Collaborative learning in an educational robotics environment

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Abstract

Learning to collaborate is an important educational goal. The concept of collaborative learning is differently defined by several authors. Problem solving and problem-based learning are also important in our educational framework. We shall situate and clarify here the instructional design concepts used in an educational setting based on a “collaborative and problem based learning environment” applied to educational robotics. Educational robotics activities are developed at several school levels (primary, secondary) and in adults’ training contexts. The instructional design of such learning activities is based on a constructivist approach of learning. Their educational objectives are varied. In our approach, the goal is not only that the learners acquire specific skills (e.g. knowledge on electricity, electronics, robotics...), but also and mainly demultiplicative, strategic and dynamic skills. The methodology focuses on collaboration to design and develop common projects and on problem solving skills development. The pupils work in small groups (2–4). In the reported research, some learners’ interactions have been observed during the activity in a primary school with an observation grid. The analysis of the verbalisations between the learners and their actions on the computers, and the robotics materials coming from those observations offer the opportunity to study the way the learners are collaborating. © 2001 Elsevier Science Ltd. All rights reserved.

Keywords: Constructivism; Collaboration; Educational robotics; Evaluation; Educational technology; Problem based learning
1. Introduction

This paper focuses on an activity based on collaborative and problem-based learning called “educational robotics”. Its instructional design implies the choice of some teaching and learning methods, of classroom management parameters, of tools to be used (e.g. computers, robotics material, reference guides, etc.) to reach determined objectives. The regulation of such activity needs the use of evaluation tools. Here they consist in observation grids that permit coding of social interactions between peers and actions on the didactic materials.

2. Context: the educational robotics framework

Educational robotics (ER) consists in building and programming small robots and conducting them with the help of computer programs that have to be built by the learners themselves. Different approaches are observed in educational robotics applications (Denis, 1993a; Denis & Baron, 1993). They aim to develop some learners’ competencies such as problem solving strategies, the formalisation of thought, the socialisation as well as the acquisition of various concepts. In four emerging trends from the ER use several differences related to their fields of application can be observed (Denis & Baron, 1993):

1. a technocentric approach aimed at the development of technical situations often close to the industrial world (Delannoy, 1993; Nicoud, 1993; Tauriac, 1993),
2. an approach based on the creation and exploration of microworlds based on the learner’s project (Denis, 1993; Leroux, 1997; Limbos, 1993; Morato, 1993; Napierala et al., 1993; Sougné, 1993; Vivet, 1993; Papert, 1984),
3. an approach based on the theory of the cognitive spectacles or computer assisted experimentation, connected to scientific contents (Nonnon, 1986; Cervera & Nonnon, 1993; Girouard & Nonnon, 1997; Hudon & Nonnon, 1993; Macherez, 1993; Marchand, 1993; Nonnon, 1993; Rellier & Sourdillat, 1993),
4. a programming or algorithmic approach (Duchateau, 1993).

Among those approaches, the specific objectives and the methodologies are varied, even if the epistemological bases of the activities are all based on an interactionist constructivism. The interdisciplinary aspect of this activity has also been emphasised. In fact, it is difficult to classify educational robotics within one given discipline since projects often vary, switching from one kind of approach to another one.

In addition, the target public is also varied, since ER addresses learners from elementary school to adult’s training.

The approach we have adopted in our study is the second one: exploration and creation of microworlds. Here, the learners’ task is complex and based on a meaningful project shared by the two peers involved in it. This groupwork should contribute to the learners’ motivation throughout the learning activity.
3. Learning objectives and learning/teaching paradigms

Two models, a four level architecture of competencies and the six learning/teaching paradigms help to analyse and characterise the educational robotics activities (Fig. 1).

