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From Spatial Intelligence to Spatial Competences: The Results of Applied Geo-Research in Italian Schools

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Abstract

This contribution explains the connection between spatial intelligence and spatial competences and by indicating how the first is the cognitive matrix of abilities necessary to move in space as well as to represent it. Indeed, two are principal factors involved in the spatial intelligence: orientation and representation. Both are based on a close interaction between spatial thought and movement in space. I show the basic features of spatial intelligence through the analysis of specialist literature. This point, however, requires a further step to be taken into consideration: how can spatial intelligence be strengthened together with the related spatial competences? Moreover, which branch of knowledge is the most suitable to do so? By referring to the existing literature on the subject, we would like to indicate that geography has a pre-eminent role in dealing with the connection between man and space and as such it is the most suitable academic discipline to aid the development of spatial abilities through a series of precise didactic activities.

The second part of this paper presents an experimental prototype of this kind of targeted teaching activity following the research-action method, an approach where theory and practice meet allowing a systematic collection of data. In effect, the stages of an experimental framework which has allowed the spatial intelligence of primary school children to be developed has been described and the methods of monitoring the results have also be illustrated.

Keywords: spatial intelligence, spatial competence, teaching/ learning of geography, geo-research

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Introduction

The theme of spatial competences of contemporary relevance as well as the recent literature on the subject highlights its cognitive matrix (Seitinger, 2009; Gunzelmann, Lyon, 2011). My suggestion goes in this direction but links the cognitive matrix to the theory of multiple intelligences which includes spatial intelligence ability. The discovery of the cognitive roots of spatial competences, as we shall see, allows us to recognize their connection with spatial thought and consequently allow us to develop didactic experiments which will strengthen the ability. At this stage, however, a number of questions must be discussed and clarified: what is intended by spatial intelligence, what is the connection between spatial intelligence and spatial competences, what is the link between these cognitive processes and learning ability?

According to Gardner (2000, 2010) and Chen, Moran and Gardner (2009) spatial intelligence is based upon the ability to transform perceptions, organize information into cognitive maps, and to propose clear and appropriate reproductions. According to Maier (1998), spatial intelligence is the ability to move in space, to orientate oneself, and to be able to think, plan and represent it. Other authors emphasize the cognitive value of spatial intelligence and give less importance to the skills useful in spatial movements. Eliot is convinced that the spatial intelligence "refers to a very broad range of capacities" (Eliot, 2002, p. 479). Diezmann and Watters claim: "Spatial intelligence may manifest as a particular aptitude for thinking and communicating spatially" (Diezmann, Watters, 2000, p. 301).

Gardner's ideas have also given rise to different research projects and experiments which have tried to observe spatial intelligence through an observation of how geometry problems were resolved or in the development of a child's ability to appropriate space for itself. Gardner's work can therefore be considered to be in continuity with the work of Piaget (1981). This standpoint is supported by Diezmann and Watters (2000) that suggest a correlation between spatial intelligence and achievement in mathematics. On the other hand, Grow (2011) enhances the correlation with the design.

"The spatial intelligence manifests in a variety of ways. Transforming mental images is a spatial skill that engineers and designers depend on. When a hiker pauses with map and compass, it is the spatial intelligence that conceptualizes the path. Through the spatial sense, a painter "feels" the tension, balance and composition of a painting. Spatial ability is also "the more abstract intelligence of a chess master, a battle commander, or a theoretical physicist", as well as the familiar ability to

recognize objects, faces, and details" (Grow, 2011). In agree with these authors, Van Schaik (2008) and Seitinger (2009) consider the spatial intelligence as a capacity basic to the design.

Other research considers spatial intelligence as a transversal capacity which is useful for everyday life but which cannot be characterized in any specific and distinctive way, as are, for example, linguistic or mathematical ability (Chen, 1993), or as something rather useful for learning the natural sciences (Reiss, Boulter, Tunnicliffe, 2007).

