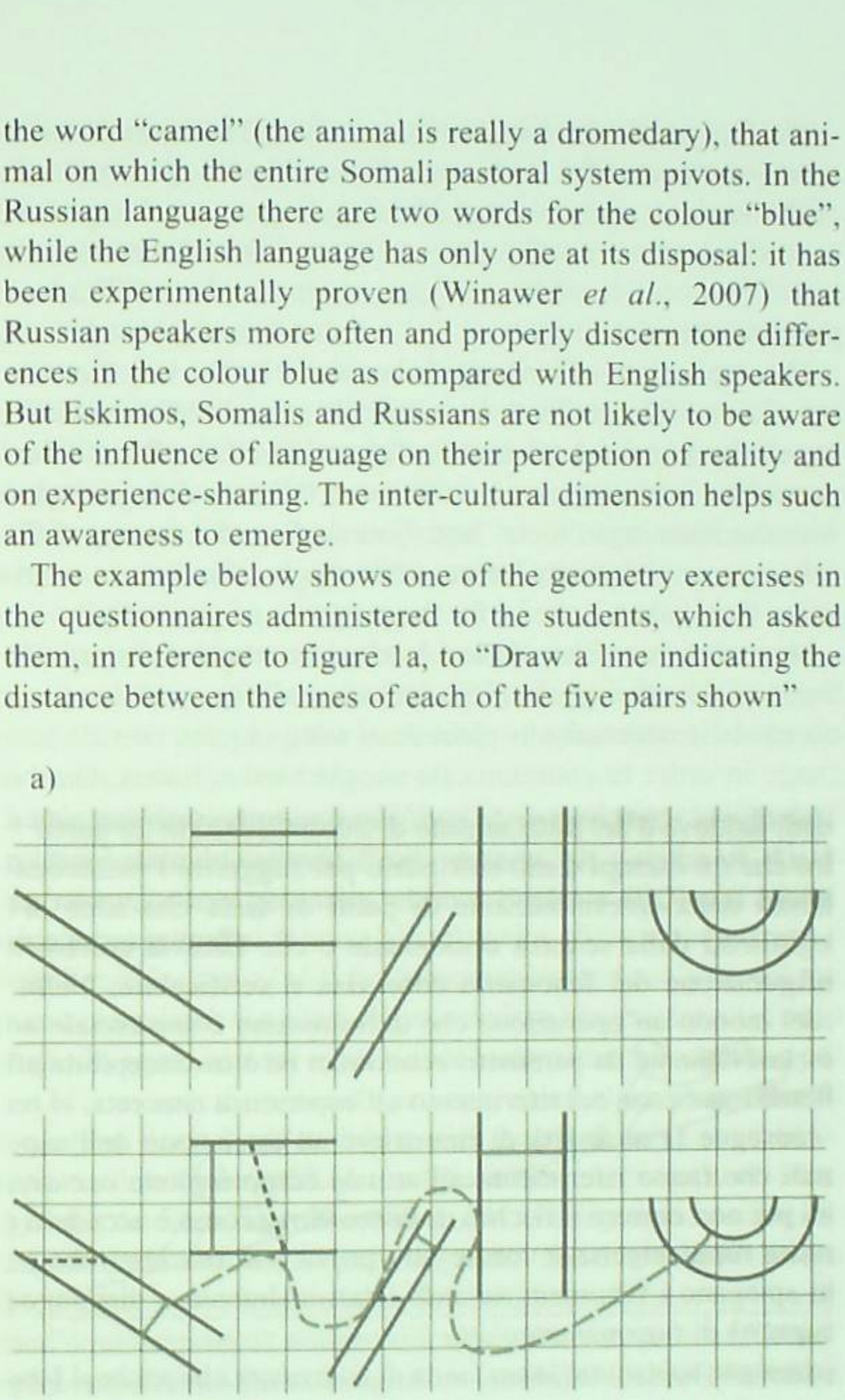
3. *Words and communication*

It is common knowledge that the quality and quantity of the words available in a language to indicate an object, in one way reflect the speaker's world view and existential peculiarities, and in another way represent more or less refined tools for reading and interpreting reality. Eskimos have many words to indicate snow, and *as a result* can create a very complex and articulate categorisation that is inaccessible and incomprehensible to European people who have only one word at their disposal (Whorf, 1940). The Somali language is no exception: there are over 40 possible words to choose from in translating