3.1. The architecture of competencies

Regardless of the approaches (out of the four options), the ER learning objectives mentioned earlier can also be categorised referring to Leclercq’s (1987) model of the architecture of competencies. He suggested that four types of competencies should be considered:

<table>
<thead>
<tr>
<th>Levels of architecture of competencies</th>
<th>E.R. objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dynamic</td>
<td>(Personal) project.</td>
</tr>
<tr>
<td>The dynamic competencies are related to</td>
<td>Meaningful activity.</td>
</tr>
<tr>
<td>MOTIVATION, i.e. the pleasure a person</td>
<td></td>
</tr>
<tr>
<td>experiences in doing things, in learning</td>
<td></td>
</tr>
<tr>
<td>specific, demultiplicative or strategic</td>
<td></td>
</tr>
<tr>
<td>competencies. This level is the most</td>
<td></td>
</tr>
<tr>
<td>vulnerable: it can be easily affected.</td>
<td></td>
</tr>
<tr>
<td>It is also the most “penetrating”, i.e.</td>
<td></td>
</tr>
<tr>
<td>the motor that drives the rest when</td>
<td></td>
</tr>
<tr>
<td>facing a new domain which the learner</td>
<td></td>
</tr>
<tr>
<td>has to enter. Those competencies</td>
<td></td>
</tr>
<tr>
<td>correspond to the learner’s initiative,</td>
<td></td>
</tr>
<tr>
<td>will, pleasure and displeasure,</td>
<td></td>
</tr>
<tr>
<td>perseverance, rigor, . . . including</td>
<td></td>
</tr>
<tr>
<td>one’s own image as a person being able</td>
<td></td>
</tr>
<tr>
<td>and motivated to learn.</td>
<td></td>
</tr>
<tr>
<td>Strategic</td>
<td>Problem solving and</td>
</tr>
<tr>
<td>The strategic competencies are</td>
<td>formalisation of thought:</td>
</tr>
<tr>
<td>concerned with METACOGNITION, i.e.</td>
<td>structuring the problem,</td>
</tr>
<tr>
<td>knowing oneself (as a learner, as an</td>
<td>definition and test of</td>
</tr>
<tr>
<td>actor, etc.), one’s weaknesses and one’s</td>
<td>hypotheses, conclusions, . . .</td>
</tr>
<tr>
<td>talents, and developing strategies to</td>
<td></td>
</tr>
<tr>
<td>adapt to complex situations (for</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
</tr>
</tbody>
</table>
instance to choose which demultiplicative competency to use for learning in given circumstances). They concern planning (e.g. how much time will it take me to master a given subject, to do a specific work), problem solving (e.g. analysis and structuring the problem, decision making, ...), communication and cooperation (how much and when do I need others? in which respect?) and self estimation of knowledge (to know one’s degree of expertise in a domain: what do I know? what do I not know?).

Demultiplicative

The demultiplicative competencies (LEARNING TOOLS) enable the learner to get information by him/herself and acquire more specific competencies: reading, listening, notes taking, communicating, interviewing, using the computer to consult a database or to produce texts, referring to guides, etc.

Specific

The specific competencies (ELEMENTS OF COGNITION skills) deal with specific contents (e.g. geography, history, physics, vocabulary of a language, ...) and are hardly transferable. These specific competencies are infinite and a human being can (and has to) know only some of them.

Electronics components, types of electric circuits, programming instructions, production procedures, syntax of a given computer language, ...

This four levels architecture of competencies model offers a useful conceptual framework which allows the learner to address important questions related to the objectives and the methodology to choose: do we want the learners just to acquire specific competencies or should they acquire strategic level skills?, etc.

Several relationships between competencies and educational robotics approaches have been described in Denis and Hubert (1999). We shall hereafter just focus on strategic ones since they deal with abilities such as collaborating and interacting with each other and to some aspects of problem solving.

3.2. Six learning/teaching paradigms

Like other educational situations, educational robotics activities can be described and analysed referring to the “six teaching and learning paradigms” model (Denis & Leclercq, 1994; Leclercq & Denis, 1998; Fig. 2). These paradigms imply very different kinds of interactions between trainers and learners and the proportion of the learner’s and trainer’s initiatives mostly depends on the chosen paradigms.

Socialisation: collaboration, socio-cognitive conflicts, ...

Reading, listening, notes taking, consultation of reference guides, using the computer.
Moreover, according to the paradigm, the learner develops some particular competencies (e.g. the paradigm of “creation” will develop more competencies such as demultiplicative, strategic and dynamic ones than specific ones).