These research projects have never defined the connection between spatial intelligence and spatial competences. Concrete action thus seems to be more a consequence of operative ability than of cognitive competence. However, on closer examination, as Gardner makes clear, spatial intelligence is nurtured and strengthened by the continual interaction between eidetic thought and movement in space. It is characterized, in fact, by the capacity to make good use of space as well as by the cognitive elaboration of images. It seems to be necessary, therefore, to return to Gardner's original idea of spatial intelligence to put aside the operative conception and rediscover the cognitive matrix by highlighting the relationship between man-space as a whole. In this context are interesting the papers about the cognitive sciences (Balcomb, Newcombe, Ferrara, 2009) that study the mental representation systems.

Indeed, space is not just a context for human existence, but also an organizer of knowledge (Pontecorvo, Pontecorvo, 1994). The continual process of inter-relationship does not involve man solely at the material level, for physical orientation, for the use of resources, for environmental adaptation, but allows man to develop a series of abilities useful for the conceptualization of space. The ability to orient in space, therefore, leads us back to spatial thought, to the capacity to construct images. "We thus see a regular progression in spatial development, from the capacity of infants to move in space to the capacity of small children to form static images, to the capacity of school-age children to manipulate these static images, and, finally, to the capacity of adolescents to connect spatial relations to verbal explanations" (Gardner, 2000, p.200).

A complex process between subject and object is so created: the concrete daily relationship, while strengthening physical abilities, is also stimulus to knowledge and develops spatial intelligence. The functionalist conception of space is thus superseded in favor of an interactive relationship between subject and space. A re-reading of Gardner's original thought makes clear, therefore, that spatial intelligence is the cognitive matrix of human activity in space as well as being its 'primary fuel'. This relationship becomes evident if we study the two chief aspects of spatial

intelligence: orientation and representation. This relationship between orientation and representation has to be reinterpreted following Gardner's ideas, in order to go beyond the distinction made by Piaget (1981) between "practical" space and "representative" space which was too clear-cut and didn't seem to correspond to facts; in fact, to move in space is not always only a sensor-motoric activity, neither is it an exclusively conceptual fact for 'representational ability'. Man is able to orientate himself in space on the basis of his experiences, which however are conceptualized thanks to spatial intelligence. Furthermore, man represents them through cognitive maps thanks to a continual inter-relationship with the environment. This synergy therefore confirms the close connection between spatial thought and use of space, as well as between spatial intelligence and spatial competences. We can therefore state that spatial intelligence considered as a whole is made concrete through a series of competences, the principle of which are orientation and representation. This clarification, however, itself requires further elucidation: how is it possible to develop spatial intelligence and the related spatial competences? Which academic discipline is the most suitable to do so? How can the potential of spatial intelligence transform into useful concrete competences?

Geography and the development of spatial intelligence

Our proposal is made with reference to geography. It is an academic discipline which emphasizes the relationship between man-space and makes greater use of representations such as charts and maps, photos, etc. Geographers have continually made use of and highlighted the relationship between man and space from different points of view.

The relationship between spatial information and visual-spatial experience has been highlighted. Bosch, Mecklinger, and Friederici (2001) have studied cognitive resources and their relationship to performances. The attention paid to abilities has also given emphasis to practical activities. Goodchild (2007) has studied the possibility of acquiring spatial concepts through field activities. Lobben (2007) has carried out research on which abilities are useful to people who find themselves in an unknown area and are trying to orient themselves with the sole aid of a map. Some scholars have looked at the relationship between psychology and geographical education and on how people think of space in an effort to understand how spatial thought develops (Liben, 2002).

Other geographers have highlighted the GIS (Geographic Information Systems) because it is the kind of technology which aids spatial thinking (Golledge, Bell, 1996; Golledge, Marsh, Battersby, 2006). Gaughran (2004) has emphasized the relationship between spatial intelligence and GIS elaboration.

More specifically, the behavioral revolution has highlighted the importance of subjective perception in the relationship between man and space and on this basis; since time_geography has developed an interest in the cognitive aspects relating to activity in space (Gold, 1980; Bianchi, 1987). On the other hand, the formation of cognitive cartography has been studied, that is to say, how, through the memorization of images, we manage to construct mental maps that are of use to us in our movements and which also give is the ability to predict (Naish, 1982). An attentive study of the literature makes clear that geography has continually and from different points of view studied the relationship between man and space and is therefore the most suitable academic discipline to aid in the development of special capacity.

