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The ethical duty to divulge geosciences and the improvement of communication skills to fulfil it

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In recent years the commitment to disseminate the geological knowledge, making it available for citizens and decision-makers, has been recognized as a precise ethical duty of the geologist. However the fulfilment of the duty to disseminate the geoscience knowledge requires good communication skills that should be adequately trained, since often the university studies don't include such training. A specific research has been carried out to explore the possibility to develop a short training course capable of improving the expressive and communication abilities of professionals. A set of exercises has been also expressly developed to improve the metacognitive skills of the participants (metacognition is the knowledge and regulation of one's cognitive activities in learning processes). The course has been delivered to professionals belonging to the Professional Association of Engineers (FOIT) in Turin, Italy, and has been able to significantly improve their expressive and communication abilities, increasing their interest and willingness to divulge their knowledge, recovering their confidence to succeed in this task and helping them to become more effective communicators. The contents of the course are now available, upon request, for anyone interested in teaching it elsewhere and/or improving its contents. Providing both professional and research geologists with means to renew their interest and ability to communicate can be a useful contribution to raise their (geo)ethical conscience and to help them to more easily carry out their ethical commitment.

Introduction

In recent years the commitment to disseminate the geological knowledge, making it available for citizens and decision makers, has been recognized as a precise ethical duty of the geologist, and more generally of all those who deal with geosciences. These disciplines, in fact, address issues that have obvious repercussions on society, such as the defence against natural risks, the exploitation of natural resources, the air and water pollution, the climate change (Bobrowsky et al., 2017). These issues affect very closely populations often unprepared to face them and condition in the long-term the economic and cultural development systems of human communities (Peppoloni and Di Capua, 2014). A debate concerning the ethical, social and cultural aspects of geosciences has been promoted worldwide in the last years by the IAPG – International Association for Promoting Geoethics (www.geoethics.org). Ethical principles and values promoted by IAPG can constitute a framework of reference able to orient geoscientists towards an ethical behaviour in performing their scientific and professional activity. A result of the efforts of IAPG has been the recent proposal of a Hippocratic-like oath for geoscientists (named the "Geoethical Promise") (Matteucci et al., 2014). Noteworthy, this Promise expressly includes, among the duties which each geoscientist should undertake, the commitment to communicate and transfer the geological knowledge to the different components of society.

Disseminating geological knowledge means making the population aware of the value of the territory and georisks to which it can be exposed. It also means to enable the population to monitor and evaluate the performance of those who practically take decisions on the territory. Moreover, informing and transferring scientific knowledge to politicians is the essential pre-requisite to create better conditions for an efficient planning of interventions on the territory. In addition, an effective communication in the increasingly frequent multidisciplinary collaborations, that imply the interaction between colleagues with different scientific and professional skills, may facilitate and optimize their actions and the achievement of common goals, with the benefit of the entire community. Finally, the transmission of geological concepts and methods to students is one of the most delicate tasks of geoscientists engaged in teaching activities and so it requires a great sense of responsibility.

Geoscientists and professional geologists would therefore need some efficient teachings and a specific training to improve their communication skills. Since university studies often don't include such teachings and training in their formative offer, we developed a course and several practical exercises specifically addressed to improve expressive and communication abilities and to raise the interest and willingness of participants to communicate. The course and the exer-

cises, which have been developed through years of research and investigation, have been beforehand successfully tested with different groups of volunteers belonging to the Professional Association of Engineers (FOIT) in Turin, Italy. The teachings have proven to be capable of involving the active participation of professionals, researchers and managers with years of career and work experience behind them. They were free to abandon the course in every moment, but they followed, instead, all the lessons to the end with great interest, finding the concepts useful and the exercises stimulating and profound. This is testified by the numerous e-mails of acknowledgment that they spontaneously sent to the secretary of FOIT. According to their testimonies the course gave them a renewed ability to communicate creatively and to successfully disseminate their knowledge.

