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MODELS OF SOCIAL CONSTRUCTIVISM, LABORATORY TEACHING AND CONCEPT MAPS TO BUILD SCIENTIFIC KNOWLEDGE AND ORGANIZE CONCEPT NETWORK

TEACHING EXPERIENCES IN FIRST LEVEL EDUCATION IN ITALIAN SCHOOLS

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Abstract. Through the various experiences described by a group of teachers involved in an innovative project about science teaching, this paper aims to show how some students, 6- 13 year olds, when given the opportunity to live and operate in a particularly stimulating and significant learning environment, are able to gain knowledge via constructive processes. While social constructivism provides reference guidelines in educational-teaching practices, concept maps are a tool used to promote, organize and synthesize acquired knowledge, while meditating on thinking operations. Teaching action is situated in significant operative contexts, in which students are driven to ask questions, make hypotheses, analyze facts, make connections, verify ideas, and create concepts. A science laboratory is a cognitive space where answers can be found to multiple questions and issues derived from observation of scientific phenomena. Teachers are aware that knowledge is not transmitted, it is built by students. Knowledge building is not a lonely, individual operation, it is a process created by sharing experiences and discovering meanings together with peers and teachers. Concept maps accompany all stages of knowledge building and are an effective teaching instrument to strengthen cognitive and metacognitive strategies, helping students to build a structured, significant knowledge network.

1 Overview

This paper is the result of analyses and reflections on strategies and methods used in teaching practices by a group of Italian primary school teachers (6-11 year old students) who have been involved for a few years in an innovative project in the field of science teaching. Some classes of junior high school participated in the project (11-14 years old). The title of the project is " The words of science". The teachers involved in the project are: Baldoni M.O Berionni A., Borioni A., Ceccotti G., Cimetta M.L., Giardina F., Liviabella I., Lorenzetti F., Morettini C., Moscatelli A.M., Passeri S., Pastuglia R., Pavoni L., Ranaldi G., Rossi G., Valloscuro M., and Zamponi D.

The project is based on systematic use of concept maps and laboratory teaching. Maps and laboratory teaching give 6-12 year students the opportunity to operate in a particularly stimulating learning environment that creates the necessary conditions for personal knowledge building.

Students are players and protagonists during teaching activities through a continuous process of discovery, investigation, research and synthesis. Students attempt to give answers to multiple questions arising from the observation of scientific phenomena or from the solution of problematic issues. In this context, the building of concept maps allows students to become aware of their knowledge building processes whilst also representing the knowledge synthesis operated by students.

2 Science laboratory and learning environment

Science laboratory activities are structured around the search for coherent and correct answers to questions aroused in students through random or programmed observation.

The questions asked spontaneously by students are not "basically different" from those that guide and urge investigations, discoveries and definition of scientific theories. Evidently, in view of the very young age of the students, questions arise from within a context of factual experiences where real knowledge may still coexist with misconceptions and fantasy.

Science teaching with a laboratory teaching method orientates the search for answers and coherent and correct explanations through learning processes in which students work and interact to gain the new knowledge that will allow them to read the cause of scientific phenomena or the explanation of observed situations.

