Use of an Infocenter to Improve the Management and Understanding of Project-Based Learning Robotics

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***Abstract*— Robotics allows the implementation of a variety of interesting experiments in conjunction with the methodology of Project-Based Learning (PBL). It has the potential to become an ideal tool in the teaching of a wide variety of scientific and technological disciplines. Furthermore, the student is brought closer to the reality of the professional world through the completion of a project. However, when applying this methodology in an extra-curricular robotics workshop, it is important to bear in mind the following question: how can we ensure that the participants are fully aware of the stages involved in a project and have a realistic experience of project-management? In this article the use of a tool inspired by the world of business will be explained. We have decided to call it an '*infocenter*'. It is a strategy designed to enhance the effective management of the project and also the feeling of forming part of a team which is central to carrying out a project. To allow an evaluation of its usefulness the experimental results from the implementation of this strategy during the NXT Baby Sumo workshop are presented. Through the evaluation of the participants and the instructor, it is shown how the infocenter can be adjusted to suit this purpose.**

***Keywords*— project-based learning, robotics, project-management, infocenter, NXT workshop**

I. INTRODUCTION

For the 21st century generation, robotics, due to its polyvalent and multidisciplinary character, is an ideal motivational teaching method, and together with the use of project-based learning (PBL) it provides an extensive range of opportunities for learning which can then be applied in various contexts: in the classroom, as an extra-curricular activity or through competitions with robots.

The combination of these two concepts (robotics and PBL) means that robotics projects provide an excellent educational platform from which the student can develop and apply invaluable skills and knowledge. These are put into practice in a realistic working environment, as is indicated by several investigations and authors [1]-[3]. They also promote the development of skills which are essential for success in the modern world.

The basic idea is to use robotics and PBL to motivate the learners from a very young age and introduce them to real world experiments. Working within a project requires a variety of skills: a team must be formed, tasks must be planned and prioritised, roles assigned, a consensus reached etc. Of course, through merely introducing this approach alone the desired objectives will not be reached if the same strategies as before are still used.

For this reason we have opted for the design of an infocenter as a project-management tool that facilitates the understanding of PBL robotics, providing all the participants involved in the project with a roadmap for the successful completion of the project. The evaluation and tests of this design are realised within the NXT Baby Sumo Workshop.

In this article a few of the key ideas about the potential of PBL and educational robotics are examined (section I); after which the basic characteristics of PBL and PBL with robots are outlined briefly (sections II and III); then a didactic description of the infocenter is presented (section IV); and finally, there is an evaluation of the infocenter by the students (section V), which allows us to formulate some initial conclusions. At the foot of the article there is an acknowledgement.

II. PROJECT-BASED LEARNING (PBL)

Project-based learning (PBL) can be defined as a teaching method in which the learners complete a project within a set period of time to solve a problem or complete a task through the planning, design and completion of a series of activities.

All of this is based upon the application of acquired knowledge and the effective use of resources [4].

It is also an action-based style of learning. It does not consist simply in learning 'about' something (as happens in problem-based learning), but 'to do' something. To complete a project one needs to combine the knowledge of various areas as well as using the appropriate materials, thus avoiding a fragmented learning process.

Another benefit is that PBL is a method based on learning from experience [5], [6] and in reflective learning [7]. The investigation of a topic, with the aim of resolving complex problems, is central. As the project is student-centred and promotes self-motivation the learners acquire new knowledge and develop new skills by coming up with group solutions to problems. We will see in the next section how PBL can be used when designing robots.

III. PBL AND THE USE OF EDUCATIONAL ROBOTS

In light of these benefits PBL has been chosen as one of the methods used in teaching with educational robots [8]. Due to the multidisciplinary and collaborative character of this pedagogical technique it provides students with the opportunity to work in teams. 'The organisations of the Knowledge Society will undergo constant change. They are organizations where people will work in teams and for teams [9].'

PBL is the fundamental work methodology employed in NXT Workshops [2], [10]. When the children construct the robots or experiment with them, they experience, at first hand, the complex process of creating ideas, solving problems and overcoming difficulties. The project work, organized within the context of the NXT Workshops, is aimed at promoting collaborative learning; this style of learning [11] is one of the most powerful tools for the development of the skill of learning to learn.