The role of geographical education

However, in order to make any development effective, another factor is necessary: the teaching element. Teaching plays an important role and it cannot be considered as the habit of adapting to the environment (Moloney, Bloom, 2001).

Such a complex interaction finds didactic activity beneficial because it acts as a filter for gaining knowledge, for interiorising knowledge, and for the representation and communication of space. Specifically, geography becomes the key factor in the preparation of activities which consider the knowledge of the reality which surrounds us and the language of representation as fundamental.

Spatial competences have to be rooted in a cognitive matrix through didactic mediation which renders the subject both competent and fully present in the process of planning and constructing the territory. Surveys conducted by psychologists (Pontecorvo, 1997) emphasised the importance of didactic mediation for the development of spatial competences.

Teaching, however, should be active and based on laboratory experimentation, and to be able to have an impact on competences. The development of spatial competence should be a permanent aspect of every level of education, but of fundamental importance is the experience obtained in the primary school years. The experience should be both systematic and scientific so as to allow a verification of the results.

Then, in the next paragraphs I will show how you can enhance spatial intelligence and related competences through specific educational activities. I will illustrate how this approach has been applied in the Italian primary school.

Italian primary school and the development of spatial competences

The development of spatial competence is a theme which has been present in Italian ministerial indications[1] since 2007, *Guidelines for the Curriculum,* with specific reference to this stage of the educative process and to the discipline of geography also (De Vecchis, Pasquinelli, Pesaresi, 2011). As the ministerial documents indicate, schoolchildren must learn how to "move knowledgeably in the surrounding space" and to "learn to move and orientate themselves following their own mental maps" and "represent" environments and territories.

As can be noted, the basics of spatial intelligence are proposed and translated into objectives to be achieved by the teachers and competences to be learned by the schoolchildren. At the same time, the ministerial indications suggest to teachers to develop a teaching by competences method, which means a teaching approach which strengthens schoolchildren's ability 'in doing' through laboratory activities.

The procedure which we here present has been warmly welcomed by primary school teachers because it is in line with ministerial recommendations and of value from a methodological point of view in the development of teaching competences.

Experimentation in schools

As we said before, it is also necessary that any experimentation is to be carried out in a systematic and scientific way so as to be able to verify the results. The most suitable methodology for this is the research-action approach.

Teaching methodology research is to be understood as applied research or research-action in which theory and practice meet, theoretical reflection and on-the-field experimentation, as well as systematic gathering of the results.

Research-action is a methodology based on a well-established literature. According to Henry & Kemmis (1985) research-action is a form of self-reflective enquiry undertaken by participants in social situations in order to improve the rationality and justice of their own social or educational practices, as well as their understanding of these practices and the situations in which these practices are carried out. According to Nunan (1990), it is trying out ideas in practice as a means of improvement and as a means of increasing knowledge about the curriculum, teaching, and learning. The result is improvement in what happens in the classroom and school, and better articulation and justification of the educational rationale of what goes on. Research-action provides a way of working which links theory and

[*] Italian ministerial indications are available from http://www.pubblica.istruzione.it/normativa/2007/allegati/dir_310707.pdf

practice into the one whole: ideas-in-action. It has a diversified approach, as Amado and Levy (2002) have made clear. Some authors place a greater emphasis on the monitoring of activity whilst others emphasise observation and the results obtained. The latest developments, as Renè (2008) has again proposed, consider research-action methodology as a suitable method of obtaining knowledge by working in a group and by structuring experiences with new meaning.

The methodology itself is based on a series of steps: first a theoretical stage in which a research group reflects on a theme, followed by further stages in which activities are engaged in and a final stage of reflection on the coherence between theory and action.

This approach has been used for the experiments which we will illustrate below and which relate to the development of spatial intelligence through geographical education. The following are the steps to be applied:
1) the creation of a team formed by researchers and junior school teachers
2) a discussion within the team of the themes presented in the preceding paragraph
3)the establishment of the principle objectives of the research-action (a strengthening of spatial intelligence through the study of geography)
4) the establishment of targeted teaching activities
5)an observation of the schoolchildren in order to observe the effective development of spatial intelligence
6) a monitoring and documentation of the entire process.

