Milena Bandiera

WESTERN SCIENCE: A CASE OF TRANSCULTURAL UNIVERSITY PROPAEDEUTICS

UNIVERSITY OF ROMA TRE

1. The general problem

Many countries are today discovering a need for teaching approaches that respond to a student population made up of diverse cultural backgrounds. The issue is complex and, for that reason, has mainly been the object of attention concerning education programmes carried out in international or inter-ethnic contexts, and of what is known as "dependency theory".

Emerging within the context of comparative education, this theory describes the risk of assimilationist education policies, i.e. of the adoption of practices that allow the dominant class (the "haves" over the "have nots", the centre over the periphery, hegemonic over dependent) to reproduce the set of values and system of stratification that marks its continued supremacy (Eckstein & Noah 1985). Thus education becomes the active reproducer in learner peoples of those values, attitudes and skills best suited to serve the interests of the dominant group (Bowles & Gintis 1976). This is especially evident in the case of science education, since it is broadly acknowledged that scientific activity – its forms, intentions and priorities – tends to reflect specific world views and their associated value outlooks (Lacey 2007).

This risk has been recognised in situations in which the cultures encountering one another are not – or do not wish to be – in competition; emblematic are cases of the scholastic integration of immigrants and of targeted formation, e.g. science education, in countries where other "sciences" are cultivated and practised.

In Europe a scenario of non-antagonistic cultural encounter was ushered in with political developments (the collapse of the Berlin Wall, the dissolution of the Soviet Union and the expansion of the European Union), and subsequent migrations from Africa and the Orient. The primary and predominant response could be defined as ingenuous and, indeed, has consisted of raising the linguistic literacy of those "foreigners" for the purpose of giving them to access "ordinary" education. Instead, sector research suggests that it is necessary to practice a sort of interculturalism, starting at the primary school level: an education founded on the ideas of negotiation between cultures that respects the individuals and all cultures, and of mapping out an itinerary leading primarily to mutual understanding and, consequently, to true integration, ensuring that learning is meaningful by rooting it in learners' own knowledge and experience systems (Coulby 2006).

The task is especially difficult in the situations cited since teachers generally have no knowledge of or means of understanding learners' cultural backgrounds, and have to teach them in a language different to their native tongue. Analysing the real needs presented by students from diverse language backgrounds, linguist David Corson (2001) authoritatively maintains that children should have the right to learn in a language similar to what is spoken in their homes, and cites effective communication as necessary for creating the conditions by which learners integrate what they learn into their baggage of meaningful and useable personal knowledge.

The communication problem worsens when it comes to teaching adult learners disciplinary specifics in contexts outside the epistemiological framework that generated them, and it therefore becomes fundamental to seek out the views and interests of those whose language, lives, and social arrangements provide the focus of any study undertaken. Teachers are advised to be sensitive to the details of the context, and to make

the most of assessment as a tool for monitoring whether learners are actually learning what they are teaching.

In reality, since all communication in a foreign language is intercultural, in the contexts cited the teachers would do well to put themselves in a position to encourage the acquisition of "intercultural competence", which always implies "communicative competence" (Sercu 2004).

2. The Somalia experience

It has been amply demonstrated that for the vast majority of non-Western students, attempts to enculturate them into Western science are experienced as assimilation into a foreign culture (Aikenhead 2002). Indeed, African universities have been accused of perpetuating cultural dependency despite their record of promoting African nationalism and political independence (Mazrui 1975). It is not surprising, then, that while founding the National University of Somalia (UNS), the Somali government decreed the introduction of Western cultural models (Western scientific topics, a Western conception of university, Western-style university degrees), and chose Italian as the official academic language (teaching and didactic materials were in Italian), so as to ensure the broadest international return on its investment.

For this purpose, in the context of a joint Italia Ministry of Foreign Affairs and Rome "La Sapienza" University convention, a multi-disciplinary research group designed and tested a special preparatory semester in Italian language for those intending to enroll in a science faculty (Serra Borneto 1981), followed by a second propaedeutic "linguistic-cultural" semester (Tedeschini Lalli & Bandiera 1988).[1] This latter assigned disciplinary courses the task not only of verifying and consolidating very fundamental concepts (content knowledge), but also of introducing the student to the specific disciplinary logic and methodology (process skills). Basic skills were exercised, such as learning from a textbook, meta-cognition and testing personal understanding and knowledge, the use of textbooks for studying, formulating and solving problems according to a logical sequence, reading of images (photos, charts, tables), reading and use of symbols and formulas, observation and description of the features of objects and events, and the construction and use of models and analogies.

A wide range of tests, presented in the form of exercises in the text of the study (Bandiera *et al.* 1989), allowed researchers and teachers to gather information *in itinere* on the cognitive style, learning habits and abilities of the Somali student, his motivations and expectations, specific fore-knowledge, general behaviour and everyday experiences, and to assess the effectiveness of the teaching project (Bandiera & Serra Borneto 1994). These tests, which were called "curricular", and more traditional ones administered at the start and finish of the semester were a continuous and reliable source of data acquisition and analysis and project-related hypotheses useful for revising teaching materials for regular university activity in support of logistical organisation, teacher training materials and educational methodology.

Without underestimating data indicating very limited and circumscribed disciplinary skills, of the elements that emerged from analysis of test performance – and that were confirmed year after year – three stood out as highly significant (Bandiera 2008). These had to do both with information that it was necessary to consider in order to comply with the Somali government's mandate, and with clues regarding primary aspects, or deriving from the indigenous culture, that constituted obstacles in the transcultural process to be carried out. In the first place, the conflict between living habits (in particular, resistance to confronting problems in the absence of any reference to real life and lived experience, and to the practical relevance of explanations and solutions) and Somali students' willingness to embrace problematic situations aimed at testing their disciplinary skills. The most outstanding example was students' refusal to take a position on the classic test of assessing and

comparing the relative effort exerted by two separate persons holding a car in place on an incline (Watts & Zylbersztajn 1981). Their refusal was based on the fact that "there are no hills in Somalia" or on the possibility of "placing a stone behind the wheels to keep the car from rolling backward". This result points to the differences in logic, rationality and scope underlined by R. Horton (1967) when comparing Western science and African mythology.