Whatever the considered paradigm, we find social interactions between peers and between the trainer and the learners. Those interactions intervene as “learning catalysts”. Nevertheless, we may consider that actual collaborative learning situations will mostly appear in the three paradigms that allows more learner’s self-initiative (creation, experimentation, exploration) than the others.

For us, our approach, which is based on “microworlds”, will essentially consider creation, that will also lead the learner to develop behaviours linked to exploration and experimentation, but always referring to learners’ personal projects. Nevertheless, that does not imply that a trainer will always base the activity only on creation. He/she can decide that the learner will have the initiative to define and realise a project (build the robots and program them), but at some moments provide a synthesis about the new notions encountered and enrich them with new concepts (transmission/reception).

<table>
<thead>
<tr>
<th>Learning/teaching paradigms</th>
<th>ER objectives</th>
</tr>
</thead>
<tbody>
<tr>
<td>Creation</td>
<td>Two facets of creation of an educational robotics activity are pointed here. One refers to the building of the robot, and, the other, to the writing of a program. Programming a computer with a given language can always be considered as creation since the learner can choose the movements the robot will execute. When the general design is defined by the trainer (Nicoud, 1993; Vivet, 1993) or by an other learner, the creativity relies on the way to build the robot and the program, but not in the project choice.</td>
</tr>
</tbody>
</table>
Exploration

To do this, the learners can explore some didactic materials (e.g. reference guides, help online, ...). We could also consider the elaboration of theories by the learners. But it is a common core between the different approaches of the educational robotics since it is based on constructivism: inside the activity, the learners have the opportunity to experiment by trial and error (experimentation) and build their process and personal theories about the current topic. How they create those theories and representations are and have to be studied by researchers (Limbos, 1993).

Experimentation

The creation of original robots mainly depends on the flexibility of the materials. For instance, in the “computer assisted experimentation” or “cognitive spectacles” approach, the learner has a standard material that will allow him/her to make his/her own experiments on a specific topic [e.g. build a model about how a battery functions (Marchand, 1993), about refrigeration systems (Hudon & Nonnon, 1993), breathing metabolism (Rellier & Sourdillat, 1993), ...].

Imitation

But, the learners could also build their robot or automate from their imagination with salvage of waste products (of Saldano) or with materials such as kits sold by Fischertechnik®, Lego®, Inventa®, ... even if those societies also provide with their materials some guidelines to build the robots. If those guides are used, it leads to the application of paradigms such as imitation (watching a video or observing a model) and transmission/reception (reading to guidelines). Emerging activities based on virtual robotics also appear now; they refer to several approaches (Meurice de Dormale, 1997; Nonnon, 1997).

Reception

4. A collaborative problem based learning

The learning activity proposed here is based upon two main methodological principles: problem based and collaborative learning.
4.1. Problem based learning

Problem based learning (PBL) is based on a constructivist approach of learning: the learner is at the centre and builds his/her knowledge. PBL has some common features with the "pedagogy of the project" (cf. Freinet, Le Grain), even if sometimes the project is given by the tutor and not especially a learner's personal project. PBL deeply implies the learners in the learning/training process since he/she (or the group) has to define a strategy to solve the proposed problem (cf. Barrows & Tamblyn, 1977; EARLI Instructional design, 1998; Leclercq & Van Der Vleuten, 1998).

Sometimes, the teacher suggests the project. Defining and managing such problem-solving situations based on personal project is not very easy for the trainer and the learners. In fact, those educational practices are not often developed among the teachers and they prefer to adopt a constructivist methodology. With the learners involved in a problem-solving situation, one has mainly to try to adopt teaching and learning paradigms such as exploration, experimentation and creation (Leclercq & Denis, 1998).

Hubert & Denis (1998, p. 33) define a “problem situation” or “challenge” as follows:

1. a “desequilibrating” situation, an obstacle;
2. an enigma (whose solution is not a priori known);
3. a problem that answers a need;
4. a problem that is significant for the learner;
5. a problem whose complexity, duration and length match with the learner’s capacities and availability;
6. a problem that can support various topics (even parallel) in the classroom; and
7. the opportunity to seek for information coming from different sources.

