Educational Robotics and Adolescents from Disadvantaged Contexts. A Research Path on Communicative Mediation

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ABSTRACT: *The paper analyses 7 educational robotics workshops carried out by the University of Milano-Bicocca from February to April 2021 at the «Antonia Vita» Popular School in Monza, as part of the Horizon C4S Project. These activities have been conducted with Coderbot with a maximum of 7 students aged between 13 and 16 years old from socio-culturally disadvantaged environments, many of them with learning disorders and difficulties.*
This research fits into the theoretical framework of Educational Robotic Applications (ERA: Catlin, Blamires, 2010), mainly focusing on 5 principles that have been identified as significant within our context: embodiment, interaction, engagement, curriculum, and personalization. Specifically, the aim is to analyse in-depth didactic mediation strategies (Rossi, 2016) in school environments that are characterised by socio-linguistic deprivation (Lumbelli, 1992), especially regarding the direction assumed by one or more expert adults (Bozzi, Zecca, 2021; Lumbelli, 1974). This is a field still little explored with respect to this specific age group, and in particular to those adolescents using the so-called «restricted code» (Bernstein, 1971).
The workshops have been carried out according to 5 phases: 1) engagement, with the aim of gathering students' representations on the concepts of «science» and «robots»; 2) Game of Science (GoS) with a robo-ethological approach (Datteri, Zecca, 2016), to let students express free scientific observations and explanations and investigate interactions between adults, students and robots; 3) algomotricity or body simulation, i.e. the unplugged phase which precedes coding (Lonati et al., 2015); 4) training of 2 student-tutors on some functionalities of the robot and programming problems; 5) peer tutoring, with a Problem-Based Learning (PBL) approach.
All activities have been video-recorded and partially transcribed; the research team is achieving and discussing the first results by leading the analysis in a mixed way, both grounded and using SOFC – Instrument for the Observation of Communicative Functions in the classroom.

KEYWORDS: *Educational Robotics, Mediation, Socio-linguistic deprivation, Popular education, Adolescents.*

Introduction. Teaching and learning… and robots

Starting from the end of the 1960s, Seymour Papert was one of the first to foresee that robots could facilitate learning (see, especially: Papert, 1980). Learning can be defined as the change of an idea or a content, but also as the acquisition of a knowledge, a skill or a competence by assimilation, reworking or accommodation in the potential area of development; the interaction with a more experienced adult through feedback enables the evolution of a given state from one point to another, through observation, imitation, reworking, or reasoning. Therefore, as highlighted by Piaget's constructivism, learning is the result of an active construction of knowledge in interaction with the world, where the construction and manipulation of physical objects play a fundamental role. In this sense, robots can become «objects to reason with» (Beltrametti et al., 2017, 124).

So, educational robots can be mediators through which to think, because they allow bodily and multimodal interaction; they are relational objects that facilitate the process of interiorization (Vygotskij, 1978), stimulating both involvement and motivation and keeping the level of immersion in the experience high. Educational robots are tools of semiotic mediation, i.e. digital artefacts that modify modalities of word and models of knowledges, moving from the classical mediation of the object to the mediation of the subject: indeed, it is the subject who assumes different postures towards the mediator, which, being digital, is infinitely reproducible (Rossi, 2016, 19).

In this process, robots can lead to unconscious insights and pseudo-concepts, starting from knowledges constructed through a situated action reaching up to the symbolic sphere: thus, a sense-motor intelligence is formed up to symbolic consciousness (Hoffmann, Pfeifer, 2018; Stoltz, 2018).

1. Theoretical framework. Educational Robotic Applications (ERA)

As underlined by Hoffmann and Pfeifer, «robots can be beneficial in operationalizing, formalizing and quantifying ideas, concepts and theories that are important for understanding cognition» (2018, 9): they embody – implicitly or explicitly – certain types of abstractions and fit squarely into the embodied and pragmatic (action oriented) turn in cognitive sciences (Engel et al., 2013). Just the embodiment is one of the key issues of the theoretical framework underlying this research, i.e. the Educational Robotic Applications (ERA: Catlin, Blamires, 2010), which presents a set of 10 principles that: 1) explain how robots help learning and the benefits of educational robots to teachers; 2) offer a checklist for those who want to design educational robots and develop activities with them; 3) justify the investment by schools in robotic technology; 4) suggest underlying cognitive and developmental processes; and finally 5) provide researchers with a set of claims to assess and reason about.