The second element of interference can be identified in the shifts in meaning resulting from the superimposition of the semantic area of a Somali term over the Italian term considered its closest translation. The most vivid and representative case was associated with the Somali term for "distance", which was synonymous with the terms "route" and "journey", the consequences of which will be mentioned below.

Finally, scholastic conventions – i.e. that series of features marking student performance and behaviour, being different and not comparable to those of Italian students – ran the risk compromising both the Italian teacher/Somali student relationship as well as the quality of the learning results. Other important considerations include the habit, cultivated in Koranic schools, of memorising without understanding, along with a broad range of unexpected difficulties associated with identifying and using the spaces provided in texts and questionnaires for elaborating data and representing the significant features of the figures, perceiving and reproducing – a Westerner might say, respecting – the qualitative and quantitative features of considered objects.

Even though twenty years have passed since the traumatic interruption of the experience in Somalia, it is legitimate to consider the results of the experimentation conducted for the purpose of building a bridge between Somali secondary schools and Italian university, as useful in mapping out effective scholastic itineraries in the situations of intercultural encounter currently under way in the Italian school system.

A concrete opportunity is offered by the results of the final questionnaire administered at the end of the last linguistic-cultural semester at UNS. Precisely for the purposes of assessing the project's efficacy, eleven of the items of the initial questionnaire were repeated on the test at the end of the semester.[2] Comparison was entirely legitimate since students had not been given the results of the initial questionnaire, nor had the items been further illustrated to or discussed with the students. It would therefore be possible to evaluate both their willingness to carry out the task, i.e. their degree of familiarity with it, as well as what specific skills had been acquired or strengthened over the course of the semester. As a result of the research project's sudden suspension, however, the data were never collected, much less analysed.[3] Finally note that, in the following sections, the translation into English of the Italian expressions the students used does its best to recreate their errors and distortions.

3. The data

3.1. Perception and use of graphic space

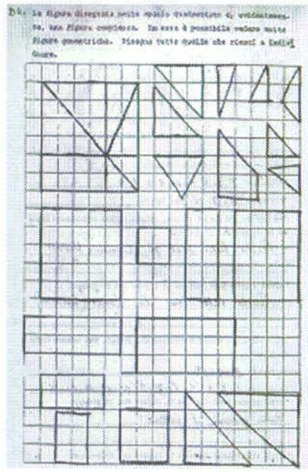
The item presented in fig.1 intends to test both the ability to analyse and take apart the complex figure, as well as the ability to reproduce the elementary figures identified within it.

Willingness to take the test increases (from 83.6% at the start of the semester to 94.8% at the end). The average number of figures drawn rises from 6.2 on the initial questionnaire to 8.9 on the final one; the average number of dimensionally correct figures from 1.9 to 4.8.

While recognising the acquisition of a certain degree of familiarity with the graph paper and with basic plane geometry shapes, it is impossible to miss the tendency to disregard measurements – "count the squares" – in the reproduction of the shapes, 46.5% of which do not match the model (examples in fig. 1) or are sketchily drawn (examples in fig. 2); the problem worsens with shapes "composed" of two or more elementary

shapes (fig. 3): only 38% of trapezoids and 23% of scalene triangles are correctly reproduced.

Fig. 1. "The shape drawn in the graph area below is clearly a complex one, containing many geometric shapes. Draw all the shapes you are able to single out". Out of 20 geometrical shapes drawn by the student, 5 dimensionally match the ones "located" in the complex shape *(left)*.
Fig. 2. "9" drawn geometrical shapes: only one dimensionally matches the ones "located" in the complex shape *(right)*



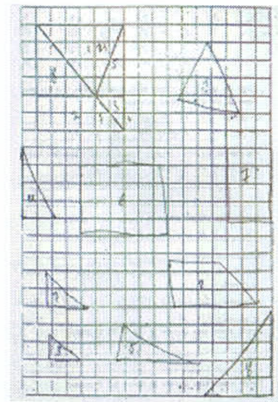
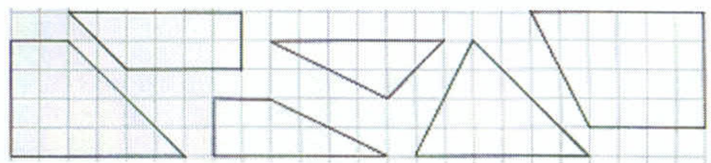


Fig. 3. The complex shape includes 25 elementary shapes. The "simple" ones are 3 squares, 6 rectangles, 8 right triangles. There are also 6 trapezoids and 2 scalene triangles drawn at left.

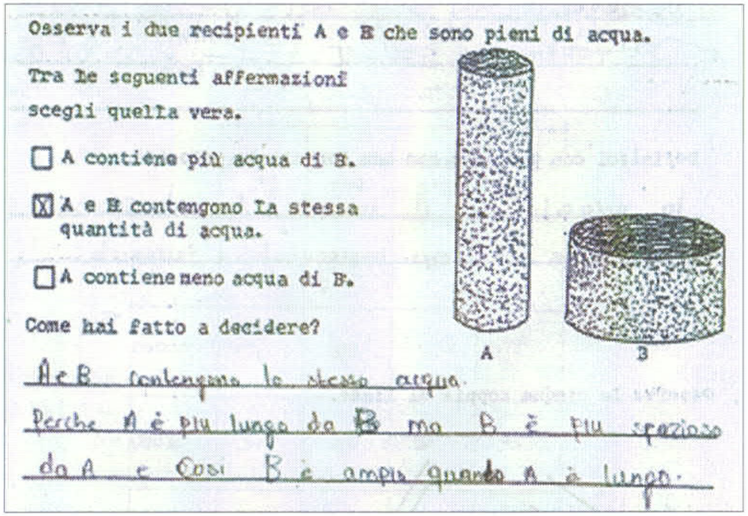


3.2. Process skills

What is known as a scientific attitude refers, first and foremost, to the adoption of rigorous processes in the examination of objects and events, and of exhaustive argumentation in the presentation and maintenance of positions taken. The related skill is tested in the item presented in fig. 4.