the word "camel" (the animal is really a dromedary), that animal on which the entire Somali pastoral system pivots. In the Russian language there are two words for the colour "blue", while the English language has only one at its disposal: it has been experimentally proven (Winawer *et al.*, 2007) that Russian speakers more often and properly discern tone differences in the colour blue as compared with English speakers. But Eskimos, Somalis and Russians are not likely to be aware of the influence of language on their perception of reality and on experience-sharing. The inter-cultural dimension helps such an awareness to emerge.

The example below shows one of the geometry exercises in the questionnaires administered to the students, which asked them, in reference to figure 1a, to "Draw a line indicating the distance between the lines of each of the five pairs shown"

a)



b)

FIGURE 1 – *Geometry test asking for a line representing the distance between the lines of each of the pair shown in "a". (In "b" the alternatives discussed in the text.)*

The five perpendicular, grey lines indicated in figure 1b were what we expected the students to draw. Even though two thirds of the students took this test (drawing fragments of segments or working on a limited number of line pairs), only one student out of four completed the exercise, suggesting how difficult or puzzling they found it.

The implication of language is borne out by the way that two out of five of the students drew a single grey dotted line touching all the line pairs (as seen in figure 1b). In the Somali language the semantic area of the word "distance" is crowded with the meanings "route" and "journey", and it is very difficult, even in University lecture-halls, to give the term a connotation that makes it useful for the purposes of geometry[7].

Moreover, "new" words can produce conceptual distortions. Some of the other goals of the Italy-Somalia cooperation project made it necessary to plant new words in the Somali language in order to communicate on extraneous issues. On the basis of its etymology the word "thermometer" was translated as *kulbee*, literally "measure hot" (Abdalla Omar Mansur, 1994). Where Italians – even those able to grasp its Greek derivation – assume the scientifically correct meaning (concerning the measurement of temperature) thanks to their familiarity with the object and with its use, Somalis are destined to form the concept of an instrument with a more limited range of capabilities.

Other new words found their way into the Somali language in a less direct manner in the course of becoming familiar with the Italian language. The students encountered difficulty doing a geometry exercise involving a comparison of arches: it was possible to attribute those difficulties to the conception of "arch" that they drew from the inscription "triumphal arch" on a sort of (horizontal) lintel resting on two pillars formed by piles of trashcans placed at the entrance to the main street of Mogadishu: a perpendicular structure at right angles to its supports!

These few examples suggest how the semantic areas of the same word can diverge and be corrupted when they are practised by interlocutors whose living experiences and backgrounds are different.

4. *School style and habits*

We were told that the inscription in Arabic at the entrance to the University offered thanks to Allah for having taught men everything they need to know. This presupposition would not encourage attendance at lessons and could be an indication of why students rejected scientific statements and theories, such as evolutionism.

The relationship between teacher and students was also compromised by a wide-spread and problematic male student resistance to accepting the leadership of a female teacher (and, more importantly, her judgement).

Also problematic was the refusal by boys and girls to come into physical contact with each other, which made it impossible to carry out a physiology lab as it had been planned, and which was intended to correlate muscular effort with pulse and breathing frequency. Each student measured only his own parameters since they refused to rest two fingers on a fellow-student's neck or to observe – indecently – her/his chest.

As far as specific aptitudes are concerned, during the semester Italian teachers were able to observe, with amazed admiration, that students were so capable of memorizing that it was difficult to distinguish between real skill and simple parroting. On many occasions I myself witnessed the exact repetition of a ten or perhaps twenty-line text read just once, but accompanied by the student's absolute incapacity to paraphrase or comment on it. This behaviour can be regarded as a consequence of Koranic school teaching methods that require students to learn verses written in Arabic by heart, thereby honing their ability to acquire sounds and signs without absorbing direct meaning.