Efficacy (or Inefficacy) of the Communication

In order to adequately divulge the geological knowledge, we should first investigate in more detail how it is learned. In a famous essay, the science philosopher Thomas Kuhn (1922–1996) writes that scientific knowledge (Khun, 1962):

"*... is not acquired exclusively through verbal means. It is rather acquired gradually, as the words are presented along with concrete examples of how they work in practice. Nature and terms are learned together. The result of this process is a tacit knowledge that is acquired while doing science instead of while learning rules for doing it. ...*"

If Khun is right, then some possible difficulties in teaching and divulging knowledge can be predicted in advance. These difficulties will appear at the moment in which the reverse operation will have to be carried out, that is when a person, instead of learning, will try to transfer to others the knowledge that he/she has acquired. In particular, teachers may lose sight of their own long training and therefore they may in part omit the steps that were necessary for them to come to learn what they know today and try to teach to others.

The outcome of this oversight could lead to the attempt to transmit knowledge without granting enough time for the acquisition of terms and concepts and, above all, without using a simplified and alternative language to do it. Translating into simple words, a knowledge tacitly learned could be not easy at all and leave too many teachings, concepts and ideas unexpressed. Students may also miss the chance to gain enough experience and moments in which "Nature and terms are learned together", to express it with the words of Khun.

In this case the outcome would be inevitably an ineffective communication of knowledge to students. Such inefficiency has already been observed and denounced by distinguished teachers of the past. Richard Feynman (1918–1988) and Gustavo Colonnetti (1886–1968), for example, are unanimous in acknowledging the small number of college students capable of demonstrating at the exams to have understood their subject and not just to have studied it (Colonnetti, 1978; Feynman et al., 2005). Feynman even comes to declare his own educational failure and to agree with the English historian Edward Gibbon (1737–1794) in arguing that:

"*the power of teaching is rarely of any efficacy except in those fortunate cases where it is almost unnecessary*" (Feynman et al., 2005).

If such a problem certainly exists in schools and universities, that are institutions specifically dedicated to teaching and training, it inevitably may occur also in any other educational activities, whenever a researcher or a practitioner has to communicate to the public the results of his/her work. The final outcome may be an ineffective communication of knowledge and information or even the complete lack of its transfer. This, of course, would result in the non-compliance with the above-mentioned ethical duty.

A closer inspection reveals that similar difficulties in communicating knowledge may be found among colleagues working in different disciplines, when they have to teach or communicate information to each other. Also the geoscientist who has to communicate the results of his/her studies or the purpose of the interventions he/she has designed to politicians and decision makers may meet the same difficulty.

Probably, another element may concur to make things even more difficult and to prevent an effective communication: the automatism that inevitably becomes part of the communication. Learning a language and learning to drive a car are very similar activities. After a person has learned to drive a car, many of its actions are performed automatically. A very similar phenomenon occurs in the use of language. Once a person has learnt a certain number of terms and has been trained to communicate with them, the communication becomes to a certain degree automatic. From then on it might be difficult for that person to express itself in an original manner, adapting its communication to the different kinds of audience to be faced. Similar mechanisms of automaticity may be found in many other fields and human activities. As an example, they may affect the manager of a company who gets used to a certain set of rules in managing his daily activity and dealing with the market. As Grove, famous CEO of Intel, has observed (Grove, 1996), when a sudden and significant change occurs in industry and in the marketplace, many managers find it very difficult to change their habits and many of them may often fail in the newly born environment. Their failure is mainly due to the automaticity developed during their previously successful career, that they now are not able to recognize and modify. Another very famous and renown character, Steve Jobs, has generalized the concept. As he states in an interview mentioned in his biography (Isaacson, 2011), "*... thoughts construct patterns like scaffolding in your mind. In most cases, people get stuck in those patterns, just like groves in a record, and they never get out of them*."

The end result of all the above teaching and communication difficulties, which affect the entire population, is testified by Tullio De Mauro, internationally renowned linguist, who stated in 2011 that 80% of people in the Italian society do not have the needed lexical competences "*to orient themselves and solve, through an appropriate use of the language, complex situations and problems of the daily social life*" (Corriere della Sera, 2011).

A large percentage of the general public, that geoscientists would like to address with their teaching and divulging efforts, certainly belong to the 80% of people without enough lexical competences mentioned by De Mauro. This might be discouraging and might be a reason of the limitations and resistance that some geoscientists may encounter to divulge their knowledge.

Is there any solution to this state of affairs?

An Experimental Approach

The results of a specific work of research and testing, carried out to

Figure 1. One of the lessons delivered at FOIT in 2015 to thirty professionals, members of the Professional Association of Engineers of Turin (other photos and details at: http://www.irpi.cnr.it/en/focus/preserving-quality-scientific-knowledge-information/).