Fig. 4. "Examine two containers, A and B, that are filled with water.
Choose the correct assertion from among the following:
- A contains more water than B
- A and B contain the same quantity of water
- A contains less water than B
How did you make your decision?"

"A and B contain the same water because A is longer of B but B is wider of A and so B is wide as A is long."

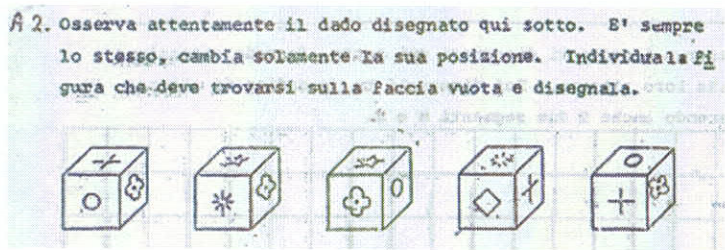


Willingness to take a position is high and remains steady (94.4% at the start of the semester, 93.6% at the end). The dominant answer has it that A and B contain the same amount of water: "Recipiente A è lungo in alto, invece B è largo in basso." (*"Container A is long up, while B is wide down"*). The increase in correct answers (A contains less water than B) is minimal (from 30.9 to 36.4%), while willingness to explain rises considerably (from 76.4 to 92.9%). At the end of the semester, approximately half of the explanations are not meaningful: "Ho deciso che B è più grande di A." (*"I decided that B is bigger than A"*), "Ho fatto a decidere che A e B contengono la stessa quantità di acqua perché sono pieni." (*"I made to decide that A and B contain the same amount of water because they are full."*). Rare are references to radius (4.3%) or calculations of volume (1.3%): "Se vediamo i raggi dei due recipienti troviamo che il raggio di B è quasi doppio di quello di A: possono essere uguali solo perchè l'altezza di A è 4 volte più di B. Come si vede non è così." (*"If we look at the radii of the two containers we find that the radius of B is almost double that of A: they can be equal only because the height of A is 4 times B. As we can see it is not."*)

3.3. Spatial orientation

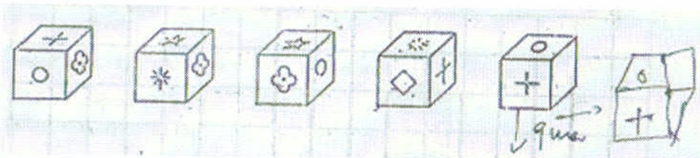
The iconoclastic aspect of Islamic culture, and the recent acquisition of the written language and, consequently, of reading verbal and iconic texts, have impacted negatively on Somali students' ability to glean information from images (drawings and photos). The task in fig. 5 could be completed by mentally rotating the cube, as well as by opening it up, in order to mark each of its faces: this appeared to be more doable at the semester's end.

Fig. 5. "Carefully examine the die drawn below.
It is the same one in each figure, only its position changes.
Decide which symbol should be drawn on the blank side and draw it."



Attempts to respond rise from 35.6 to 65.2%, but forms of approach appear inadequate for the most part (fig. 6), and the increase in meaningful and correct responses among those who do the task is very limited (from 18.8 to 26.3%).

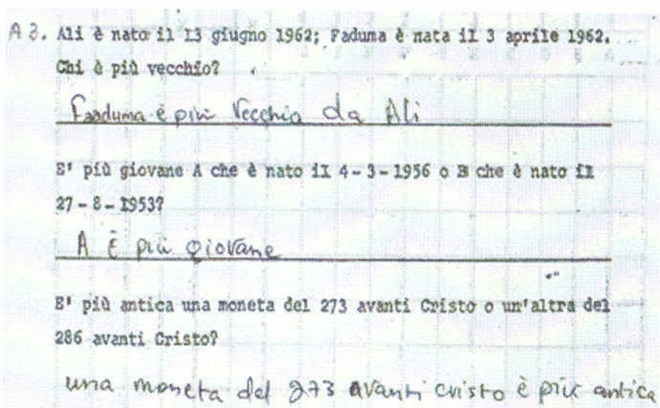
Fig. 6. An attempt at finding the solution that helps realize the difficulty both in understanding the task and in completing it (*"here"*)



3.4. Temporal orientation

A basic skill that is believed to be acquired at a very young age and that is not subject to ethnic/cultural interference. Indeed, the related test (fig. 7) is considered easily accessible, and approximately 99% of the students do it both at the start and at the end of the semester.

Fig. 7. "Ali was born on June 13, 1962; Faduma was born on April 3, 1962. Who is older?" *"Faaduma is older than Ali."* "Who is younger, A who was born on 4/3/1956, or B who was born on 27/5/ 1953?" *"A is younger."* "Is a coin from 273 before Christ older than one from 286 before Christ?" *"A coin of 273 before Christ is older."*


A 3. Ali è nato il 13 giugno 1962; Faduma è nata il 3 aprile 1962.
Chi è più vecchio?

Faduma è più Vecchia da Ali

E' più giovane A che è nato il 4-3-1956 o B che è nato il 27-8-1953?

A È più giovane

E' più antica una moneta del 273 avanti Cristo o un'altra del 286 avanti Cristo?

una moneta del 273 avanti cristo è più antica

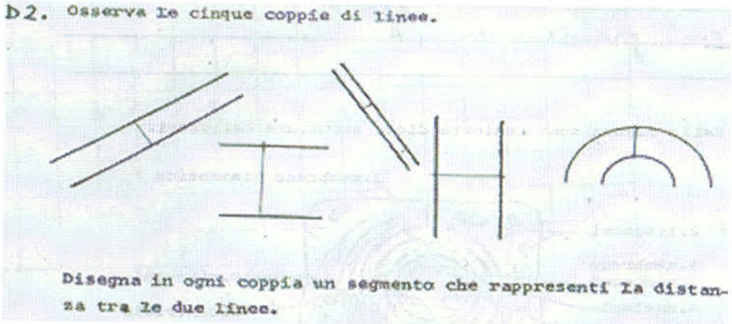
Comparison within the same year of birth is frequently correct (from 70.0 to 83.5%). Nevertheless the idea remains strong that Ali and Faduma are the same age, a notion either expressed categorically or implied: "Se misuriamo i mesi Faduma è più vecchia, altrimenti sono stessa età." (*"If we measure months, Faduma is older, otherwise they are same age"*). Success rates drop suddenly in the comparison of dates in the period before the birth of Christ: 64.1% correct answers at the start of the semester and 27.5% at the end. Only one student in five correctly answers all three questions.