In another example, the textbook designed for the UNS lin-

guistic-cultural semester contained tasks and exercises, each of which was accompanied by a grid made up of smaller or larger number of lines depending on the length of the answer expected. Many of the students avoided writing in the grid (which, by *filling up* the page, made it no longer useable), and instead wrote in the margins, crosswise, or at the bottom of the page. This showed how unaccustomed they were to using graphic space and can be regarded, as W. J. Ong cited (1982), as a consequence of the oral nature of the culture.

Students' attitudes toward images calls for an entirely separate treatment.

5. *Production and understanding of graphics*

The iconoclastic feature of the Islamic culture suggested the insertion into the textbook of a task/exercise that was originally aimed at exploring student conceptions about the Earth's shape, and which had been administered in many Western countries (Vicentini Missoni, 1981). It was also suitable for testing student skill in representing real and symbolic objects. The task was to draw "the Earth as seen from the outside" and include the representation of four men, four boats, and four birds.

I will ignore the many, either predictable or anomalous, features that the drawings of Somali and Italian students of the same age share, and point out three peculiarities that seem to be very significant, owing to their high frequency, some representative examples of which are shown in figures 2 and 3.

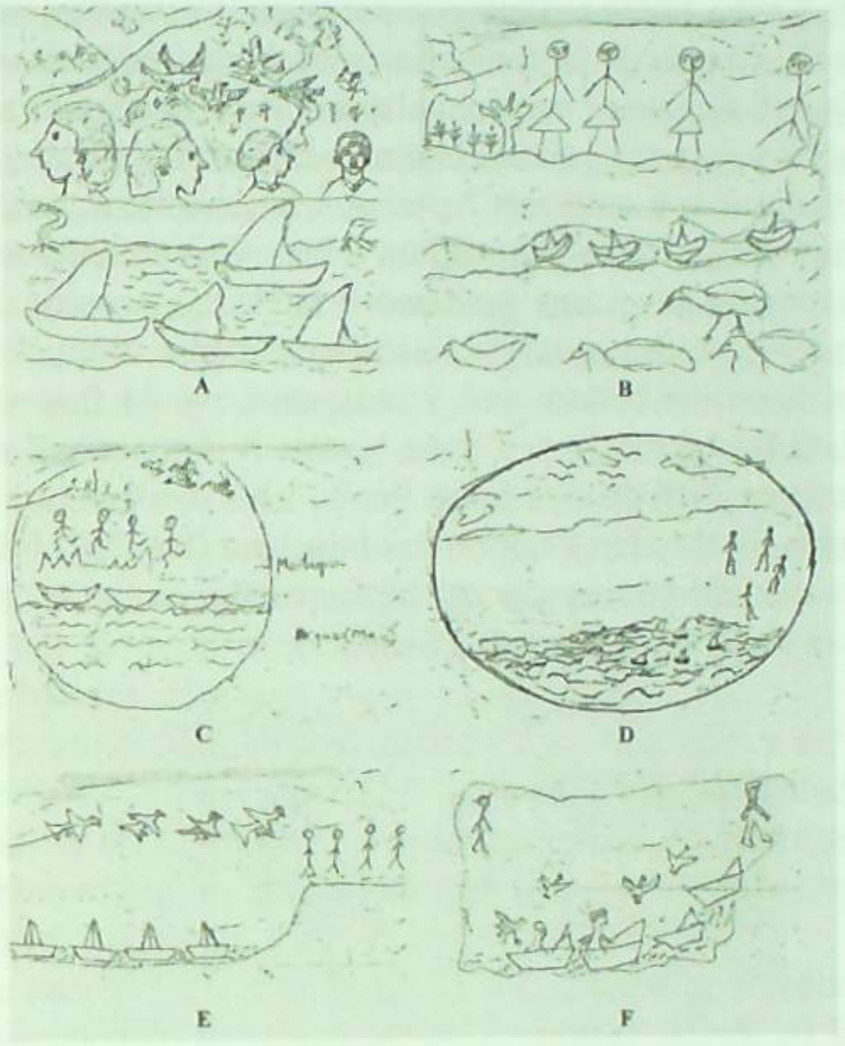


FIGURE 2 – *Drawings representing "the Earth as seen from the outside", including men, boats and birds.*