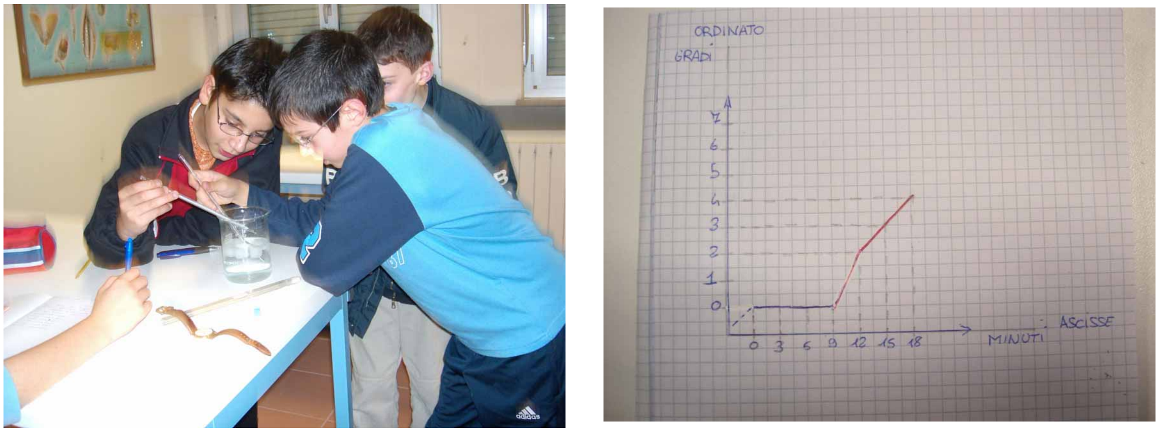

Figure 1. Junior High School first-grade students (11 years old) ask questions, make hypotheses and verify them to calculate latent heat of fusion.

In this teaching practice students and teachers play well-defined roles, that is to say invert the direction of traditional transmissive teaching, creating a learning-teaching process in which the student is given a central role as protagonist and the teacher a second-level role as organizer, guide and facilitator of teaching processes.

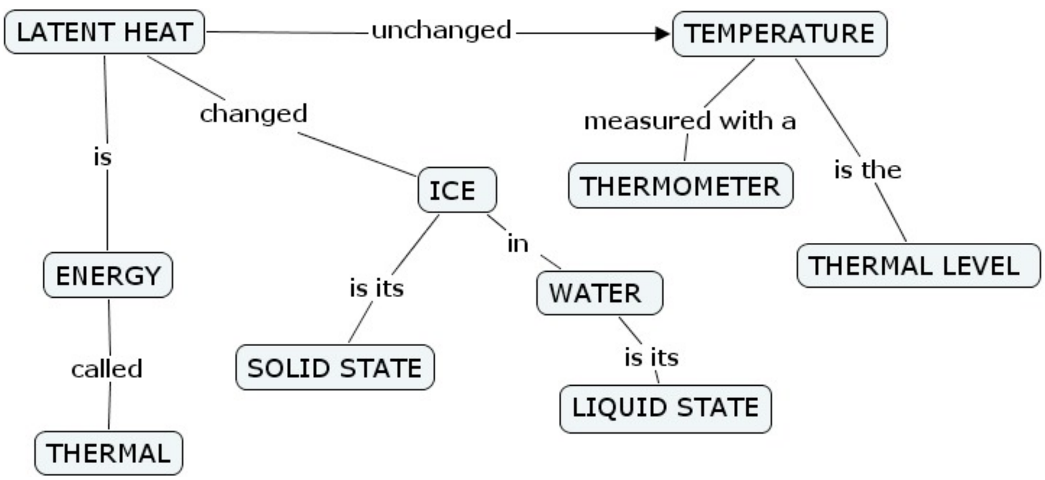

Figure 2. Concept map built by students to express the knowledge acquired during laboratory teaching session.

2.1 Designing the learning environment

Designing a science laboratory means to elaborate teaching practice and teaching role in a constructivist approach in which knowledge gained by students is an active process. The teacher prepares and organizes materials, procedures and relevant contexts to urge and guide self-learning processes.

With his/her expert map, the teacher defines:

- the knowledge field to promote
- the aspects to investigate
- the knowledge synthesis at which the students should arrive.