3.5. Awareness of intercultural status

This is not a canonical skill, but it is a crucial one. It signals the student's becoming conscious of acting in a different educational context than he/she is accustomed to, and of his/her ability to distinguish the semantic area of the terms adopted in didactic communication – and not only in specialised lexicons – from those of the terms that translate them in the mother tongue.

The first year the task shown in fig. 8 (where it is correctly answered) was given, it was possible to ascertain two negative consequences of such awareness. A large number of students drew transversal line segments instead of the expected perpendicular ones, explaining this choice in later exploratory interviews as a reference to "real" distances (e.g. between the banks of the Shebeli river) and to the "real" route dictated by the current's drift or to the need to shorten the route. Others, students that had drawn a line linking all the line pairs admitted having made reference to the meaning of the Somali term for the word "distance", which also encompasses the idea of a walk or a journey; at the same time they admitted not knowing specific Somali terms within the framework of geometry (Bandiera 2009).

Fig. 8. "Examine the five pairs of lines. Draw a line segment in each pair that represents the distance between the two lines."



After attending the semester activities students' willingness to take the test rises considerably (from 55.2 to 89.8%) as does their correct performance (from 41.3 to 67.9%).

Nevertheless, signs of puzzlement associated with their still poor understanding of the task at hand persist, ranging from the unjustifiable completion of the semicircles to the drawing of random segments in the page space below (8%), partial or total reproduction of the pairs in the page space below (13%), or the explicit declaration: "Non capisco questa domanda." ("*I do not understand this question.).*"

Frequently (from 70.3 to 20.2%) they draw line segments at the extremes of each pair to "close" the space between the lines, for which no plausible explanation emerges: "Tutti sono chiusi perchè ha detto scegli la strada giusta. Grazie." ("*All are closed because he said choose the right way. Thanks*").

Statistically negligible, on the other hand, are some semester-end performances that could, nevertheless, be considered emblematic: there are the occasional "intentional" diagonal (not to be attributed to poor graphic dexterity) or continuous route (fig. 9).

Fig. 9. Adaptation of the figure and cancellation of the distances previously drawn in order to join the pairs by a single line, path, route.

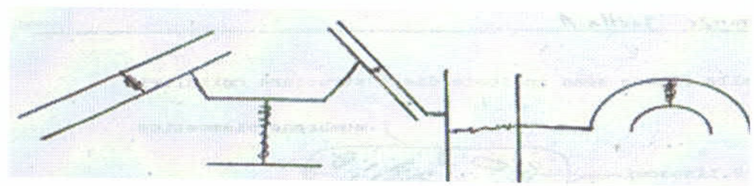
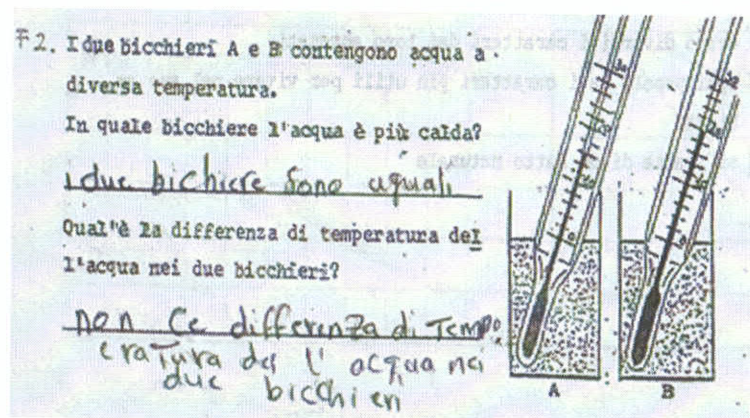


Fig. 10. "The two glasses A and B contain water at a different temperature. In which glass is the water warmer?" "*The two glasses are equal.*" "What is the temperature difference between the water in the two glasses?" "*There is no temperature difference from the water in the two glasses*"
Linguistic skill also influences performances on a test that makes strict reference to Physics skills.



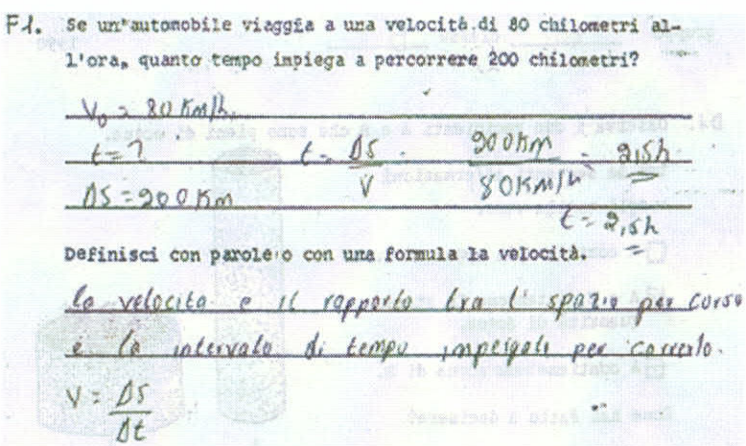
At both the beginning and the end of the semester approximately 90% of the students are willing to do this task. As regards "summary" measurement, i.e. comparing thermometer temperatures, the correct answer (B) is more frequent in the second semester (from 79.1 to 89.2%), but a noteworthy difficulty in taking an "exact" reading is witnessed by the range of errors in calculating the difference: 0, 0.5, 2, 5, 5.5, 6, 7, 7.5, 8, 10, 16, 17, 20 (50.5% total).