Men, boats and birds – either inserted into a hemisphere/planisphere or circular/elliptical framework (see G, C, D, E), or else depicted in scene running off the page (see A, B) – are generally grouped together, reflecting the structure of the task formulation and a preference for modular composition at the expense of overall graphic message. (This paratactic configuration is another one of the traces of the culture's oral nature described by W.J. Ong.)

As far as the *landscapes* are concerned (i.e. the representations of a scene containing the twelve required objects, inserted into a circular or elliptical frame intended to evoke a sense

of the Earth), some recurring features are noteworthy, such as the lack of any scale in comparing men, boats and birds (see C, D, E), and the use of intellectual rather than visual perspective that makes man the greatest in size (see B, C, D). Among other odd features is a recurrent layering – from bottom: sea, land, and sky (see C, D) – that differs from our representations of seascapes (as in picture postcards): land, sea and sky. Many interviews yielded a single astonishing explanation: the sea, water, is on the bottom and, in any case, would flow downward, to the bottom, since at the bottom it is *contained* within the concave "frame" of the land. This explanation also accounts for the step-like profile of the land (see E, F) forming a space in which the water can be contained.

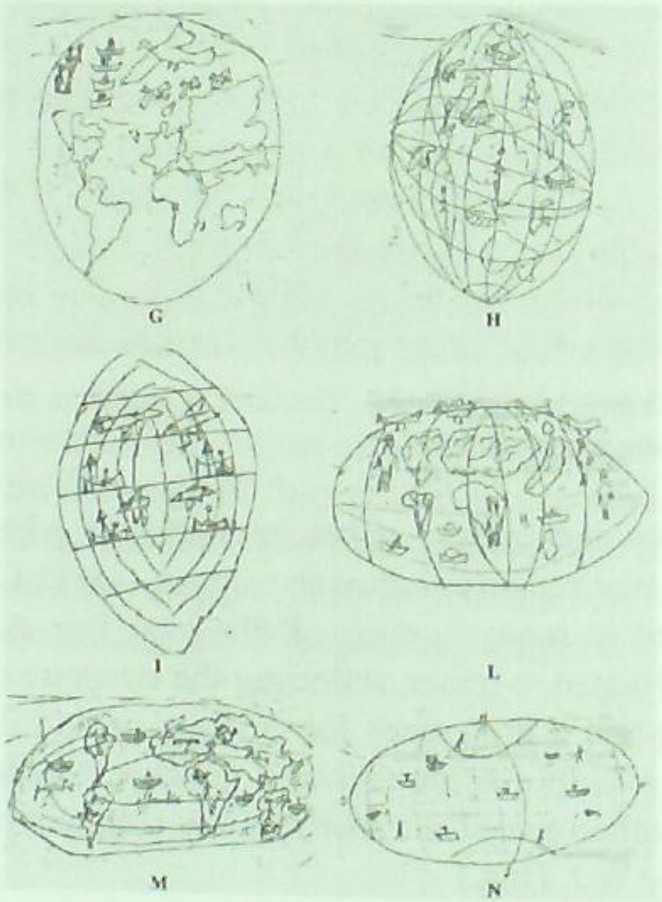


FIGURE 3 – *Drawings representing "the Earth as seen from the outside", including men, boats and birds.*

Reference to recollections of the *represented* Earth[8] induced many students to depict not the terrestrial globe, but a planisphere (see G, H, L, M) and to include anomalously-shaped cartographical elements: parallel (see L) or concentric (see I) meridians, and concentric parallels (see M) or those that converged at the equator (see H). This is proof of a lack of education about images (both reading and producing them). Moreover, I would like to point out the function that students ascribe mainly to the parallels as *supports* (see N: men walking on Polar Circles), which could be viewed as a clue to the supposed *real existence* of meridians and parallels, potentially linked to the primary meaning of the corresponding Somali words: *dhig* (meridian) originally denotes the branches that form the skeleton of a nomad's dome-shaped hut (Abdalla Omar Mansur, 1994).