Students learn through intentional and meaningful interactions with educational robots, located in the same space and time: so, this research first considered the Embodiment's principle. Moreover, for our purposes, the following ERA's dimensions were also taken strongly into account:

- Interaction, because students are active learners, who interact with educational robots through a variety of multimodal semiotic systems;
- Engagement, because educational robots foster emotional states and relationships that can promote positive attitudes and learning environments;
- Curriculum, because they can facilitate teaching, effective and long-term learning and assessment also in traditional curriculum areas;
- Personalisation, because they allow to personalise several learning experiences to meet the individual needs of students.

2. The laboratory of Educational Robotics in Monza

As part of the Horizon SwafS C4S Project («Communities for Sciences. Towards promoting and inclusive approach in Science Education»)[1], the research team of the University of Milano-Bicocca carried out 7 educational robotics workshops from February to April 2021 at the «Antonia Vita» Popular School in Monza (Lombardy). This school welcomes adolescents between 13 and 16 years old in conditions of severe discomfort and early school leaving and drop-out, many of them from disadvantaged socio-economic and cultural backgrounds and with learning difficulties (both certified and non-certified), with the aim of achieving the lower secondary school diploma. These activities have been conducted with Coderbot with a maximum of 7 students at a time, both boys and girls, following a protocol consisting of 5 different phases.

All activities have been video-recorded (with the consent of the parents of the minors) and partially transcribed; now the research team is achieving and then discussing the first results by leading the analysis in a mixed way, both grounded and using a tool named SOFC, i.e. Instrument for the Observation of Communicative Functions in the classroom (Zecca, Piastra, 2020).

2.1. Working hypothesis and research questions

The main purpose is to analyse in-depth didactic mediation strategies (Rossi, 2016) in school environments that are characterised by socio-linguistic deprivation (Lumbelli, 1992), especially regarding the peer tutoring and the direction assumed by one or more expert adults during

[1] http://www.communities-for-sciences.eu.

the peer tutoring activity (Bozzi, Zecca, 2021; Lumbelli, 1974). Indeed, this is a field still little explored with respect to this specific age group (Pelenc, 2017) and in particular to those adolescents from disadvantaged contexts using the so-called «restricted code» (Bernstein, 1971).

So, the first endogenous factor to the school system we considered is the interaction between peers, from consideration of the starting conditions of students, who have not sufficient expressive, communicative and relational skills and therefore are limited in their possibility of learning. Since

Peer tutoring can generate positive changes and enable participants to develop aptitude for initiative, goal setting and goal achieving, time and emotion management as well as empathy and the ability to establish relations with others. In particular, tutors indicated the improvement of key skills like the ability to establish relations with peers, to work hard at their goals, to take over responsibility and the ability to manage relations, rights and duties when working with others (Schir, Basso, 2018).

The first research question is: Can peer tutoring be a good strategy for enhancing the learning of adolescents from socio-culturally deprived contexts?

Following interaction between peers, the second factor endogenous to school system considered is the relationship between students and teacher, in particular the relationship between tutor students and expert adults. Thus, the following research questions emerged: What are the characteristics of the didactic mediation strategies of the more expert adult? What dialogical patterns are activated between the expert adult and the tutor student?

In order to select the tutor students who could be trained and carry out peer tutoring activities, the research team adopted some criteria, which resulted from a consultation process with both students and school educators. Indeed, we conducted first of all some mini-interviews with students, to find out from their own voices which classmates they thought were the best to explain and support others in learning. Secondly, we consulted the educators themselves, especially on two specific focuses: 1) the students' communicative competence and abilities to manage interactions; and 2) the students' level of engagement and motivation for this type of activity.

2.2. Laboratory design and structures. The five phases

The workshops followed a protocol consisting of 5 distinct phases, designed specifically to accompany the students through the knowledge of Coderbot to the more complex steps of problem posing and solving. The 5 phases were the following.

1. Engagement. This phase started with an initial manipulation of Coderbot to get to know its main components and continued with a focus group which had the aim of gathering students' representations and conceptualizations on some concepts, such as «science» and «robots». A meeting with the inventor of Coderbot,

Roberto Previtera, was also organised, in order to get to know and start learning basic glossary related to educational robotics.