Moreover, the second task is interpreted as meaning "What is the difference between the two glasses" (32%): "La differenza è più caldo, meno caldo." ("*The difference is more hot, less hot.*"), "La differenza nei due bicchieri è la loro temperature non è uguale: uno più caldo, l'altro non è più caldo." ("*The difference in the two glasses is their temperature is not the same: one more hot, the other is not more hot*"), "Uno è caldo, l'altro meno caldo." ("*One is hot, the other less hot*").

3.6. Disciplinary skills - Physics

The test is a classic, elementary exercise requiring the application of a basic formula of kinematics:

Fig. 11. "If a car travels at a speed of 80 kilometres per hour, how long will it take to cover 200 kilometres?" "*v_0 = 80 km/h; t = ?; Δs = 200 km; t = Δs/v; 200 km / 80 km/h = 2.5 h; t = 2.5 h*" "Define speed in words or with a formula." "*The speed is the ratio between the space covered and the time interval spent for cover it. v = Δs / Δt*"


F1. Se un'automobile viaggia a una velocità di 80 chilometri all'ora, quanto tempo impiega a percorrere 200 chilometri?

V_0 = 80 Km/h

t = ? $t = \frac{\Delta s}{V}$ $\frac{200 km}{80 Km/h}$ = 2,5h

Δs = 200 Km

t = 2,5h

Definisci con parole o con una formula la velocità.

La velocità è il rapporto tra l' spazio per corso e la intervalo di tempo impiegati per correrlo.

$V = \frac{\Delta s}{\Delta t}$

Their attendance of the physics course seems to have impacted on students' willingness to do the task (from 86.4 to 97.4%), both in their use of the formula and on the correct resulting calculation in 77.8% of responses (compared with 34.7% at the start of the semester). Persistent errors (15.4%) mainly concern the inversion of the terms of the fraction (t = v/s, or 80/200, thus t = 0.4) and the transformation of the result of the application of the formula "2.5h", in hours and minutes (150 s, 2 hours and 30 sec, 2h 5m, 3 hours and 3 sec, 1449 sec, 0.041 min...). Errors are also recorded in ways of applying the formula (200 km: 80 Km/h), which mostly leads to a confused simplification of measurement units and, consequently, to expressing the result not in *h* but in *km*, *km*^{2} and *km/h* (2.5%).

Correct speed formulas rise from 29.1 to 67.7%. Peculiar and thought-provoking are nearly half of the verbal definitions recorded at the end of the semester: "La velocità è movimento di un oggetto che impiega tempo." ("*Speed is movement of an object that employs time.*"), "La velocità è movimento di un oggetto cioè diverse posizioni che l'oggetto occupato nello spazio durante il moto." ("*Speed is movement of an object, that is, various positions the object occupied in space during the motion.*"), "Se un automobi viaggia si dice aumentata la sua velocità." ("*If a ca travels it is said increased its speed.*"), "La velocità è distanto con spiaga da Mogadisci a Afgoi." ("*The speed is distanted with beac from Mogadisci to Afgoi.*"), "Velocità è quantità deve raggiunge un automobile luogo lui vuoli raggiungere." (*"Speed is amount a car has to reaches place he want to reach".).*

3.7. Disciplinary skills: Biology

Two tests: the first (fig. 12) is typically "notionistic".

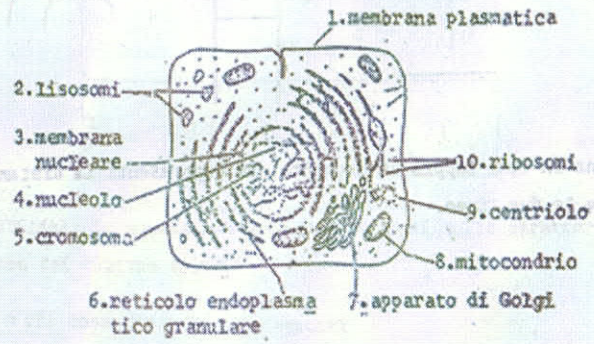
A full 97.9% of the students do the task (as compared with the 66.4% at the start).

Compared with results at the start (32.5%) 93.9% of the students correctly locate cell respiration in the "mitochondrion" cited in the figure. The increase in correct responses is lower (from 36.1 to 53.3%) for nucleic acid synthesis: the figure is lacking the classic "nucleus", which, nevertheless, the students cite frequently (24.3%). They correctly opt for "chromosome" (27.9%) or else are deceived by assonant terms indicated in the figure: "nucleolus" (28.3%) and the "nuclear" attribute associated with "membrane".

Compared with an initial 21.7%, 75.7% of students correctly locate protein synthesis ("ribosomes" – 68.6% – and "endoplasmic reticulum" – 5.5 – cited in the figure). The choice of "lisosomes" (6.1%) is to be attributed to its assonance with "ribosomes".

Fig. 12. "Ten cell structures are shown in the figure: 1. plasmatic membrane, 2. lysosomes, 3. nuclear membrane, 4. nucleolus, 5. chromosome, 6. rough endoplasmic reticulum, 7. Golgi apparatus, 8. mitochondrion, 9. centriole, 10. ribosome." "Specify where the following take place: cell respiration *Mitochondrion*, nucleic acid synthesis (DNA and RNA) *The nucleus*, protein synthesis *The ribosomes*."

B2. Nella figura sono indicate dieci strutture cellulari.



Indica dove avviene

la respirazione cellulare: Mitocondrio

la sintesi degli acidi nucleici (DNA e RNA): Il nucleo

la sintesi delle proteine: I Ribosomi

The second item tests speculative orientation by proposing three alternatives to explain the human population's diversity of features, all of which are correct to some extent and cannot, therefore, be mutually exclusive (fig.13):

Fig. 13. "Peoples living on various continents have very different features (for instance, skin colour, shape of face, height). How would you explain that? Choose from among the following explanations: a) their ancestors' features were different, b) each people has the features most suitable to its living environment, c) this is natural." *"It is not natural, but is a shape that Allah gave it to them."*

B4. I popoli che vivono nei vari continenti presentano caratteri molto diversi (per esempio, il colore della pelle, la forma del viso, l'altezza). Come lo spieghi?
Scegli tra le spiegazioni seguenti.