The textbook contained a second classic test, known as "hole in the Earth", (Nussbaum, 1979), aimed at exploring students' familiarity with physics concepts, specifically with regard to the force of gravity (but which yielded quite different indications).

The exercise refers to figure 5a: "This drawing represents a cross-section of the Earth which is shaped, as we all know, more or less like a sphere. The human figure, who is not drawn to scale, is you: you have a stone in your hand; you are standing in front of a well that has been sunk perpendicular to the Earth's surface and that goes through to the other side. You drop the stone down into the well".

In Western countries students asked about the course of the stone drew three alternatives (shown in figure 5b, and) that were strongly correlated with their interests and specific scientific knowledge: the stone will stop at the Earth's centre, seen as the gravity centre (a "weak" scientific hypothesis, preferred by biologists); the stone will come out at the South Pole and get lost in space (a non scientific hypothesis, preferred by those with a humanities educational background); the stone will first fall down toward the South Pole, and then up toward the North

Pole (a "strong" scientific hypothesis preferred by physicists). The final, correct, option was ignored by Somali students (except a scanty percentage intended to enrol in the Faculty of Engineering). The vast majority hypothesised that the stone would stop at the obstacle, i.e. the line at the bottom of the page sealing off the sphere to the south: this option was never considered by students taking the test in Western countries.

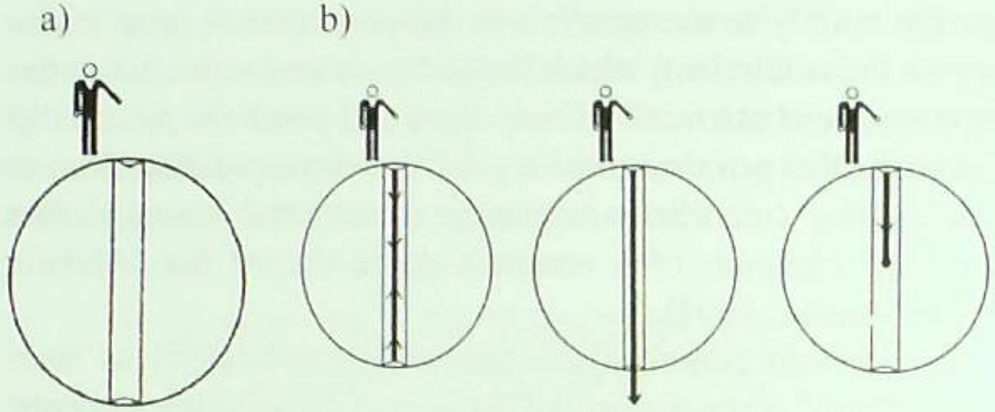


FIGURE 4-5 – *Drawing associated with the test known as the "hole in the Earth" (a). Alternatives concerning the course of the stone dropped down into the "hole" (b).*

These and many other clues indicated a widespread illiteracy regarding images of reference resulting from the pre-university school system's widespread use of textbooks devoid of pictures (including biology textbooks). Such clues also supported the idea that the drawing was not a symbol of the reality represented but its reconstruction, to which to apply the criteria and principles of phenomenological interpretation.

6. *Explanations and problem-solving procedures*

Figure 6 shows a third classic exercise (Watts and Zylbersztajn, 1981): two men, each bracing a car on a slope to prevent it from rolling down. The cars are exactly alike and neither one's hand brake is engaged. The object is to compare the effort exerted by each of the two men.