2. Game of Science (GoS). In this phase the research team built an arena in which to move the robot in front of the students, adopting a robo-ethological approach (Datteri, Zecca, 2016) and so encouraging the students to express free scientific observations, explanations and inferences. This was a very important moment to investigate interactions between adults, students and robots.
3. Algomotricity (Lonati et al., 2015). Before looking at functionalities and commands of Coderbot, the team organised an unplugged phase or body simulation, i.e. a series of play activities in which each student, playing the role of the robot, had to act out movements, completely blindfolded, orienting his/her own body in space, based on instructions said aloud by their classmates. Instructions were written on paper by students to form small programming problems, which were constructed using the same semantics and syntax of the Coderbot language, i.e. the Blockly language: in this way, the phase in question took the form of a mini training session, useful to start getting familiar with the programming language.
4. Training. This specific phase, preparatory to peer tutoring activities, was dedicated to the learning by 2 tutor students both of some commands and functionalities of Coderbot, deepening the Blockly language. Just at this stage the tutors began to construct some simple programming problems, some of which would later be proposed to their classmates.
5. Peer tutoring. At this point each of the two tutor students teaches 2/3 tutee students some programming tasks, supporting them towards the construction of a programming problem and its possible resolution. This was another significant moment to study peer interactions and those between students and adults.

2.3. Methodology. Data gathering and analysis tools

The research is still in progress. The research team started by investigating the phase 5 on peer tutoring, and in particular the meeting 6, held on 24 March 2021 (duration: 70 minutes). Interactions were coded through the videos of ATLAS. ti software, using a specific tool, SOFC, i.e. Instrument for the Observation of Communicative Functions in the classroom (Zecca, Piastra, 2020).

The tutor students were asked to teach the functionalities and commands of Coderbot, in particular to get the tutee students to think and code a programming task previously constructed by the tutors themselves

TAB. 1. *Meeting 6. 24 March 2021*

Tutor students	Francesco	Honey
Tutee students	Domenico, Hicham	Ivan, Alex, Morena

TAB. 2. *SOFC teacher / tutor student coding system*

Communicative function	*Description*	*Codex*	*Type of intervention*
G – Management (Gestione)	The teacher makes explicit the tasks useful for understanding the activity, checks the conduct, and sets out the rules. (Introducing the lesson; making explicit the stimulus question, the task or the problematic situation from which the discussion starts; assigning new precise tasks; clarifying, reformulating or reminding of the tasks or objectives; indicating the procedures; soliciting the pupils to maintain, focus or re-establish their attention; regulating and correcting the pupils' conduct with reprimands or reminders to respect the rules of behaviour).	OP	Organisational-procedural
		CC	Conduct control
		REG	Recalling rules and values in interaction
M – Moderation	The teacher organises communication in the group, manages turn-taking, encourages participation in the discussion, invites clarification or continuation.	DT	Giving the floor
		TT	Taking the floor
		IT	Ignoring the turn-taking
		RIC	Summary (without development of reasoning)
		RIF	Request for reformulation
		ICG	Invitation to a generic participation or continuation
		ICS	Invitation to a specific continuation
O – Orientation	The teacher intervenes on the merits, introduces new	CONF	Confutations

	elements into the discourse or asks questions in order to direct the discussion, i.e. to induce the participants to continue the discourse in a certain direction, or to preclude another, or in order to make the point and conclude.	COLL	Connections
		INF	Adding information
		DC	Closed question
		IMB	Rhetorical intervention or prompt
R – Reasoning	The teacher promotes and relaunches reasoning and critical thinking on a given topic. He or she supports pupils in going deep into their reasoning.	SPI	Request for explanation, motivation or argumentation
		RISP	Mirroring and expansion
		RIEP	Taking stock of the situation or summarising
		SC	Explaining the cognitive strategies
		PROB	Problematisation
		RA	Request for agreement
		CONS	Request for consent
V – Assessment (Valutazione)	Assessment function.	FP	Positive feedback
		FN	Negative feedback

The team made use of intrinsic cases (Yin, 2006), with the aim of examine communicative functions and dialogic patterns of micro-situations.