Experiments which have already taken place will be taken into account. A number of research projects (Sarno, Barone, 2004; Sarno, 2006; Sarno, 2008; Sarno, Siniscalchi, 2011) have demonstrated through a statistical analysis the development of spatial competence in children of nursery school age. Through a series of finalised educational activities, both the development of spatial intelligence was demonstrated as well as the related competences. Following on from the research conducted on this theme, we would here like to document a research-action pathway which permits the development of spatial competences in junior school children.

Experimental making

To be able to elaborate a scientifically correct framework, I have developed an applied research project in which teachers and students of two primary schools in Molise and some university students studying geography in the faculty of Primary Education Formation Science at the University of Molise (Italy) and who were in training in these same institutes in the years 2005-2007.

The framework, developed following the logic of research-action and in continuity with experiences matured in a preceding experience (Sarno-Barone, 2004; Sarno, 2008), was structured in such a way as to create a balanced synergy between school and university; in effect, the school-teachers applied themselves to the observation of the pre-requisites considered necessary in children and to plan and elaborate work units. My task was to discover the spatial competence that needed to be developed, develop the monitoring system for the entire project, and to gather the data relating to learning. The trainee university students participated in the experience by acting as points of contact between school and university. The survey, which lasted for about two years, involved six teachers and two university trainees. The sample group was significant because it was made up of 85 children coming from the second, third and fourth years of primary school, all attending two schools in the town of Campobasso.

The two schools were chosen because they have been working with the university for some time and have been the places where students have been training as well as having often taken part in teaching projects which have given them a certain experience in the research-action approach. Three classes were used in each used school: a second, a third and a fourth year junior school class, as this was to guarantee coherence in the research. In this way, six classes participated in the experiment, making a total of 85 school children and 6 teachers, to which we should add two university trainee students and myself as the co-ordinator of the research. Having established the team and sample of school children to be used in this experiment, we followed the above-mentioned protocol. Moments of discussion were initiated and space was given to an analysis of the prerequisites**.**

The initial theoretical reflection was based upon the experience of nursery school pupils, where the development of spatial intelligence occurs essentially in terms of orientation and representation. In our role as teacher-mediators we structured the project in such a way as to verify that the children had matured the capacity for orientation and representation during the passage from nursery school to primary school. Adequate observations were made as well as simple proofs to check that they were able to make a correct use of their spatial-environmental experiences, to describe them using graphs and to carry out some basic activities. The two macro-competences of orientation and representation were further sub-divided into the following micro-competences:

1) follow simple paths in space (classroom/school);
2) use objects and elements from the environment in a creative way;
3) explore and observe;
4) group together, compare and order objects on the basis of given criteria;

5) carry out measurements;
6) locate objects, people discriminating from a distance, from nearby, from in front and behind etc.
7) represent simple pathways.

The discussion which followed allowed us to highlight the fundamental bases of spatial competences also taking ministerial indications into account. With reference to the ministerial recommendations, it was also clarified what was intended by orientation and representation in primary schools. At this stage of the formative process, the cognitive code has to be of support not only for an initial recognition of the surrounding reality, but must guarantee both a reading of the territorial system and the possession of a series of tools to represent it using geo-graphics and geo-writing with an ever greater awareness.

For these reasons the two macro-competences for the primary school have been identified to be 1 - the territorial viewpoint and 2 - the multi-perspective representation (Sarno, Siniscalchi, 2011). Therefore, they have been taken as variables for the investigation.

The development of a territorial viewpoint allows the pupils to comprehend that the territory is a system to be understood with all its characteristics, analysing its ties and interrelationships, starting with an experience of the territory to which each belongs, up to acquiring a clear mental map of Italy as a complex territorial structure, both diversified and built upon interdependence. This experience requires the development of a second macro-competence, which synthesises the capacity of representation through description, pictures and maps (Fig. 1).