Approximately one-third of the Somali students thought that the man at the top of the slope ("A") was working harder, one-third said the man below, and one-tenth that both were making the same effort (this is the right answer considering the equal weight force deriving from the uniformity of the slope). Justifications for the students' answers (furnished during clinical interviews) mostly corresponded to those of Western students and pointed to a tendency to adopt school roles, except for a recurring explanation that the greater effort of "A" was due to the length of road he would have to cover in reverse in order to reach the bottom of the slope, i.e. stability.

Remarkable clues were given by one out of five students who adopted positions quite unheard-of in Western experience: some refused to give an answer since there are no slopes in Somalia (in their personal experience) and therefore the problem "does not make sense"; and some contested the wisdom of the question, suggesting the possibility of avoiding any effort at all by placing a stone behind the wheels to block the car.

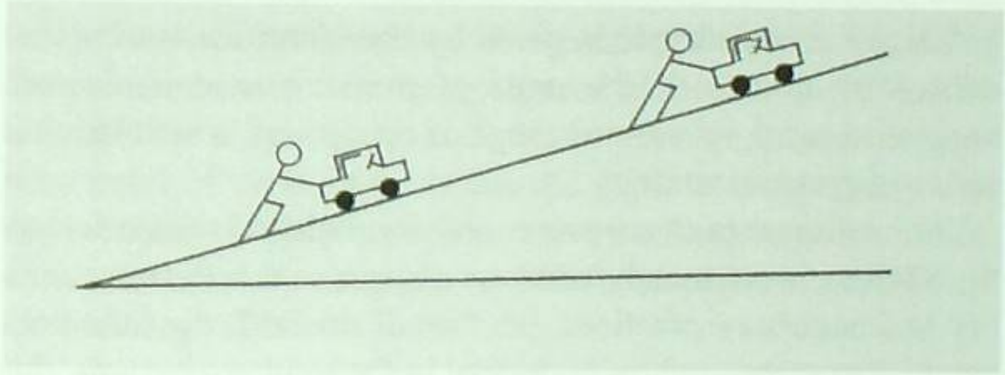


FIGURE 6 – *Drawing associated with the exercise involving cars without hand brakes on a slope.*

The entry questionnaire section dedicated to elementary mathematics included a "20:1000" exercise. About half of the students answered "50", explaining that it was impossible to divide 20 objects into 1000 parts, whilst dividing 1000 objects into 20 parts made quite a lot of sense.

The frequency of references to real life, to lived experience,

to the practical relevance of explanations and solutions (one might say, the resistance to abstraction) corresponds with the differences in logic, rationality, and scope that R. Horton underlines (1967) when comparing Western science and African mythology, at the same time highlighting the similarities between their peculiarities and methods. Nevertheless these differences undermine the usual scientific attitude on which Western science teachers would like to base their analyses of phenomena and methods of problem-solving.

7. *The everyday context*

Our theoretical and methodological orientation required that information be collected on Somali students' everyday life, and on their habits, which had some chance of affecting their formation of scientific concepts. This requirement was also taken into consideration by some of the "exploratory" activities included in the textbook, the results of which could and should have directed Italian teachers' attitudes.

A significant example is given by the identification by student work groups of the units of measure used in Somali regions to carry out a broad range of operations, which led to a series of generalizations.

The instruments of measure, and the units of measurement themselves, were mostly concrete objects and reflect customary and necessary practices: the "small tin can", the measurement instrument used by the *madal* in the southern regions; the "little bottle" and the "big bottle" for measuring milk respectively in *dhalo yerey* and *dhucey*. In light of this information the question was how to go about facilitating the transition to non-practical operations (see: measuring the distance between the Earth and the Moon, or the weight of a molecule)?

Units of measure are often related to practices that solicit their establishment: the *geedi* (15-20 km) is equivalent to one day's walk in the bush, and the *masaafo* (about 90 km) to one leg of the religious pilgrimage (and also to the shortest distance

that two young lovers' have to cover between their place of residence and the place they can celebrate a marriage their families oppose). How to bridge the meaning gap that certainly marks both the platinum-iridium meter held at Sèvres and the distance traveled by light in a vacuum in 1/299,792,458 of a second?