In the light of the students' difficulties mentioned above, the non-verbal behaviour and paraverbal has gained in importance: for this reason, we decided that each teacher and student code can refer to both verbal and paraverbal/non-verbal behaviour.

3. Results and analysis

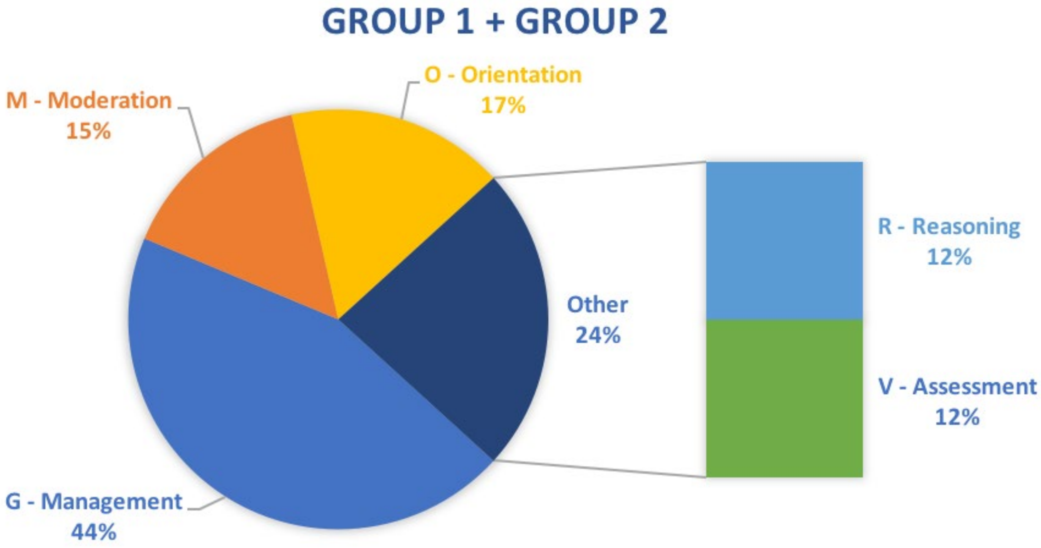
3.1. An overview on tutor student codes

Management (G – Gestione) is by far the most used communicative function by tutors (see Tab. 3 and Fig. 1).

TAB. 3. *SOFC tutor student codes*

			Gruppo 1 – Francesco		*Gruppo 2 – Honey*	
G – Management (Gestione)	*OP*	Organisational-procedural	32%	87,5%	48%	68,9%
	CC	Conduct control		12,5%		28,9%
	REG	Recalling rules and values in interaction		0		2,2%
M – Moderation	*DT*	Giving the floor	32%	0	11%	10%
	TT	Taking the floor		62,5%		10%
	IT	Ignoring the floor		12,5%		10%
	RIC	Summary (without development of reasoning)		12,5%		10%
	ICG	Invitation to a generic participation or continuation		12,5%		40%
	ICS	Invitation to a specific continuation		0		20%
O – Orientation	*CONF*	Confutations	0	0	21%	20%
	COLL	Connections		0		35%
	INF	Adding information		0		30%
	DC	Closed question		0		10%
	IMB	Rhetorical intervention or prompt		0		5%
R – Reasoning	*SPI*	Request for explanation, motivation or argumentation	12%	33,3%	12%	0
	RIEP	Taking stock of the situation or summarising		33,3%		27,3%
	SC	Explaining the cognitive strategies		0		9,1%
	RA	Request for agreement		33,3%		0
	CONS	Request for consent		0		63,6%
V – Assessment (Valutazione)	*FP*	Positive feedback	24%	66,7%	8%	62,5%
	FN	Negative feedback		33,3%		37,5%

FIG. 1. *Which communicative functions are most used by students when they act as tutors?*