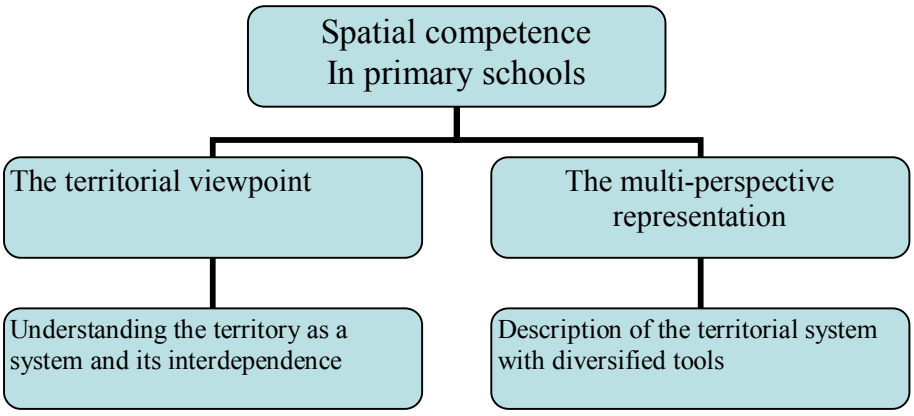

Figure 1. *An elaboration of spatial competence in primary schools*

After theoretical reflections and the verification of the prerequisites following the research-action methodology, the teachers planned a series of teaching activities that would strengthen the two macro-competences identified and the methods of observation to be used for the results.

From the moment that the children demonstrated that they possessed this background, they were deemed ready, from the second year on, to mature both territorial and descriptive competence, for which the teachers, together with the university trainees, then planned coherent work units which were built in such a way as to give maximum emphasis to on-the-field experiences, such as exploration of their own municipality, exploration of the itineraries of the neighbourhoods around the school, and experiences through play to get to understand the territory to which they belonged. Going out required an active participation and the collection of information and note-taking, which made possible a subsequent process of abstraction and generalisation, useful for the development of the ability to interpret the phenomena observed. The children could in this way acquire a territorial viewpoint and become acquainted with the diverse ways of representation and consequently to geo-writing, that is to say, a way of describing referential texts, and to geo-graphics, that is, to using pictures and maps both as a codified source and as something to be produced autonomously.

Scientific elaboration through monitoring has allowed us to put together the results and to verify the growth of the two macro-competences. Through intermediary verification, often based on play, the teachers and the trainees noted that the children matured a territorial viewpoint which was understood as the 'stratigraphic' capacity to recognise territorial elements, to notice their links, and to be able to understand the systemic logic of the territory, as for example, when the roads of the landscape were considered as links to follow in order to discover the buildings, churches and structures, to see the fountains as functional resources, and the mountains or the sea in their interaction with man-made structures.

Some files were created to monitor the results obtained and observe progress made. They were particularly useful because they not only allowed us to monitor the work done, but they also represented the operative scheme for the students in their understanding of the logic of the territory and of the diversified ways of representation. By working on the files, they were able to concentrate on the processes observed, and understand them both in their entirety as well as in their complexity. All the results were gathered and tabulated in graph form in order to understand the results of the entire sample, as figure 2 shows, which summarises in percentage terms the results of the monitoring: 80% of the sample group understood

the territory as a system and understood the relationship between natural and anthropic data.

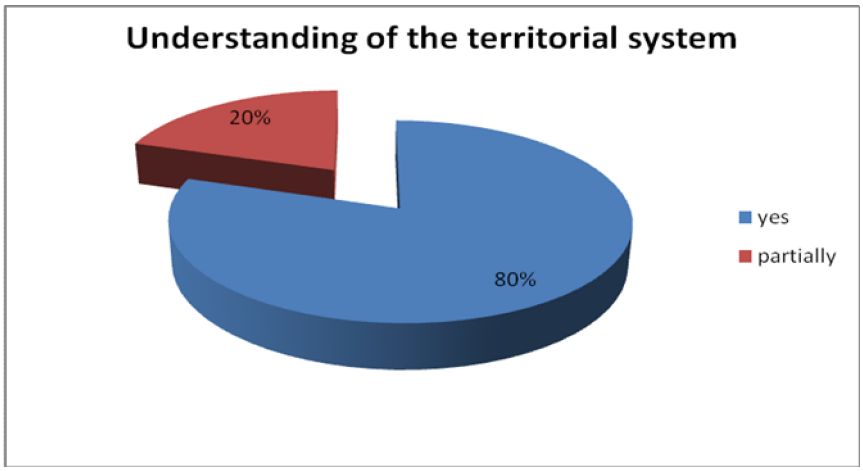

Figure 2. *80% of the sample group developed and strengthened the competence defined as territorial viewpoint*