Moreover, measurements are essentially approximate in nature: referring to a metre-rule students estimate the length of an "arm" (*dhudhun*) as varying from 40 to 80 cm; in general, even consulting informers, it is impossible to define the equivalence between Western units of measure and Somali ones that, since they not established by norms, vary from source to source. How to induce students to employ a strict and rigorously defined set of measures?

8. *The contribution to teaching*

No Western teachers in Mogadishu had the professional training at that time – or even now – to equip them to cope with the differences between their own points of view and those of their students; nor were they prepared to face having to justify the need for a systematic and rigorous *scientific* and *disciplinary* point of view. In any case, the gap was so glaringly evident that the cooperating teachers were willing to adopt immediate and adequate measures even at the expense of established methodological habits.

It was impossible for me, and all the other Italian university personnel cooperating in Mogadishu, not to wonder what would happen when the discrepancies were not so easily perceived. How many Western teachers were aware of the differences between their own points of view and those of the students? How many were willing to consider the students' points of views as their point of departure in planning an educational itinerary?

Being implicit the assumption that student/teacher-shared language, history, and living environment guarantees a solid

foundation for the building of scientific knowledge, it took macroscopic diversity owing to non-shared elements to change an espousal of constructivism based on abstract ideology into a set of behavioural rules.

At this point I would like to specify that by constructivism I intend that derivation of cognitivist theory exhaustively explained by E. von Glasersfeld (1989), that proposes a model for how learning happens rather than a theory on how rationality develops (Yager, 1991), and that describes the quality and quantity of knowledge as the fruit of an individual's own personal direct and indirect experience. This experience is subject to active organization within a framework according to genetically and culturally determined modalities (therefore, also depending on experience). Consequently, although the frameworks of individual members of a social group with a shared history, language and environment are, for the most part, similar, they surely differ in function of the individual's experiences.

Although hacked up by radical interventions, the constructivist theoretical framework still has many positive features: it allows for consideration as obviously physiological both differences in conceptions among subjects and resulting teaching-learning difficulties; it provides tools for the exploration (in the course of research, but also while teaching) of cultural and metaphysical issues that are crucial for an understand of what scientific education is from different cultural perspectives; and it identifies inter-personal dynamics and communication as the principal terrain on which to work in order to foster meaningful learning (Ausubel, 1968) and negotiation between interlocutors as the route that gradually leads to learning (Bruner, 1986).

The Italian teachers in Somalia were forced to acknowledge the importance of cultural factors in the formation of view points that differed from those accepted by Western science and that, nevertheless, corresponded to a shared and verifiable view of phenomena. In fact they renounced *Western* interpretations of the tests administered, which referred to the prevailing *Western* understanding of phenomena, thereby avoiding the

risk of *proving* (as happened in the case of rural Nigerian communities that were studied using such tests) that the subjects involved were irrational in their explanation of natural phenomena or poorly endowed with the ability to reason (Okebukola and Jegede, 1990). Above all, they began to regard the scientific foundation as a system of beliefs corresponding with cognitive interests and skills, that applies to everyday life objects and events and that often coincides with "local" common sense (R. Horton, 1979). These features give a holistic connotation to the system that makes it incompatible with analogous systems of other social and cultural social groups. Therefore the relationship between a Western teacher and students of a different culture is no less than a *clash of civilisations* that the educational intention is to transform into a *meeting of civilisations*.

Much easier said than done, as witnessed by P. Logan (1981) who taught physics at the University of Technology in Papua New Guinea to 97 students who spoke 76 different languages. He was alarmed by the realisation that he would have to deal with 76 different interpretations of each lesson by students who would have adapted the new concepts to suit their own linguistic and cultural matrices. At the time, in Mogadishu, it appeared that Logan's alarm was not only to be shared by those intending to teach science to non-Western students, but that the same alarm had to be extended to the variety of dialects, regional origin, socio-economic class, living environment and situation where the teaching-learning processes took place. Didactic mediation, nevertheless, was revealed to be an essential moment, suitable for identifying and coping with intra-cultural traps that hinder an effective and sound learning of science (suffice it to think of Italian students who study the solar system and continue to refer to the sun as rising and setting!). Without didactic mediation it is almost impossible to avoid the activation of a parallel, and precarious, cognitive channel for the sole purpose of pleasing the teacher or being promoted.