A. Advantages of PBL Robotics

The use of PBL in robotics-based learning will allow us to achieve objectives such as:

- *Solving new problems.* As science and technology advance, it is impossible to impart the knowledge and skills that an individual will need in the future. For this reason, rather than teaching them what to think, we must teach them *to think*, rather than giving them information we must teach them to *seek information.*
- *Group work.* This facilitates the student's personal development. The learners acquire useful experience as well as a sense of the value of group work, besides the skills which result from group work and which are essential in all professions.

It is possible that PBL in combination with robotics produces other benefits, which are described in the literature that has been consulted [1]-[3], [12].

- It provides a practical way in which to learn to use technology.
- It allows the students to see and then make connections between the various disciplines.
- It presents a problem in a context similar to that in which the learners will encounter in their professional life, thus connecting the learning process with reality.
- It enhances their communicative and social skills.
- It encourages creativity and curiosity.
- The students learn to take their own decisions and to work independently.
- It strengthens their self-confidence.
- Being founded on experience it increases their motivation to learn and encourages the conception of objectives based on the task.
- It allows them to apply their knowledge, their skills and the new outlook they have acquired to specific situations, along with an improvement in the corresponding skills.

B. The Phases of PBL

In general, PBL is characterized by five [13] processes: (a) engagement, (b) exploration, (c) investigation, (d) creation, and (e) sharing. Underlying these five processes is an interactive analytical evaluation of the students' problem-solving approaches and solutions.

The TERECoP project [8] has identified several similar stages: the engagement stage, the exploration stage, the investigation stage, the production/creation stage and the evaluation stage.

The variations in the stages of PBL are numerous. This is due to the fact that each of the stages can vary from one educational facility to another. In the following section a visual tool will be presented which allows for the improvement of PBL as applied in the NXT workshops.

IV. INFOCENTER – DIDACTIC APROACH

As part of the NXT Workshops [14], more than a dozen activities have been organized since 2006. This has meant that the most recent workshops have been composed of a mixture of novices and experts. This enriches the activity significantly but also requires a greater commitment, not just from the instructor but also from the participants, to ensure that the tasks are completed within the stipulated period of time.

The continual desire to improve have led us to look for a simple project-management tool, from the professional world, and we aspire to introduce into the robotics workshops tools in order to work in a more efficient way and increase speed and flexibility during the execution of a project.

With this aim in mind, we investigated what is being used in the professional environment and thus introduced a tool which will be a genuine aid to them in their professional future. From this the infocenter emerges, inspired by the tool developed by the Scrum and Kanban processes [15] which help us work more effectively, to some degree, defining what must be done, how and by whom. Furthermore, both tools use a board as a visual representation to show the sequence of tasks and activities which are carried out during the project.

It is necessary to point out that as a visual management tool, apart from the control that visualization gives, it promotes 'the ability to see the potential to transform' and in

this case transformation also includes the mental processing and interpretation of what has been seen. Moreover, a visual environment is very powerful as it is expressed in a language that the human brain is particularly efficient at processing: visual language. People absorb visual instructions more quickly, as it is the shorter learning curve.

The infocenter we have designed can be defined as a visual tool whose purpose is to manage, control and constantly update the information supplied to those participating.

In all of the previous workshops, during the final session before the competition or exhibition, each team has presented the robot that they designed and constructed together for their friends, family and classmates. This is accompanied by a small investigation into the main theme of the workshop. This activity is the only one in which we can appreciate the final product. This project-management tool would allow the instructor, the participants and even people who are not involved in the workshop (parents, friends etc.) to appreciate, in a visual way, the magnitude of the work entailed in each session leading up to the final challenge.

A. Basic Concepts of Scrum and Kanban

Experts in Scrum and Kanban [15] recommend avoiding a limitation to one tool, suggesting instead a combination of them to best meet the needs of each team. For example, many Kanban teams have daily meetings (a practice taken from Scrum). They urge us to be aware of the limitations of each tool and to experiment until we find something which works. Kanban and Scrum are not the objective. Continual learning is the objective.

In this sense, Scrum and Kanban are empiricists. It is expected that we experiment with the process and personalise it to suit our own environment. In fact, we must experiment. Neither Scrum nor Kanban give us all the answers – they merely set out a series of basic guidelines which direct our own process of improvement.

A few important concepts in which Scrum and Kanban [15] resemble one another are:

- Both are *Lean* and *Agile*.
- Both establish work in progress limits.
- In both the visibility of the process is the basis for its improvement.
- Both work with self-organized groups.
- Both require the division of work into modules.