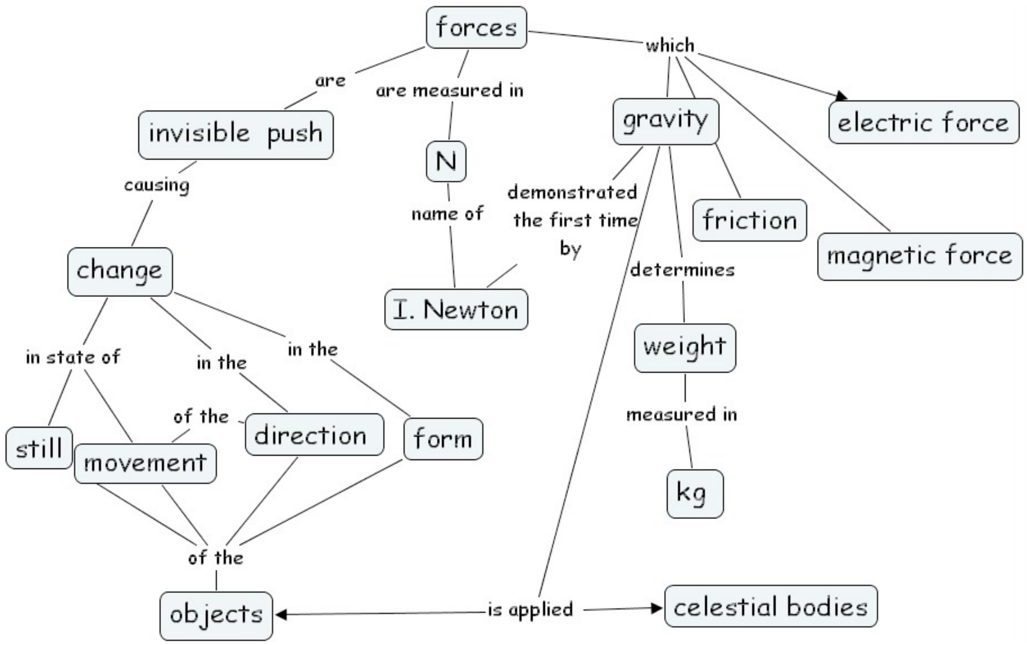

Figure 3. Programming map of a large teaching unit on forces in fifth-grade primary students (10-11 years).

Once activities start, the class of students becomes the protagonist and each student is the main actor in a knowledge process that generates significant learning whenever students structure, integrate and reconfigure their previous knowledge. The teacher recedes from the foreground and only provides inputs, stimuli, suggestions to strengthen and direct the thinking procedures and strategies activated by the students.

2.2 *Promoting and addressing knowledge processes*

Receding from the foreground means for the teacher to avoid giving explanations, examples and direct answers, whilst guiding students towards active processes, such as analysis, observation, comparison, and the search for alternative routes in problem-solving.

Knowledge is considered an active, unique and personal process for each student through interaction and social cooperation with the other students of the class in a perspective that refers to social constructivism paradigms (Varisco 2004). Consequently, the teaching activity is expressed according to three guidelines:

- to address the students' action towards multiple routes, searching for logical, coherent solutions and explanations, solicited and anchored with a concrete context;
- to promote collaboration, discussion, mediation, negotiation with the other students;
- to use language and c-maps as tools for reflection, reasoning, analysis and synthesis.

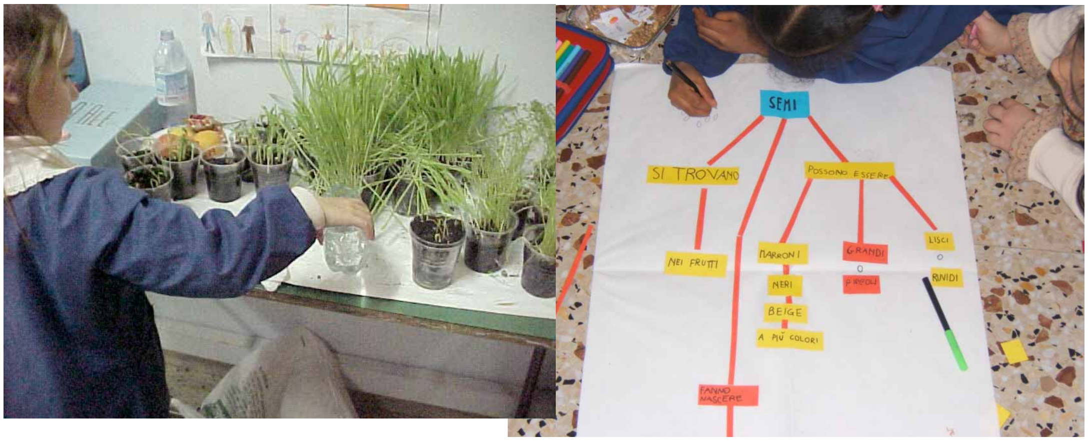

Figure 4. 6-7 year old students make laboratory experiences to understand seeds. They build the first c-maps divided into small groups with 3-4 students in each.

The science laboratory becomes the learning environment where students work together, helping each other, and learning how to search for and use tools and resources in problem solving situations. The teacher facilitates, encourages, promotes activities in which students interact, design, express and discuss solutions, ideas and theories.

2.3 The role of language

In the different phases of teaching activities, verbal communication and conversation among students are used to clarify thinking processes, express doubts, highlight intuitions, logical connections, including doubts, perplexities, misunderstandings, incoherent associations, errors.