As far as the multi-perspective representation is concerned, the children gradually acquired a number of useful tools, ranging from the vocabulary necessary for descriptive language to the autonomous productions of mental maps (fig. 3).

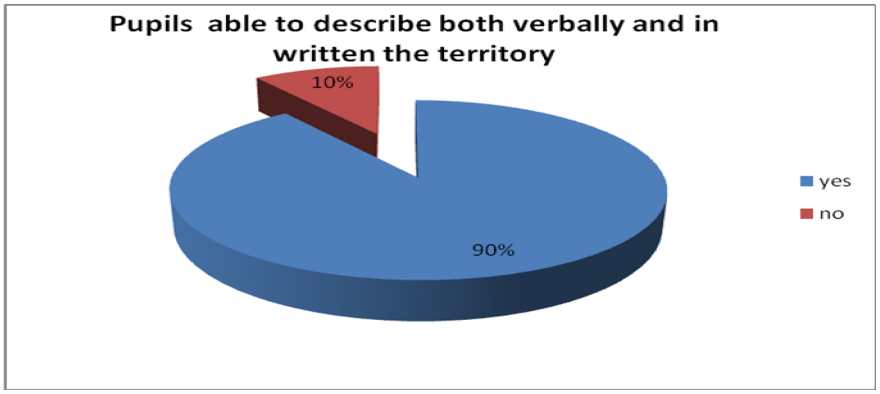

Figure 3. *90% of the sample group developed and strengthened the competence described as multi-perspective representation*

Conclusions

The results are therefore valid; although we must emphasize that the experiment was a methodological prototype. The sample used was certainly too limited but the systematic nature of the study was significant and can thus become the starting point for further and wider similar experiments.

The experiment has demonstrated how targeted teaching activities are valid in the development of spatial intelligence. As we have illustrated through an analysis of the literature, spatial intelligence is aided by concrete experience which is the way to strengthen spatial thought. Geography is the academic discipline which is particularly useful for its development because it acts on the two fundamental aspects of spatial intelligence: orientation and representation. The other important element of this approach is the understanding of the link between geography and spatial intelligence, which is something which past literature has not paid sufficient attention to, having emphasized instead the observation of results through mathematics, informatics or through transversal situations (Maier, 1998; Nicolini, 2000; Aszalós, Bakó M. 2004). The experiment emphasizes the value of the particular nature of spatial intelligence, which is made up of both cognitive and operative experiences which are at the origin of many spatial abilities necessary in daily life as much as in observation as in movement.

The case study has, therefore, demonstrated that a scientific and verifiable framework has been created, and that the pupils matured spatial competences suitable to their programme of study and necessary as a prerequisite for progressing to secondary school. The path shows that the development of spatial competences is characteristic of geographical knowledge according other papers (Sarno, Barone, 2004; Sarno, 2005; Sarno, 2008). The experience was useful for the synergy created between schools and universities, whilst the teachers took part in a formative on the job process, working in the classroom together with the pupils. In this way, both teaching and learning came happily together and produced enduring results. Furthermore, the interested participation of teachers indicates that this approach can be used in the daily teaching successfully.

Geo-didactic research, therefore, can promote the analysis and development of spatial competence through on-the-field experience, leading to a form of applied research through scientifically organized pathways and the systematic collection of data.

Biographical statement

Emilia SARNO has a PhD in Historical Geography, and is researcher in educational methodology at ANSAS-Molise, as well as a professor of Geography at different Italian Universities from 2000. She has published numerous books and papers about geography didactics and historical geography. About the geography didactics, her focus area concerns teaching methodologies, relationship between geography and spatial intelligence, geography education.

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