Table 1. Information regarding the participants to the course delivered at the Foundation of the Professional Association of Engineers (FOIT) in Turin

Locality	Dates	Number of participants	Average age (years)	Profession	Schooling
Turin, Italy	March, 2015 May, 2017	40	40	Professional engineers	University training

this purpose in 2015 and 2017 at the Foundation of the Professional Association of Engineers (FOIT), would seem to provide an encouraging answer to the question posed at the end of the previous chapter. Providing the geoscientists and other geosciences professionals with tools to improve their expressive skills and to more easily address their public could certainly be a solution.

The research has been conducted by a multidisciplinary team named "Sapercapire", consisting of experts in geosciences and other disciplines, including psychologists, doctors and drama teachers (www.sapercapire.it). A course has been set up and organized to improve the expressive and communicative ability and it has been delivered to forty professionals, members of the Professional Association of Engineers of Turin (Fig. 1, Table 1).

Thanks to a series of specific exercises, expressly designed to improve the metacognitive skills of the individual, it has been possible to produce a significant improvement of the capacity of expression and communication of the participants, their desire to communicate and their trust to succeed. Metacognition was originally referred to as the knowledge about and regulation of one's cognitive activities in learning processes (Veenman et al., 2006).

The first part of the course consisted of a series of exercises that have revealed, that many participants don't know the precise meaning of terms of their own disciplines and professions, as well as common words of the Italian vocabulary. The exercises proved that De Mauro was quite right about the small percentage of people capable of a competent use of their lexicon. The exercises acted as tests to prove this particular fact. In Table 2, two of the exercises are shown to provide an example.

Table 2. Example of two of the exercises provided to the participants during the first part of the course at FOIT

	YES	NO	MAYBE
Which of the following substances is a fluid?			
• water			
• wine			
• air			
• oil			
• methane			
Which of these words is a grammatical term?			
• his			
• the			
• adverb			
• for			
• pronominal particle			

Among the participants, 45% gave more than one wrong answer to the tests proposed. For instance, with regard to the tests of Table 2, some of them answered that air and methane were not fluids. Others answered that "his" or "the" are grammatical terms. The exercises, besides

correcting eventual wrong interpretations, served to increase the awareness of the audience about the importance of knowing the precise meaning of words. In particular, it helped the participants to realize that the same lack of knowledge that they experienced may affect every audience that they could have to address. Participants learnt how to pay attention to the choice of words and to the clarification of their meaning while addressing a specific audience.

The exercises produced three important results:

1. they significantly increased the interest of participants in the proposed teachings and exercises;

2. they increased the trust of participants about the possibility to improve their expressive abilities and, consequently, their chances of more successful future communications;

3. they taught to recognize the lack of understanding of an audience, its origin and how to solve it.

All the exercises that have been developed and proposed can be provided to anybody who were interested, to offer the chance to replicate the course elsewhere, provided that some adjustments could be needed when translating the course contents in a different language.

In order to improve the ability to regulate the cognitive activities of participants and develop their awareness about them, some further exercises have been specifically addressed to train learners to put into words elementary knowledge, non-scientific but tacitly acquired, like the concept of shadow, sea, bottle, clothing. In fact, the modality of the knowledge acquisition described by Khun is similar to those adopted by the child in the learning of the language. Much of the language can therefore be learned tacitly, without the need of a subsequent stage of verbalization and expression of the acquired knowledge.

It has been surprising to observe every time the difficulties faced to perform such a task by the majority of the students, and the improvement of the quality of expression produced by these exercises, properly driven.

Before the experience at the FOIT, the exercises had been tested at length during the years on a generic public, of different ages and cultural backgrounds, proposing them at public events such as the "European Researchers Night" or, more recently, the "Science Festival of Genoa". During this latter, in particular, some facilities were presented to improve knowledge and understanding of the debris flow phenomena (Dutto et al., 2015) and the risk related to such natural events (Arattano et al., 2010), taking advantage by the improvement of the capacity of expression and learning granted by the exercises built to facilitate a more rapid assimilation of the concepts by the public.

In general, exercises have all been aimed to provide learners with a greater awareness and mastery in the use of language and to improve their communicative ability. The improvement obtained has been verified and confirmed by the participants themselves, through a series of subsequent interviews and the creation of a mailing list, through which many of them have voluntarily told us and shared very significant experiences.