Language and thought express themselves and get enriched with new elements in a circular relation of mutual influence (Piaget 1979). Students build disciplinary micro-languages that are well structured and anchored in the processes of significant learning. The teacher records significant interventions, stimulates conversation, collects and directs coherent interventions, promotes reflection, and stimulates students to search for other elements to confirm or refuse the hypotheses made.

Through dialogue students mediate their knowledge with the group and activate efficacious strategies to achieve the new knowledge, operating in what Vygotskij (1980) defines as *proximal development zone*. The laboratory creates the cognitive space in which new tasks and knowledge can be faced through communicative and social relations with peers and teacher.

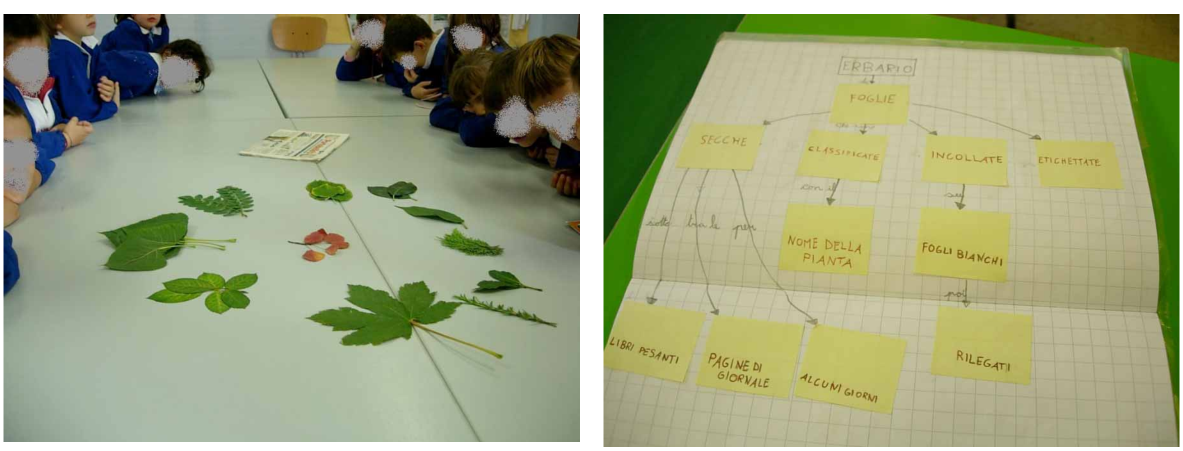

Figure 5. Through language and guided conversation 7-year old students elaborate the experiences made when making a herbarium and synthesize them with a c-map.

2.4 Building a concept map

In these teaching practices concept maps are the most significant process and are systematically used by the students to express and synthesize the knowledge they have acquired. Students operate individually using the concepts identified through the communicative-cognitive mediation operated with peers. The result is maps that show the knowledge that the learning context has produced in each student. Each map therefore allows the teacher to evaluate the learning process.

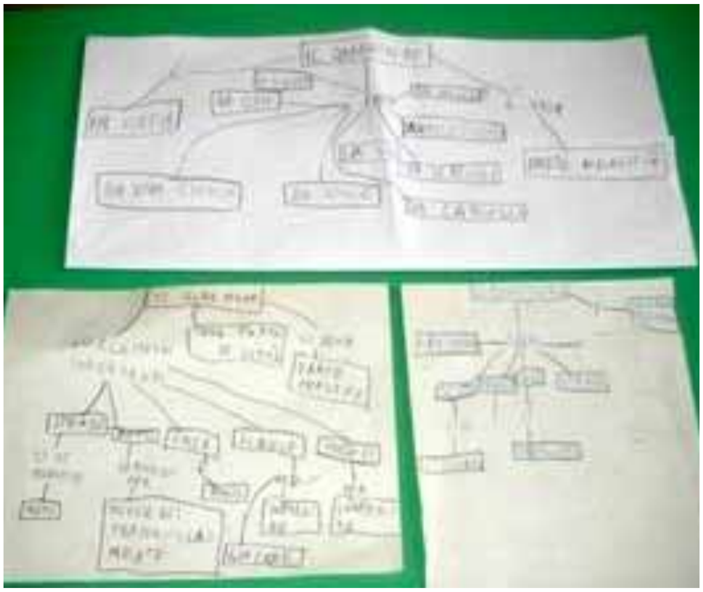

Figure 6. The maps individually prepared by third-grade primary school students (8-9 years) show that each student has activated personal learning processes and structured new knowledge in a personal way.