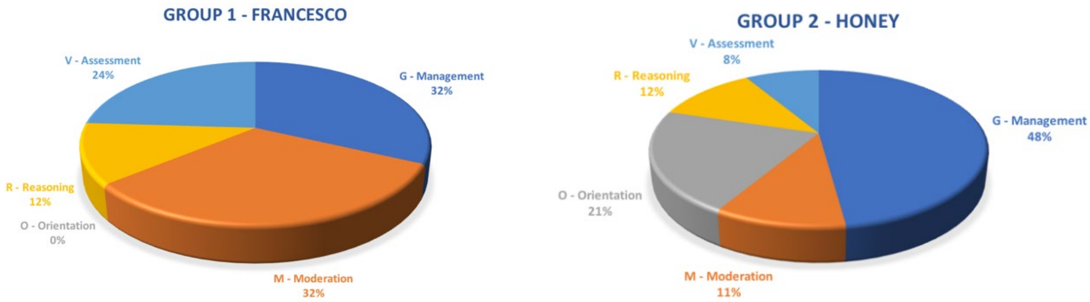


3.2. Codification of tutor student interventions

Reasoning (R) is little used by either, especially with regard to cognitive strategies.

Orientation (O) is not used at all by Francesco, while Honey makes very little use of the assessment function, especially with regard to the negative feedback (see Fig. 2).

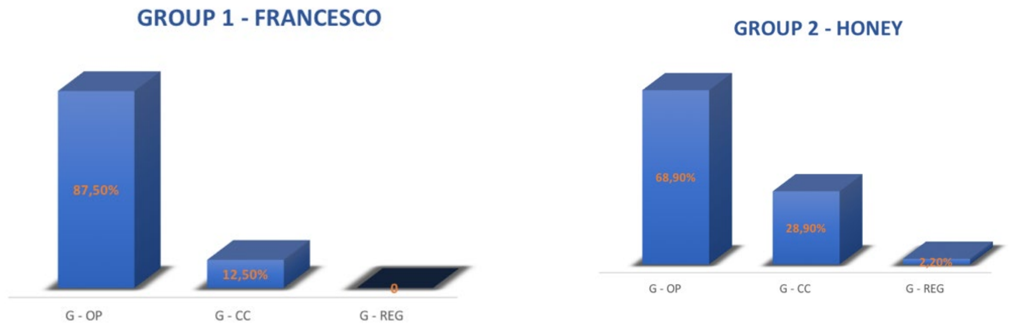
FIG. 2. *Comparing the two groups – Francesco and Honey*



In G – Management, both authors use the OP category much more frequently than the others (Francesco: 87,5%; Honey: 68,9%: see Fig. 3).

In Francesco's tutoring the category REG (Recalling rules and values in interaction) is completely absent; it is also very little present in Honey's tutoring.

FIG. 3. *Focus on the Management communicative function*



3.3. An overview on tutee student codes

SOFC provides a coding system not only for functions of teachers / tutor students, but also for those of students / tutee students (see Tab. 4).

TAB. 4. *SOFC tutee student codes*

			GROUP 1 – Francesco		*GROUP 2 – Honey*	
R – Answers	*NIMP*	«N'importequisme» answer	14%	0	16%	28,7%
	RSA	Answer without argumentation		0		13,9%
	RCA	Answer with argumentation		0		28,7%
	COMPLI	Completion answer		100%		28,7%
C – Continuation	*COLLN*	Non-argumented continuation	72%	0	32%	7,10%
	COMPLC	Completion continuation		20%		14,3%
	COLLA	Argumented continuation		80%		78,6%

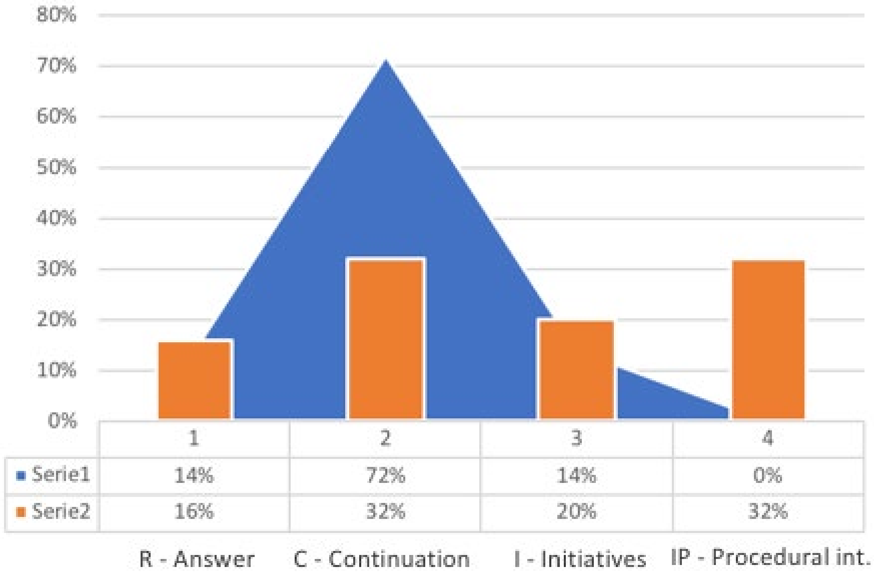
I – Initiatives	*CHI*	Questions of clarification	14%	20%
IP – Procedural Intervention	*PROC*	Procedural intervention	0	32%