The most peculiar and significant feedback has been given us by some students who stated they had discovered of being capable of a more effective and direct dialogue with their younger children. Facing with the typical questions of children, addressed to satisfy the childish curiosity, they have been able to offer effortlessly simple and effective solutions, fully suitable to those young interlocutors, and to relate to them in full harmony.

Improving the Simplicity and Quality of Exposition: the Search for Hypernyms

In order to provide a further idea of the type of exercises developed and used in the course taught in FOIT, we have chosen to describe another exercise that proved to be particularly effective in making students able to communicate more easily and with better quality. The exercise is founded on principles of basic linguistics and may enhance the ability to rapidly choose the best lexicon to address any kind of audience, including children.

The exercise is aimed to let the students identify the hypernyms of some of the names we use daily. Hypernym is a linguistics term used to classify lexical units that have a more general and extended meaning than other units (hyponyms), which the hypernyms themselves include. Thus, for example, "furniture" is the hypernym of "chair", "wardrobe", "table", etc. In turn, chair, wardrobe and table are hyponyms of furniture.

The hypernym and hyponym concepts have not only a mere classificatory function, but also interesting applicative implications. In fact, to identify the hypernym of a name (hyponym) means to single out its distinctive character, the fundamental nature of the object to which that particular name refers. That distinctive character is what joins together the different hyponyms of that hypernym, making possible their grouping in a specific category whose name is identified by the same hypernym. The distinctive trait that unites a wardrobe, a chair and a table, in fact, is that all of them are objects used to furnish a house and, as such, they belong to the category of "furniture".

The hypernym of a name is also the first word which is useful and appropriate to start with when defining it. For example, we will define a chair saying first that it is a "piece of furniture". Then, we will append additional features that will differentiate it from other types of furniture. The Great Italian Dictionary by Hoepli (Gabrielli, 2015), for example, defines a chair as "a piece of furniture for one person to sit, of various shape and style, consisting of a variously shaped seat having usually four legs, joined or not by crossbars, and provided with a back."

Therefore, exercising a student to identify the hypernyms of the common names that he/she more frequently uses, also helps him/her to express with greater ease and simplicity concepts previously acquired in a silent manner (like those above mentioned: "shade", "bottle", "chair"). So, thanks to the exercise of searching for hypernyms, it is possible to help a student to bring to light and to express more easily a considerable amount of knowledge he tacitly acquired during the learning process of the language. Thus the exercise improves the expository simplicity of the student and his/her effectiveness in communicating. It is crucial to be capable of choosing the most correct and appropriate hypernym to explain a concept, as many of the tests we have carried out have shown, because this can facilitate the understanding of the interlocutors from the very beginning of the explanation.

On the basis of the didactic experience accumulated over the years, it has been possible to observe that this exercise also helps to develop the student's judgment and at the same time trains his/her ability of making a choice. In fact, there is often more than a single and unequivocal hypernym for each name. For example, the "sea" is defined by some dictionaries as "extension of salt water that covers most of the earth's surface", so identifying the extended surface as a distinctive characteristic of the sea. Other dictionaries define the "sea" as a large mass of salt water, high-

Table 3. General information regarding the participants in the exercises of search for hypernims delivered at the Science Festival of Genoa in 2013

Locality	Date	Number of participants	Average age (years)	Profession	Schooling
Genoa, Italy	November, 2013	1030	30	High school students (60%) General public (40%)	Unavailable

lighting as its distinctiveness the (large) amount of water (mass) it consists of. Which is the most correct of the two choices? Probably it is not possible to establish this, as indeed it is a matter of taste, judgment, choice and of course also of the context in which the word is used.

How the Exercises were Developed and Tested prior to the Course at FOIT

The usefulness of identifying the hypernyms of nouns and improving the capacity of their rapid identification had already been verified before the teaching experiment at the Foundation of the Professional Association of Engineers (FOIT). This actually happened for most of the exercises and concepts of the course. For instance, the "search for hypernyms" exercise had been tested with participants at the Science Festival of Genoa in 2013, as previously mentioned (Table 3).

On that occasion, new phenomena and concepts were explained to a completely unprepared public. In particular, the phenomena of debris flow were presented to an audience that had never heard of them before. For about an hour and a half, the audience, divided into groups of about 30 people each and accompanied by a dedicated trainer, was guided along a multimedia tour. The debris flow was introduced initially by showing some videos of the real phenomenon, and then, by using an interactive 3D educational video (Fig. 2).