- ☐ erano diversi i caratteri dei loro antenati
- ☐ ogni popolo ha i caratteri più utili per vivere nel suo ambiente
- ☐ si tratta di un ~~fatto naturale~~ non è uno fatto naturale ma è una forma che Allah l'hanno dato.

Despite a limited increase in willingness to take a position (from 87.2 to 94.5%) no significant differences are noted in the choice of various alternatives: around 25% choose the reference to ancestors (a phenomenological observation); around 40% suitability to the environment (indirect adhesion to Darwin's Evolutionism); "natural fact" (abstention from explanation) drops 8%.

Some explicit references to religion persist, which initially led to some forms of hostility toward the question: "Allah crea così." ("*Allah creates so*"), "Ma anche altra cosa che non la sapete voi." ("*But also other thing you do not know it*").

3.8. Disciplinary skills: Geometry

The item tests familiarity with three primary plane geometry shapes, ability to draw them according to shape and dimensional correctness, and knowledge and application of elementary formulas. The only element of ordinary complexity is the indirect request to calculate the height of the right triangle. Two cases are given in Figures 14a-b:

Fig. 14a. "Draw a square whose side is L = 3 cm and calculate its perimeter (P) and its area (A)"

"$P = 3 + 3 + 3 + 3 = 12$ cm"

"$A = l^2 = (3\ cm)^2 = 9\ cm^2$"

"Draw a circle whose radius is R = 2 cm and calculate its circumference (C) and its area (A)"

"$C = 2\pi r = 2 . 3{,}14 . 2 = 12{,}56$ cm"

"$A = \pi r^2 = 12{,}56\ cm^2$"

"Draw an equilateral triangle whose side is L = 3 cm and calculate its perimeter (P) and its area (A)"

"$P = 3 + 3 + 3 = 9$ cm"

"$A = b.h / 2 = (3\ cm \times 3\ \sqrt{3}cm)/2 = (9\sqrt{3}/2)cm^2$;

$h = \sqrt{3^2}\ cm - (3/2)^2 = \sqrt{9cm^2 - 9/4}$; $h = (3\sqrt{3}/2)cm$"

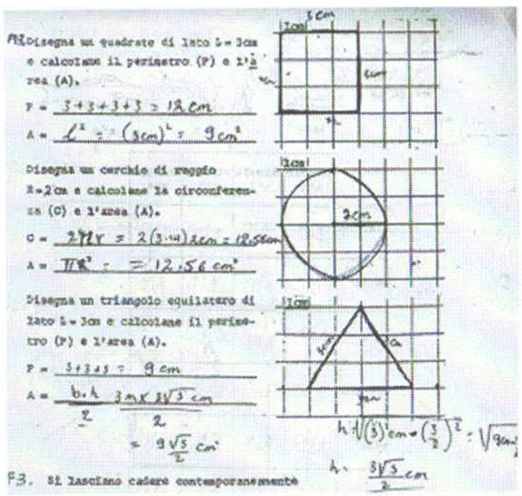


Fig. 14b. "Draw a square whose side is L = 3 cm and calculate its perimeter (P) and its area (A)"

"$P = 4 \times l = 4 \times 3\ cm = 12$ cm"

"$A = b.h = 3 \times 3 = 9$ cm"

"Draw a circle whose radius is R = 2 cm and calculate its circumference (C) and its area (A)"

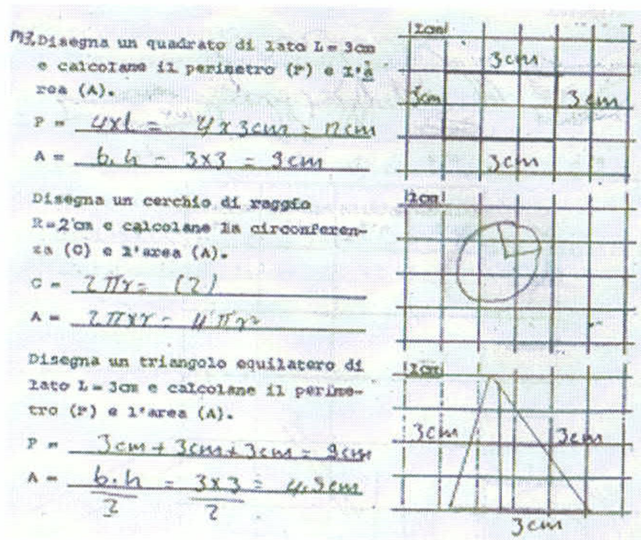
"$C = 2\pi r = (r)$"

"$A = 2\pi rr = 4\pi r^2$"

"Draw an equilateral triangle whose side is L = 3 cm and calculate its perimeter (P) and its area (A)"

"$P = 3$ cm $+ 3$ cm $+ 3$ cm $= 9$ cm"

"$A = b.h/2 = 3 \times 3 / 2 = 4{,}5$ cm"



Noteworthy and systematic are the increases in willingness to do the required drawings (from 72.4 to 91.7% for the square, 70.0 to 91.3% for the circle, and 70.0 to 95.0% for the equilateral triangle) as well as the calculations (62.8 to 91.0% for the square, 34.0 to 80.5% for the circle, and 42.4 to 91.2% for the triangle). The correct performance of the students who do the task also shows a large increase (e.g. calculation of area: from 49.6 to 95.0% for the square, 23.5 to 55.3% for the circle, and 2.8 to 11.7% for the triangle).

Despite clear evidence of the semester's general and generic success, some habits persist that are capable of interfering with specific learning or are indications of major cognitive and procedural gaps. Figure 14 provides some insight into that.

4. From past to future

In considering the data presented, first of all, the very long time taken to make a cultural transition on both the linguistic front as well as, we could say, the procedural one, has to be emphasised. The Somali students who underwent full immersion in the Italian language – five hours per day for at least eight months – do not seem to have satisfactorily overcome those comprehension difficulties capable of compromising proper fruition of the didactic offer of the science faculties; nor do they seem capable (as the examples show) of fully and unequivocally expressing their positions, albeit essential and schematic, in Italian. They have, however, acquired a sort of familiarity that induces them to embrace tasks almost systematically, apparently confident in their ability to understand, know, and perform – and certainly understanding, knowing and performing better than at the start of the semester.