This list is not exhaustive. It just helps to determine if a proposed situation is a real problem solving one. All the criteria do not have to be present. Nevertheless, some of them are more fundamental than others. That is the case for the criteria 1–5.

This approach has been used in secondary schools to manage activities linked to the course of Education par la technologie (Hubert & Denis, 1998) and in a research on the pedagogical uses of Internet (Hubert, Denis, Detroz, & Demily, 2000).

In the present context of ER activities, small groups (two or three students) have to manage the challenge to realise their personal projects, so they have to solve meaningful problems.

4.2. Cooperative and collaborative learning

Interactions between peers are an important and well known factor on the cognitive development, since there are confrontations of points of view (Mugny, 1985; Doise & Mugny, 1981; Perret Clermont, 1979) or exchanges of skills or strategies (Clark & Lampert, 1986) or reflections on one’s practice to help to regulate it (Denis, 1990). The share of core knowledge and the interaction between the learners’ proximal zones of
development (Vygostsky, 1962) permit learning by the way of social interactions (Lewis, 1996). The management of educational situations based on PBL and collaborative learning such as the S.E.R.P (Séquences d’Entraînement à la Résolution de Problèmes; Leclercq, 1979) or the LOGO environment (Denis, 1990) helps the learners to structure their knowledge, but also implies some changes in the teacher’s role.

The definitions of collaboration and cooperation are not unanimous. Even if different typologies or taxonomies of collaboration situations exist (Bennett & Dunne, 1991; Pepitone, 1985), they finally always deal with the contribution of individual competencies to an explicit common objective and on the repartition of the group members’ roles.

According to Rogalski (Peeters et al., 1998), we shall retain “three main form of cooperation, depending on the relation between the task and the actors of the collective work: (1) collaboration, for the situations where the actors share the same goals along the task realisation; (2) distributed cooperation, for the situations where sub-tasks having a common goal are a priori distributed among different actors; and finally (3) mediatisation, when an actor is in the situation of let other actors execute tasks that participate to the realisation of his/her mission defined at a more general level”. To the term mediatisation that generally refers to the notion of media, we prefer the expression cooperative delegation that refers more to the activity itself.

As we shall see hereafter, in our educational robotics activity, we can talk about collaboration inside the groups and about distributed cooperation between them since the learners share and work on a common objective or sometimes since their project will be part of a bigger one (e.g. build a city with cars, trains, pedestrians passages, …; Chung, 1991; Lewis, 1996; Peeters et al, 1998; Slavin, 1986).

Collaboration can be a learning topic, in a creative activity (here try to answer to a challenge or realise a project) (of Learn Nett, 1999). In fact, we have observed in another situation that collaboration or cooperation can be learned and regulated at the level of the roles or actions of the members of a group (Denis, 1981). It is important to structure the collaboration to obtain benefits from it: self-esteem, socialisation, etc.

Considered at distance or not, synchronously or not, we consider that collaborative learning:

1. Reduces the gap between teachers and learners: in collaborative learning environments, the trainer’s role evolves and becomes that of a facilitator, regulator of the learners’ interactions. When learning is at distance, the tutors’ role also deals with the management of learners’ interactions (Charlier, Daele, Cheffert, & Peeters, 1999a; Charlier et al, 1999b; Peeters et al, 1998).
2. Leads to active and creative learning: the learners have goals and problems to solve together. They create knowledge.
3. Creates a sense of community: considering the evolution of our society to a knowledge and information society, it is very important to accentuate their sharing and to focus on the development of community of practices and references among the members of groups or organisations to reinforce their coherence and efficiency. ER could help to reach this kind of goals.
5. Evaluation process

Hereafter, the evaluation process will only focus on some aspects of the learning process. The observation will not consider the different levels of the educational system, but it will contribute to study and regulate the interactions between peers in a collaborative learning environment.