The main differences appear in table 1:

TABLE I
DIFFERENCES BETWEEN SCRUM and KANBAN

Scrum	Kanban
The team takes on a work commitment for each task.	This responsibility is optional.
The teams must have multiple functions.	The teams are specialized.
Several teams or persons share the same board.	The board belongs to one specific team.
3 roles are assigned.	No roles are assigned.
The tasks must be prioritised.	Prioritisation is optional.

Both Scrum and Kanban can cover the entire system of the production of a product, including the work in progress limit, the capacity, the duration of the cycle, the quality and the changes in predictability, among other factors. Our objective is not as broad nor does it involve as many variables as in the case of the business world. Instead, it concentrates on improving the management of the teams, giving the children a visual guide of the tasks to be completed during a robotic workshop and the opportunity to experiment with a model that is very similar to a real world project.

Fig. 1 Design of the infocenter for Baby Sumo NXT

B. *Design of the Infocenter*

The infocenter consists of a visual board inspired by that used by Scrum and Kanban [15]. It possesses the advantages of these boards, which are as follows:

- Each person (team) chooses the task to be carried out. In other words, responsibility is assumed, not assigned.
- It is a light and valuable tool, which makes the work flow clearly visible.
- It is easy to respond to: Where are we?
- It focuses the team
- Bottlenecks are quickly observed.
- It is easy and cheap.
- The correct task is carried out at the exact moment in which it is possible.

Therefore, the infocenter is composed of two sections; the section on the upper left is used to show everyone the number of tasks to be done and the time available. It is important that the tasks accurately represent the complete process involved in the realisation of the project. They must be specific and easily comprehensible to everyone. As an extra guide for the students it is also helpful to organise the tasks in order of priority.

This board eliminates the necessity for group leaders. Everyone, the instructor in particular, can examine the board and observe, for instance, that a team is falling behind and offer them a little help.

The next decision we had to make was whether to use defined roles (Scrum) or shared responsibility (Kanban). We decided to try shared responsibility. One fundamental reason behind this decision was the level of experience of the students, who ranged from beginners to almost experts.

After selecting and distributing the sections that appear on the board it is put in the classroom of the workshop in a place that is easily visible by all of the teams.

Fig. 2 Placement of the infocenter in the classroom of the workshop

The second part of the design involves generating awareness of the steps to be followed in each session, both by the instructor and by the students. With this purpose in mind the sequence for the robotics workshops is described as a guide to students.

In the first session, the instructor explains to the students what this new visual tool is composed of, its purpose, and how it should be used (next section).

They are then told that the next sessions will begin with a stand-up meeting. This is a characteristic of Scrum and the objective of this meeting is to facilitate the exchange of information and collaboration between the team members so as to increase their productivity, while also indicating areas in which they can help one another.

To achieve this, each team must answer the following questions within a maximum time of 15 minutes.

- What have I done since the last session?
- Was I able to do all I had planned to do?
- What was the problem?
- What am I going to do next?
- What obstacles do I face or am I going to face in order to meet the requirements of this task?

It is worth pointing out that the purpose of the meeting about the state and the synchronisation of the team is not to resolve problems, the problems are resolved after the meeting.

The experts recommend:

- To carry out this meeting while standing, so that the team members don't relax nor spend too long speaking about superfluous details.
- To carry out the team collaboration meeting directly after the end of this meeting.

It is evident that these visual boards in isolation do nothing; rather it is the participants that do the work. The process will become evident through the interaction among the participants which of course will be different with each team and each project. Once the team members understand the aim of these meetings and they get used to concentrating and exercising discipline the meetings become effective. This eventually becomes another group work habit which helps them meet their responsibilities. Moreover, it facilitates learning, as they can see how their fellow team members work and react to circumstances.

C. *Description of the Use of the Infocenter during the NXT Baby Sumo Workshop*

As we have already mentioned previously, the infocenter can be defined as a visualisation of the project on a board in which the participants regularly enter information in the relevant sections. The advantage of this is that the work to be done and ongoing tasks are always present. This ensures that no one is without work at any time and that all the important tasks are carried out in the correct order.

First we had to select appropriate section headings in the 'NXT Baby Sumo Infocenter' which were tailored to our objectives. These were: the title of the project, a detailed plan of the tasks to be completed, the duration of the project (divided into 6 sessions), the names of the teams and the list of those taking part.