4.1. Understanding

There are numerous clues that point in favour of a significant improvement in literal comprehension, from a systematic increase in willingness to engage, to the pertinence of the responses supplied. Margins of inadequacy appear, with "how did you make your decision?" being read as "what is your decision?"; or where "distance", in a context in which it is applied to "segment" and "line", continues also to mean "journey", leading to disorientation in those undertaking the task.

The persistence of cultural specificities occasionally alters comprehension, resulting in not determining which of two persons born in the same year is the older, or to elaborating a personal definition of "speed" with reference to experiences in daily life rather than to disciplinary constraints.

4.2. Knowing

Literacy training in scientific knowledge results in encouraging progress. It is necessary, moreover, to point out that in the context of a noteworthy level of success in identifying the cell structures in which certain functions take place, the prevalence of memorisation over so-called meaningful learning (Ausubel 1968) can be explained by the positive impact of the availability in the figure of the "name" of the structure chosen (and by the interference of terms named in the figure that sound similar to the ones memorised). This is confirmed, for example, by the frequent reference to nonsensical formulas in calculating the circumference and area of the circle (see $2\pi r/c$, $4\pi r$, $2\pi r^2$, $4\pi r^2$).

It could be hypothesised that this is one of the effects of imperfect memorisation in the absence of the ability to give geometric concreteness to the symbols ("π" and "r") that the students, correctly, believe they are to use. The application of knowledge (for example, the use of formulas) is a non-habitual and scarcely cultivated practice, as demonstrated in the positions taken when comparing cylinders, which the students very rarely examine on the basis of geometric coordinates. The analogy with Piaget's well known test for children (Piaget 1950) would legitimate reference, in a Western cultural context, to the pre-operational stage!

4.3. Performing

If one's vision of the world is based on the completion of vital concrete functions, only the object or event that has recognized value (e.g. in Somalia, the dromedary, which is called a camel) requires attention and accurate description (there are over 40 words to choose from when translating the word dromedary to describe phases in the life cycle, functions and features). Less important objects are subject to considerable degrees of approximation; summary characterization and sketching are usually sufficient. This could explain the frequency and range of errors in assessing the difference in temperature when observing the two thermometers represented in the figure, which involves the simple observation of the thermometric scale and the position of the mercury column. Even the interpretation of the task ("What is the temperature difference between the water in the two glasses?"), the response to which is that the water is more or less warm, is evidence of a superficial reading of the text and the context.

What also appears significant is the lack of conformity with the shape and size of the geometric forms both extracted from the complex figure as well as those considered in the explicit geometric context, where the frequency of approximation in drawings results as 1 out of 3 in the case of squares, 1 out of 2 for circles, 4 out of 5 for triangles, skewing overall performance of the task.

Indeed, it is possible that the prevailing representation of an isosceles triangle (base and height 3cm) in place of the equilateral one requested, is to blame for the incorrect use of h = 3 in the formula "(b x h)/2" for calculating the area, given that only one student in four applies Pythagorean theorem in calculating the height of the triangle. In the same item 50% of students' inappropriate use of "cm^2" for linear measurements and of "cm" for surface area – in other words, their absolute randomness of choice – would suggest their lack of recourse to relative skill or critical analysis of the result expressed, but also their acritical trust in the results of a prescribed procedure: application of formula, calculation, simplification.

Two additional observations: the first concerns the rotation of the cube, which is emblematic of a difficulty in gathering information from images in the absence of specific forms of training. It would be necessary to make reference not only to the iconoclastic aspect of Islamic culture and the oral nature of

the traditional culture (Ong 1982), but also to the highly limited diffusion of books and, in particular, of illustrated books (local markets sold biology textbooks without figures!).

The second concerns the rare, but existing, interference of religion in determining the causes for diversity in the features of human populations and the popularity of the "natural fact" alternative, a formula that, in fact, neither compromises nor explains.

At this point an attempt can be made to evaluate the substance and the positive outcome of the linguistic-cultural semester teaching project aimed at westernising Somali students, i.e. at preparing them to attend university science courses taught by Italian professors. Over the years adjustments were gradually made to the curriculum and methodologies employed, based on the data collected and on a type of analysis that led to an increasingly accurate definition of the students' learner profile. A strong constructivist approach was maintained (von Glasersfeld 1989), discouraging memorisation, rote learning and regurgitation, and foregrounding practices that later earned the label of active and cooperative learning (Sharan 1994, Silberman 1996). Foreknowledge, experiences and examples were solicited from students for the purpose of better contextualising the new material learned as it was treated. Reference tended more toward objects and events that could be meaningful to Somali students and "spontaneous" ways of perception and analysis were compared with scientific attitudes. Discussion was prompted, rejecting mere repetition of what had been said or read, as well as the use of paraphrasing.

Validation of the "adjustments" was monitored and a gradual increase in the differences between initial and semester-end performance were recorded, leading to that reported here. On the one hand, it was demonstrated that research activity could proceed in close parallel with the practical programme that was its object of study; and on the other hand, it would seem reasonable to surmise that, although students' full satisfactory competence was not accomplished, it would have been had the research been allowed to continue.

Therefore, it can be considered as well-founded the choice of proposing a propaedeutic activity aimed at heavily foregrounding acquisition of linguistic and transactional skill (Bruner 1986) on both procedural and conceptual terrains. Furthermore, the experience certainly supplied data crucial to the development of educational processes for conveying Western Science to non-Western learners. First and foremost, the need to understand the salient aspects of other cultures, even in the absence of the intention of navigating the intercultural dimension, precisely in order to be able to promote the constructivist teaching approaches that have been acknowledged as the most appropriate to teaching science to non-Western countries and students (Cobern 1996); and to be able, to that end, to carry out transactional and investigative activities with the tools, and within the timeframes, of "normal" academic activity. Last but not least, to adopt an approach to metacognition, i.e. to facilitate all the many aspects of student development ranging from academic skill to self-learning (Lin 2001).