5.1. The regulation process

We shall situate our ER activity referring to the regulation process described by Leclercq (1995). This author defines six phases in any regulated process (or teaching/learning process) that we have illustrated referring to the ER framework:

1. Needs analysis or problem identification: we consider here that it is the fact that everybody should acquire a technological culture and competencies of the four levels described earlier (cf. Fig. 1).
2. Project or definition of the general objectives: among several possible projects, we choose to develop ER activities to contribute to answer the needs.
3. Planning or operationalisation: the ER activities are planned in the agenda (e.g. 2 h per week), with specific materials, in a group of three students, with detailed objectives (a learner’s target profile) and methodology (an animator’s profile) (Denis, 1993).
4. Action or execution: the activity is organised. The learners and teacher act and interact.
5. Observation or measure: the observation of the process is possible with adequate tools (see later).
6. Decisions of regulations or feedback loops: the results of observations help to take decision to ameliorate the activity.

This process can also be presented in different numbers of phases: in four phases (Hornke & Kluge, 1996; Leroy, 1991), in six (other) phases (Bahr, 1990), in seven phases (Brien, 1986), in eight phases (Gagne & Briggs, 1986), in 17 phases (Kessels & Smit, 1994). These phases are also observed at several levels, for instance the society, the organisations (e.g. companies, schools, ...), teachers, learners, ... (Denis, 1997).

The retroaction coming from the results of the evaluation will deal with one (or several) phase(s) of the regulation process. So the feedback loop can be as shown in Fig. 3.

5.2. Evaluation tools

To focus our observation and regulation on the interactions between learners, we have chosen to develop observation grids (Denis, 1993b; Denis & Villette, 1995). The analysis of the verbalisations between the learners and their actions on tools such as the computers, the robotics materials and reference guides coming from those observations offer the opportunity to study the way the learners are collaborating and use those tools.
The data collected permits analysis of what has happened during the action phase and to regulate it (during the next activity—R4) or eventually to regulate the planning phase (R3—e.g. modify the target profile of a learner: having observed some difficulties related to prerequisites, decide not to focus first on computer skills).

There are two grids, one deals with the learners’ behaviours, the other one with the animator’s ones. To directly code interactions between the learners and their actions we use the first one (with 25 categories of coding). So the results can be communicated to the animator and the learners just after the activity and decisions of regulation can be taken at once.

In this grid, some categories focus more on the collaboration between learners. The interactions between learners can be observed by verbalisations (elicitations, explanations, descriptions and evaluations). But the collaboration can also exist concerning the actions of building of the robots and programming them.

6. Learners’ collaboration in an educational robotics environment

We shall focus here on learners’ collaborative behaviours when they are involved in an ER activity. What are their roles? How are the tasks distributed?

6.1. ER activity and observations

We shall present, hereafter, some results from the observation of two couples of students of a primary school in Liège (cf. Villette, 1995). They are 10 years old. The two groups have been observed during six periods of 80 min.

In this classroom, only one computer is equipped with the ER interface and software and there is just a little robotics material. The pupils worked on LOGO for 2 years. In the approach that we have adopted, the task is generally complex and based on a meaningful project. The task of the couple 1 was to build and program a robot or an automate with some LEGO® material; the second one has to understand what was a prebuilt model (a merry go round) and to let it move with the help of the computer. Since the creation paradigm appears both in building and
programming for the group 1, we can consider that it will involve the pupils in strong collaboration and the development of dynamic competencies (linked to the development of their own project). This could be less observed in the second group that only has to invent the computing program.

6.2. Hypotheses

Our hypotheses are:

1. The learners collaborate during the definition and the realisation of the ER project: they use the tools provided in the environment and are task centred.
2. There is a repartition of the tasks (build the robot, program it and verbalise the process) between the learners.
3. There is less collaboration behaviours observed in group 2 than in group 1.
4. When there is a leader among the group, it is possible to regulate the interactions between the learners in order to let the others act and verbalise more than observed.
5. Socio-cognitive conflicts have positive effect on the structuration and the realisation of the learners’ project.

ER activity’s observations allow us to obtain some indicators concerning these hypotheses.

6.3. Results

Referring to Table 1, that indicates the behaviours of each pupil observed, some of the hypotheses have been tested.