Before giving further verbal details, the concept of hypernym was briefly introduced and some exercises on this subject were proposed to the public. At the beginning, generic names were used for the exercises and only later the audience was asked to try to identify what could be the correct hypernym to describe the phenomenon (a debris flow) observed in the videos, starting a fruitful debate.

Previously the public had been informed that searching for hypernyms equates to try to answer the question: "What is it, in one word?".

Figure 2. The 3D educational video shown to the public at the Science Festival in Genova, in November 2013. The video allows a direct interaction of the public with the debris flow process through a joystick and 3D glasses (Dutto et al., 2015).

Soon the public realized the difficulty to use only one word to describe the hypernym of the phenomenon that had been observed in the didactic videos, and so an expression consisting of multiple terms was searched for. In fact, it is often not possible to indicate a hypernym with a single word and a locution must be searched for. For example, "sea" may require the use of the three words "expanse-of-water", "animal" may need the two words "living-being" and "pencil" the two words "writing material". During the debate at the Science Festival the expression "debris flow" was sometimes proposed by the public itself among the many possible hypernyms, together with others very similar to it. At the end of the debate the audience was informed that the scientific community had chosen just the locution "debris flow" to name the phenomenon, among the many possible hypernyms. So, it was highlighted that there is always a certain degree of arbitrariness in the allocation of terms (scientific and not) and that these can also vary from one language to another (in Italian the term was adopted to name the debris flow is "colata di detriti", which is not the literal translation of the English term).

Once the hypernym was found that was the most suitable to describe what the public had seen in the videos, we went on, letting the public try to describe the phenomenon in the most complete and exhaustive possible way. To facilitate this task, we first resorted to the exercise of fully and exhaustively describing simpler objects and concepts, such as "apple" and "cube". Only later we ventured to define what the debris flow is. At the end of this educational process, a satisfactory and exhaustive definition of the debris flow almost always emerged.

This type of approach has allowed to get a much more participatory lesson, which ended, according to many participants, with a sense of mastery not only of the phenomenon, but also of the terminology used to classify and study it. It was interesting to note, in some cases, that the audience got curious and asked how the main variables of the phenomenon (velocity, height, etc.) could be measured, allowing us to introduce the concept of "debris flow monitoring" (Arattano and Marchi, 2008; Coviello et al., 2015), "experimental equipped area" (Comiti et al., 2014), "alarm sensors development" (Arattano et al., 2015) and, in certain cases, even "standardization of the measurement procedures". The public has appeared always enthusiastic and quite amused by the experience. Such a participation of the public, if recreated with similar tools and exercises, would make much easier the introduction of concepts and terms such as "risk" and "prevention" that are fundamental for their implications in the daily life of the population and therefore deserving a proper communication.

The success of this specific initiative at the Science Festival in Genoa suggested us to introduce the exercise of search for hypernyms among the other topics and exercises of the course at the FOIT.

Conclusions

Nowadays, the knowledge at disposal of society does not include the opportune and basilar information on the geological processes and

dynamics that undoubtedly can affect life and development of human communities.

Among all their obligations, geologists are ethically called to fill this gap, through education and information to citizens and decision-makers, as well as to professionals working in different fields of activity and to students. The effectiveness with which geologists, or more in general geoscientists, can transfer this body of knowledge to an audience of non-specialists depends on their ability to communicate in a simplified way concepts and experiences and on the possibility to use tools not only scientific but also linguistic and expressive.

Transferring scientific knowledge to society requires competence and professionalism, but it implies even the responsibility of everyone to ensure the appropriate preparedness and the necessary attention to the way of communicating that knowledge.

Providing geoscientists, both professionals and researchers, with means to renew their ability to communicate and be understood can contribute to develop an ethical consciousness and to easier carry out their ethical obligation to serve society in the best possible way.

An experimental course has been developed to provide the above mentioned means. The course contents have been successfully tested on a sample of volunteers belonging to an association of professional engineers. The original exercises proposed in the course have produced important observable results among the participants, including an increase of their interest to improve communicative skills and their trust to be more successful in future communications.

The course could be easily reproduced by other teachers and/or scientists and could be introduced as part of the university training of geoscientists worldwide, further testing its validity in improving communication skills.

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