Tutee students did not make use of many of dialogical categories provided by the SOFC tool (see Tab. 5). Problematisation is the category least used by both tutor and tutee students.

TAB. 5. *SOFC tutee student codes not used*

Communicative function	*Codes*	*Description*
Initiatives	PROB	Problematisation
	PROP	Proposal for a new theme
Conceptual insights	INT	
Mis-knowledge	MISC	
Conventional knowledge	CONV	
Descriptive observation linked to direct experiences	OSS	
Type of argumentation	EP	Personal experience
	LIB	Reference to the textbook
	CLASS	Reference to what the teacher has said or done in class

FIG. 4. *Comparing the two groups – Francesco (Series 1) and Honey (Series*



3.4. Codification of tutee student interventions

Group 1 students (Francesco's tutees) tend to complete what Francesco said (Continuation: 72%), mostly by arguing (C-COLLA: 80%). Instead, Group 2 students (Honey's tutees) tend not only to argue (C-COLLA: 78,6%), but also to intervene with procedural interventions (IP-PROC: 32%; see Fig. 4).

4. Discussion of preliminary data. Co-occurrences

First of all, we identified the most recurrent dialogical patterns.

For what concerns the Group 1 of Francesco, the most recurrent patterns see G-OP (the most used function: 28% in total) with:

– COLLA (55,6%):

Francesco: «Go to movements, put turn right». Domenico: «Ok!». (Domenico moves his hands on the keyboard.) F.: «Put 2». D.: «I have already put it!». F.: «Turn 90 degrees». D.: «And that's it, the end!»;

– FN (55,6%):

Francesco: «How to make commands, your f* business!». Domenico: «Eh, but he hasn't told us anything, we can't understand a s*!». Hicham: «He speaks in German, you can't understand a s*!» (F. stares at them and laughs).

Regarding the Group 2 of Honey, the most recurrent patterns see always G-OP as the first occurrence (the most used function: 33% in total), with:

– FP (41,9%):

Honey: «Come here a minute!». Ivan: «I arrive!»;

– FN (29%):

Honey: «We have to do a problem». Alex: «Nuuuu».

– PROC (25,8%):

Honey: «We start from here...». Alex: «Wait, first of all... The glove!»;

– CHI (25,8%):

(Honey indicates the end point of the itinerary.) Alex: «Where is the Coderbot?». Honey: «Yes».

During Francesco's tutoring, non-verbal modes and modelling prevail. They stimulate tuning and shared attention (in terms of relationships and contents) on the part of tutee students. Francesco repeatedly asks, with words and/or with a look, for the help of the expert adult: adult mediation is structured and directive (hetero-regulation).

Instead, during Honey's tutoring, verbal interventions prevail. They stimulate tutee students to give feedback, but also to ask for clarification and propose some procedural changes. Honey rarely turns to expert adults and tries to work autonomously: in this case, adult mediation is orientative and transformative (from hetero-regulation to auto-regulation, unlike with Francesco.

Therefore, different tutoring styles seem to activate different patterns in terms of dialogue, involvement and regulation.

Conclusion

We can conclude that in vulnerable educational contexts peer tutoring seems to struggle to work, because structured and directive adult mediation is often – although not always – required (see especially the case of Group 1).

So, in these educational environments, peer tutoring may not be the didactic strategy more efficient. Generally, the tutor student seems:

1. not sufficiently familiar with the object or able to use it;
2. to have no words or adequate modes of communication, verbal or non-verbal.

Consequently, in order to make peer tutoring more efficient also with socio-culturally deprived students, it may be necessary to design a more structured training pathway for student tutors.

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