6.3.1. The learners collaborate during the definition and the realisation of the ER project: they use the tools of the environment and are task centred

We can observe that:

1. During the activity the pupils of each group always work together and communicate about the task (Nx1 = 813, Ny1 = 602, Nx2 = 455, Ny2 = 481).
2. At least a quarter of their activity concerns the use of the didactic tools (27–34%): they use the robotics materials (4–12%), the computer (5–19%), the reference guides (2–7%) and they take and write personal notes (3–7%). They also elicit many actions on computer, robotics material and documents (20–25%).
3. They announce what they are going to do or have done (16–29%) and ask questions about this (13–19%), so they talk about the project and how to realise it.

There is a collaborative learning since the learners are “(i) more or less at the same level and can perform the same action, (ii) have a common goal, and (iii) work
We can also consider that all the learners are task centred. They do not give up their project and interact about it. Some demultiplicative skills (e.g. consultation of reference guides, note taking) and strategic ones (e.g. explanations, collaboration, ...) are observed (Table 1).

### Table 1
Repartition of users’ behaviors

<table>
<thead>
<tr>
<th>Behaviors</th>
<th>Group 1</th>
<th>Group 2</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X1</td>
<td>Y1</td>
</tr>
<tr>
<td>Actions</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Action on robotics materials (LEGOS)</td>
<td>218</td>
<td>202</td>
</tr>
<tr>
<td>Action on the computer</td>
<td>95</td>
<td>47</td>
</tr>
<tr>
<td>Action on reference documents</td>
<td>41</td>
<td>80</td>
</tr>
<tr>
<td>Action on notes (keeping/reading)</td>
<td>23</td>
<td>45</td>
</tr>
<tr>
<td>Towards the animator</td>
<td>59</td>
<td>30</td>
</tr>
<tr>
<td>Calls the animator</td>
<td>21</td>
<td>10</td>
</tr>
<tr>
<td>Listens to the animator</td>
<td>12</td>
<td>6</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>4</td>
</tr>
<tr>
<td>Verbalisations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elicitation of actions</td>
<td>95</td>
<td>12%</td>
</tr>
<tr>
<td>Elicits an effect to produce on the computer</td>
<td>30</td>
<td>5%</td>
</tr>
<tr>
<td>Elicits an action on robotics materials (LEGOS)</td>
<td>19</td>
<td>2%</td>
</tr>
<tr>
<td>Elicits an action on documents</td>
<td>23</td>
<td>3%</td>
</tr>
<tr>
<td>Towards the animator</td>
<td>75</td>
<td>9%</td>
</tr>
<tr>
<td>Calls the animator</td>
<td>39</td>
<td>5%</td>
</tr>
<tr>
<td>Listens to the animator</td>
<td>12</td>
<td>3%</td>
</tr>
<tr>
<td>Verbalisation</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Elicits some information</td>
<td>29</td>
<td>4%</td>
</tr>
<tr>
<td>Elicits a feedback, an agreement</td>
<td>25</td>
<td>3%</td>
</tr>
<tr>
<td>Elicits an explanation—how?</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td>Elicits an explanation—why?</td>
<td>19</td>
<td>2%</td>
</tr>
<tr>
<td>Elicits a description—of an action</td>
<td>41</td>
<td>5%</td>
</tr>
<tr>
<td>Elicits a description—of a project</td>
<td>28</td>
<td>3%</td>
</tr>
<tr>
<td>Descriptions, explanations</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Announces an action to realise</td>
<td>31</td>
<td>4%</td>
</tr>
<tr>
<td>Describes a past action</td>
<td>10</td>
<td>1%</td>
</tr>
<tr>
<td>Explains—how?</td>
<td>9</td>
<td>1%</td>
</tr>
<tr>
<td>Explains how to structure the project, the action</td>
<td>12</td>
<td>1%</td>
</tr>
<tr>
<td>Explains—why?</td>
<td>34</td>
<td>4%</td>
</tr>
<tr>
<td>Evaluates</td>
<td>29</td>
<td>4%</td>
</tr>
<tr>
<td>Predicts the result of an action</td>
<td>33</td>
<td>4%</td>
</tr>
<tr>
<td>Yes/no</td>
<td>102</td>
<td>13%</td>
</tr>
<tr>
<td>Agrees</td>
<td>72</td>
<td>9%</td>
</tr>
<tr>
<td>Disagrees</td>
<td>30</td>
<td>4%</td>
</tr>
<tr>
<td>Total behaviours</td>
<td>813</td>
<td>602</td>
</tr>
</tbody>
</table>
6.3.2. There is a repartition of the “tasks” (build the robot, program it and verbalise the process) between the learners

Each pupil contributes to the robot creation (some more than others), especially in group 1 (X1 = 12% and X2 = 8%).