My experience in Somalia, therefore, led me to consider each school class as a multicultural whole containing the multiplicity of beliefs and knowledge held by both Italian and non-Italian students (individual persons, not members of any particular ethnic group); and teaching/learning as an intercultural activity whenever the scientific sense of what is being taught does not correspond with the student's broader view of reality.

The Somali experience itself can be regarded as a cross-cultural operation as far as validation of the theoretical constructivist framework and promotion of teaching innovation in the national context goes. This in order to redesign a school that – in the still current conception of most people[9] – remains predominantly the setting for the transfer of knowledge from teacher to student and therefore destined to produce no more than an accumulation of notions. In order to make more systematic the practice of teacher–student dialogue, which constructivists call for based on the conviction that real phenomenology is complex (not traceable to individual disciplines) and susceptible to subjective interpretations both in intra-cultural and inter-cultural contexts. This is a conviction that assigns dignity and responsibility to science, understood as the matrix for a unified world-view shared by all those who practice it and draw upon it for explanations and tools (the R. Horton, 1979, *secondary theory*).

NOTES

[1] "University teaching reorganization, respective training phase as well as organizational and didactic experimentation", D.P.R. July 11, 1980, no. 382.
[2] "Reform of University didactic regulations", L. November 19, 1990, no. 341.
[3] "... the teacher will link not only the anatomy, but vegetable, animal and human physiology; and especially will insist on endocrine, nervous, muscular physiological life and on reflex action with reference to the question of human conscience and activity, and will then present clear notions on hygiene ..." (Syllabus of "Liceo classico", second year, "Geography, Natural Sciences, Chemistry", Gentile Reform, 1923).
[4] "... pupils will be engaged, individually and in groups, in operative activities, investigations and reflections, suitably guided and supplemented by the teacher, arriving, according to the nature of the subject matter, more in-depth and general mathematical developments, and, respectively, a consistent framework of experimental results." ("Syllabus, Teaching Time-Tables and State Lower Secondary School Examinations", D.M. February 9, 1979, "Mathematical, Physical and Natural Sciences").
[5] "Primary School Syllabus", D.P.R. February 12, 1985, n. 104.
[6] "... it is essential that the teacher is open to the conceptions that they – *the children* – express and to the ways they formulate them, makes room for their questions and avoids prematurely answering, ... exploits personal viewpoints and thinking with one's own head, does not penalize errors that, as expressions of one's own viewpoint and an opportunity for self-correction, foster critical thinking." (Guidance for Educational Activities of the State Pre-Primary School, D.M. June 3, 1991, "Things, Time, and Nature").
[7] The test also explains students' tendency to refer to their own concrete experiences: those who drew diagonal lines (black and dotted in figure 1b), when interviewed stated that they had referred to the distances they met in the real life, such as the distance between the banks of the Shebeli river: the river's current renders the crossing *route* longer than a simple perpendicular.
[8] In the years following adoption of the textbook used in the linguistic-cultural semester it was ascertained that the image of the Earth to which all the students referred was a planisphere displayed in the offices of Somali Airlines in the centre of Mogadishu: an oval-shaped hemispherical distribution of all the continents, showing meridians and parallels.
[9] Proper tools and strategies for supporting a suitable type of teaching role have been designed, validated, and grouped under the label "active and cooperative learning" (Sharan, 1994; Silberman, 1996). The actions presented here have two features in common: the first was the request that those preparing to learn express their experiences and conceptions and have a chance to compare them with disciplinary knowledge; the second was that information be gathered on students' previous knowledge and their way of managing school messages, which then helped teachers plan effective lessons and supplement or change lessons that turned out to be somehow inadequate.

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