Fig. 3 Detailed plan of the tasks with the duration of the project

Some additional sections were also included such as: comments, incidents, risks and milestones. *Who are we? How do I feel today? How do we have fun?* All of this allows us to record each stage of the project and to feel part of the team throughout the exercise.

Fig. 4 Additional section: How do we have fun? of the infocenter

In the first session the students are offered some general information: what an infocenter is, what its purpose is and the way in which it is used. Each team is asked to place a post-it in the appropriate box in the progress monitoring board each time they complete a task or wish to remark on a section of the infocenter. This post-it must include the state (complete or ongoing) and the name of the team. This makes it possible for all the team members to see exactly how the team is advancing with the project, in an impressive example of visual control.

One initial design flaw arose as a result of using the same colour of post-its for all the teams. As the rapid identification of the post-its is of crucial importance in an infocenter of large dimensions and with many teams it is important not to waste time. Therefore, as a result of this first test, we suggested the use of post-its of different colours as a solution, assigning a specific colour to each team and including special post-its depending on the type and priority level of each task. Here are some examples: a post-it in the form of a rhombus indicates that a decision has been taken, a green post-it is used for improvements, a yellow one for project tasks and red for errors. In addition to this, the post-its must include the name of the team member who is carrying out the respective task as well as the date of entry in each quadrant to allow the observation of each team's evolution throughout the project.

How does the infocenter support continuous development? With the stand-up meetings that are carried out at the beginning of each session of the workshop. This is the point at which each team inspects the progress of the tasks which are currently ongoing using the detailed questions supplied in the previous section. At the end the meeting can continue and/or the necessary modifications can be made which allows the fulfilment of the joint objective which the team undertook. During the meeting, the instructor takes note of any hitches and ensures that the team members stay focused.

On the one hand, this new initiative serves as a vehicle for the participants to acquire a new perspective on project management. On the other hand, it gives them the opportunity to put into practice important skills which they will require in their future professional careers. In the following section we will examine the results of several surveys carried out with the students in order to test the effectiveness of PBL with robots and of the infocenter in project management.

V. EVALUATION OF INFOCENTER BY THE STUDENTS

This baby sumo NXT workshop involved 20 participants (aged between 8 and 15 years old), three of whom were girls. They were separated into 7 teams, who attended six Saturday sessions of 3 hours each.

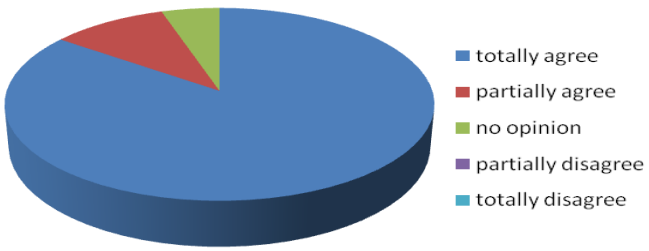

Fig. 5 *Results of the evaluation of the infocenter by the students*

The introduction of the infocenter has been evaluated periodically. We took into account the fact that the participants showed a growing interest in it. They began interacting with the visual board more and more, adding more annotations and even asking if they could include photos of their progress.

In the final session of the Baby Sumo NXT workshop they were asked if the info centre is a good tool for visualising their advancement during the project; 85 per cent of the participants totally agreed with this assessment.

The instructor also decided that this visual tool- which they described as an excellent resource for project management- will be a part of all subsequent workshops.

VI. CONCLUSIONS

In this article the incorporation of an infocenter as a didactic resource, for the first time, in the context of the NXT robotics Workshops has been presented. PBL is the fundamental work methodology employed in NXT Workshops. The aim of infocenter is the improvement of the project management.

The infocenter is an innovative tool within PBL with robots. Its low cost and cheap design allows for easy implementation. In addition to this, thanks to its special design, the infocenter can be used in a wide spectrum of pedagogical activities, unrelated to robotics.

The participants in the Baby Sumo workshop have shown their satisfaction with this new tool. It affords them quick access to the tasks that they need to complete and also to see the continuous progress they are making towards the culmination of the project. The instructor also noted its usefulness in the management of the teams during the workshop, simplifying their job as a monitor.

The change that takes place in the participants won't only have a significant impact on their conception of science and technology, but also on their social relations and their future professional development.

Finally, as part of the process of continuous improvement of the robotics activities, it is possible to investigate whether a digital version of the infocenter would generate even greater benefits than the current model that has just been tested.

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