Likewise, emerge weak, poorly thought out structures from students who have structured on incomplete cognitive synthesis presenting misconceptions and errors. In these situations, maps make the teacher aware of specific educational needs of some students. The teacher does not correct errors directly but guides students towards self-correction through a series of inputs. Also in these cases mediation and interaction with peers is extremely effective, especially when students share and discuss individual maps to work an additional synthesis before building the group map.

Figure 7. (Third-graders /8-9 years). The group map is created on a large table with sheets and labels that can be moved and modified. This allows students to work in group in a functional, constructive way.

The abilities of each student come into play through dialogue and collaborative interaction. Each diversity of thinking is an opportunity for personal enrichment and growth. The building of the group map provides an additional opportunity for reflection and realization of meanings, including them in a reticular structure that is a social and shared construction of knowledge. Another strategy used by the teacher is to give students a map structure with some concepts, while other concepts must be added by the students. In other situations the students work on maps with concepts only and must include links, or vice versa.

Being a tool for knowledge, concept maps accompany students along their entire school career. They start building maps in first grade of primary school (6 years old). The map allows students to represent their knowledge through a reticular structure, which uses a limited number of elements and rules, which are easy to acquire and use.

The first maps are built playfully in large spaces. Concepts are represented by objects or drawings. Connections are described and explained. In this way students structure meanings and at the same time learn the “syntax" of the map, becoming aware of space and meanings that labels, arrows, concept-words, and links have in it.

Figure 8. 6-year old students building the first concept maps.

Secondly students realize that c-maps can be used to "tell" their knowledge. The building of the map becomes a dynamic process, by moving, deleting, and integrating elements on paper. Pencils, erasers, post-it notes are the working tools.

The use of CmapTools (Cañas et al. 2004) software allows students to fully experiment the potential of concept maps, such as their capacity of being reticular, dynamic and adaptable to thought processes.

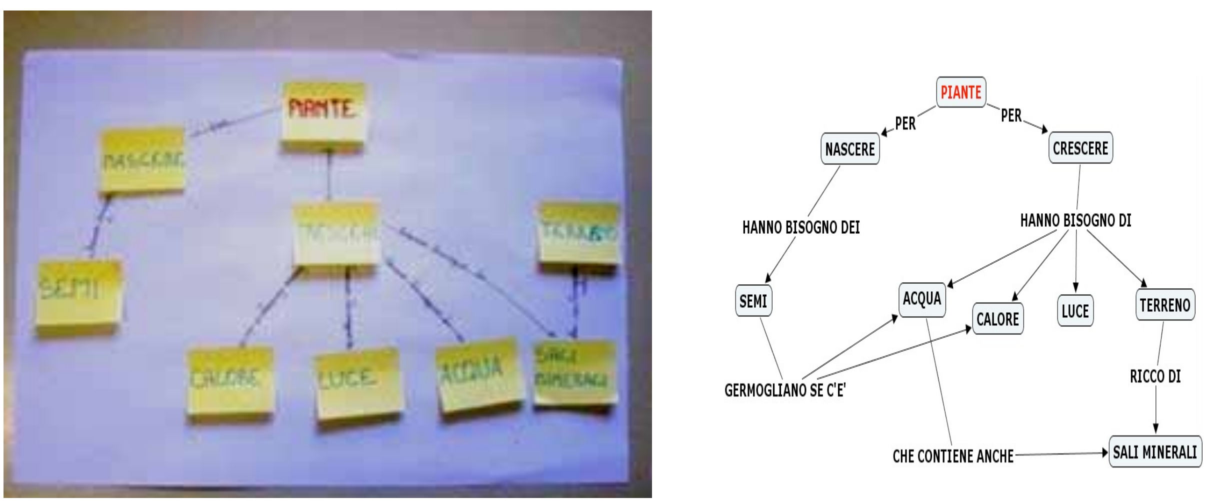

Figure 9. Group maps built by 8-year old students.