As foreseen, group 2 does not have a lot of action on the robotic materials (4%) since the model is already built and then they have proportionally more verbal interactions and behaviours centred on computer and robot programming.

Pupils of group 1 are complementary since the one (Y1) who uses the robotics materials least (N = 47 vs. 95 behaviours) programs the computer model (N = 80 vs. 41). Explanations (how to do, why this consequence is observed, and project decomposition) are given by everybody. X1 and Y1 also express evaluations (on the work done) or predictions.

6.3.3. There are less collaboration behaviours in group 2 than in group 1

The type of projects (free or forced) seems to influence the quantity of behaviours: there are more interactions in group 1 than in the second one (respectively, 1415 and 936). But this could also be linked to individual differences (Denis, 1993a). In fact, both groups act and interact about the task, even if in the repartition of the behaviours, we observe few differences (e.g. less descriptions and explanations in group 1).

So we cannot conclude that the collaboration is qualitatively lower in group 2 than in group 1.

6.3.4. When there is a leader among the group, it is possible to regulate the interactions between the learners in order to let the others act and verbalise more than observed

In group 1, we observe 813 behaviours of pupil X1 and 602 for the pupil Y1. Generally and proportionally, X1 acts more on the robotics materials, elicits more action on it, explains, evaluates and predicts more actions, elicits information and feedback and reacts (agrees or disagrees) more than Y1. In the second group, the differences between the two pupils are less obvious: they have almost the same number of behaviours. We can note that X2 elicits more action on reference documents and description of the action, evaluates and predicts more the result of his action than Y2.

To regulate the leadership behaviours and help everybody to take part actively in all the phases of the project, the animator has to play a certain role. For instance, he/she can ask the pupils to use alternatively the computer, to take personal notes or/and share them. He/she has to play the role of moderator until the pupils learn to share and exchange regularly and autonomously their roles.

6.3.5. Socio-cognitive conflicts have positive effect on the structuration and the realisation of the learners’ project

The present grid as it has been used does not allow pointing out socio-cognitive conflicts that appear among the pupils. Nevertheless, if we observe sequentially the learners’ actions and verbalisations, it is possible to identify some of them (Denis, 1990).
The sequences of behaviours such as “explanation of action to be done; action on the computer, negative feedback—explanations, . . . ” should indicate the possible presence of socio-cognitive conflicts (e.g. an “explanation A” confronted to an “explanation B”). Nevertheless, this grid in itself does not allow a sequential analysis. To do it, it is necessary to use video recording and to code and analyse the behaviours a posteriori.

7. Conclusions and perspectives

ER environment centred on the learning paradigm of creation offers a great opportunity to collaborate to a project, even if the teacher has imposed this one first. The pupils have to create at least the program to move the robots. This permits building of strategic competencies (e.g. explanations skills), demultiplicative ones (e.g. consultation of reference guides, note taking and specific ones (e.g. computer programming).

Many interactions focused on the tasks are observed. The learners work together. They mainly developed strategic competencies such as problem solving and collaboration. The type of interactions can vary inside a group and from one group to another. Some leadership can appear in a couple of learners and be detected by the coding of the activity. So the interpretation of the results can help to take the decision to regulate the learners’ way to interact.

Coding directly the learners’ behaviours with the grid presented here is possible, but is mainly focused on a cognitive dimensioning (some aspects of problem solving). The use of a more specific grid focused on social dimensions such as the roles centred on the climate of the group or on the task (e.g. Bales) should permit observation of other types of learner interactions and attitudes.

The role of the trainer is also important in the method of animating groups and reaching the objective of letting them collaborate on a project.

References