While not directly pertinent, nevertheless significant and encouraging is the realisation that a Western teacher involved as a researcher or teacher/researcher in an intercultural educational project, is in a position to assert that the situation in itself, and the teaching dedicated to it, are a source of rich reflection on the skills, features and attitudes required for science-related learning. The resulting dividend is considerable growth in terms of epistemological and professional awareness.

Notes

[1] A large amount of didactic material was elaborated and validated: two Italian language textbooks; original Mathematics and Physics textbooks; a teachers manual (lexical analysis and classification of images) supplementary to the Biology textbook (H. Curtis and N. Barnes "Cellula, organismi e ambiente", Zanichelli); a lab manual supplement to the Physics textbook ("Esperimenti, esperienze e riflessioni").

[2] The entrance questionnaire was administered on 28 January 1990 to 388 students (78.5% males; 70.3% between 20 and 22 years of age, and 6.9% >25 years of age). The semester-end questionnaire was administered on 24 May 1990 to 420 students (79.8% males; 67.0% between 20 and 22 years of age; 6.5% > 25 years of age). The students were enrolled in 6 scientific faculties and subdivided into a total of 24 classes of from 15 to 22 per class.

[3] In the following paragraphs, devoted to the essential skills and abilities required to define the student profile, the above-mentioned items and their relative data are presented in a concise form. "Willingness" is to be construed as any way of confronting or attempting to complete a task. Percentages regarding student performance assessments refer to the subsample made up of those who proved willing.

References

Aikenhead, Glen (2002). Whose Scientific Knowledge? The Colonizer and the Colonized. In: Roth, Wolff-Michael & Jacques Désautels (eds.), *Science Education as/for Sociopolitical Action*. Peter Lang, New York, pp. 151-166.

Ausubel, David P. (1968). *Educational Psychology: A cognitive view*. Rinehart & Winston, New York.

Bandiera, Milena (2008). Per una didattica interculturale delle scienze. In: Fiorucci, Massimiliano (ed.), *Una scuola per tutti. Idee e proposte per una didattica interculturale delle discipline*, Franco Angeli, Milano, pp. 176-203.

Bandiera, Milena (2009). The cross-cultural dimension of science education. In: Puglielli, Annarita (ed.), *Lessons in survival: The language and culture of Somalia. Thirty Years of Somali Studies*, L'Harmattan Italia, Torino, pp. 113-135.

Bandiera, Milena & Carlo Serra Borneto (1994). Interazione tra lingua e pensiero scientifico: propedeutica linguistica presso l'università nazionale somala. *Atti dei Convegni Lincei, 107, Lingua, pensiero scientifico e interculturalità: l'esperienza dell'interazione universitaria in Somalia*, Roma, pp. 99-122.

Bandiera, Milena, Lucilla Cannizzaro, Anna Ciliberti & Carlo Serra Borneto (1989). *Materiali di lingua italiana per scopi accademici*. Il Bagatto, Roma.

Bruner, Jerome (1986). *Actual minds, possible world*. Harvard University Press, Cambridge, MA.

Bowles, Samuel & Herbert Gintis (1976). *Schooling in Capitalist America: Educational Reform and the Contradictions of Economic Life*. Basic Books, New York.

Cobern, William W. (1996). Constructivism and Non-Western Science Education Research. International Journal of Science Education 4, 287-302

Corson, David (2001). *Language Diversity and Education*. Lawrence Erlbaum Associates Publishers, Mahwah, NJ.

Coulby, David (2006). *Intercultural education: theory and practice. Intercultural Education* 17(3), 245-257.
Eckstein, Max A. & Harold J. Noah (1985). Dependency theory in comparative education: the new simplicitude. *Prospects* XV(2), 213-225.
Horton, Robin (1967). African traditional thought and Western science. Part I: From tradition to science, Part II: The "closed" and "open" predicaments. *Africa* 37, 50-71/155-187.
Lacey, Hugh (2007). The Interplay of Scientific Activity, Worldviews and Value Outlooks. Science & Education 18, 839-860.
Lin, Xiaodong (2001). Designing Metacognitive Activities. *Educational Technology Research & Development* 49(2), 23-40.
Mazrui, Ali A. (1975). The African University as a Multinational Corporation: Problems of Penetration and Dependency. *Harvard Educational Review* 45, 191-210.
Ong, Walter J. (1982/1986). *Oralità e scrittura. Le tecnologie delle parole.* Il Mulino, Bologna.
Piaget, Jean (1950). *Introduction à l'épistémologie génétique.* Presses Universitaires de France, Paris.
Sercu, Lies (2004). Assessing intercultural competence: a framework for systematic test development in foreign language education and beyond. *Intercultural Education* 15(1), 73-89.
Serra Borneto, Carlo (1981). Problemi relativi alla costruzione di materiale linguistico per scopi speciali con particolare riferimento al Corso di italiano per l'Università Nazionale Somala. In: Puglielli, Annarita & Biancamaria Tedeschini Lalli (eds.), *Studi Somali, Vol. 3, Ricerche sull'insegnamento dell'italiano in Somalia*, M.A.E., Roma, pp. 43-67.
Sharan, Shlomo (ed.) (1994). *Handbook of Cooperative Learning Methods.* Greenwood Press, Westport.
Silberman, Mel (1996). *Active Learning.* Allyn & Bacon, Boston, MA.
Tedeschini Lalli, Biancamaria & Milena Bandiera (1988). Approccio sperimentale alla propedeutica linguistica e scientifica dell'Università somala. In: Puglielli, A. (ed.) *Third International Congress of Somali studies*, Il Pensiero Scientifico, Roma, pp. 378-394.
von Glasersfeld, Ernst (1989). Cognition, Construction of Knowledge, and Teaching. *Synthese* 80, 121-140.
Watts, D. Michael & Arden Zylbersztajn (1981). A Survey of Some Children's Ideas about Force. *Physics education* 16, 360-365.