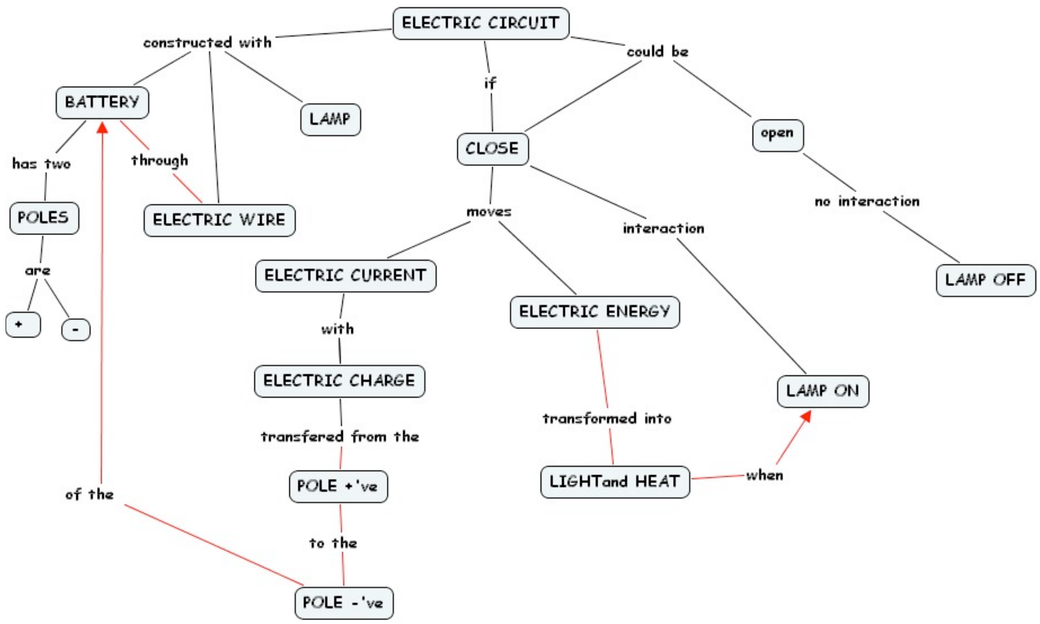

Figure 10. Group map built by 10-year old students.

Although the early use of concept maps creates the ideal conditions to promote significant learning, nevertheless students can familiarize with this metacognitive instrument at any time along their educational process.

This year teachers from a junior high school have joined the teaching innovation project for science teaching and a first group of 16 students from first and second junior high grade (11 - 13 years old) are using concept maps in the science laboratory for the first time. A second group of 28 students uses concept maps as a tool to acquire or strengthen their studying method. In spite of being a very recent initiative (3 months), significant aspects have been identified for analysis and reflection. Students and teachers using and experimenting this metacognitive tool for the first time, can therefore understand how this system helps them to organize and structure meanings and knowledge.

The potential of maps and CmapTools becomes clear when maps are used, contextualized, and represent a knowledge field or space. At first, some problems may appear if the said field refers to a large topic, because students are not used to structuring knowledge in a reticular configuration through submaps and are not able to introduce everything they want only one map. Once students are guided to organize a map outline, showing the plot to generate other connected maps, the work will continue without any problems and students will discover that maps can help them to reflect, organize and synthesize the knowledge they have acquired. Using the maps becomes an effective means for all students, regardless of the skills they have already acquired, because they stimulate metacognitive reflection processes and contribute to make a structured synthesis of any educational topic. Maps give each student, including students with difficulties, an additional instrument towards significant learning.

3 Summary

The teaching experiences described in this paper have proved especially effective since they are guided by an educational and training model that privileges laboratory discovery and problem-solving processes and procedures in a cooperative group.

In this context concept maps support and substantiate the different steps faced by students to build meanings and knowledge. They become a method and a strategy to promote significant learning, combining the leading role of the single students (individual map) with the group cooperative mediation (group map). Moreover, the maps play a relevant role in the acquisition of metacognitive competences, because they induce reflection and thought , through a reticular structure, on the knowledge that students have acquired or assume to have acquired.

Thinking, reflecting, representing a knowledge "space" through maps, means to test a personal knowledge experience, which is likewise mediated and enriched through dialogue and interpersonal-social communication.

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